6 Assessment

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ANSWERS TO SELECTED ODD-NUMBERED PROBLEMS APPEAR IN APPENDIX A.

Lesson by Lesson

6.1 Work

Conceptual Questions

60. A friend makes this statement: "Only the component of force perpendicular to the direction of motion does work." Is this statement true or false? Explain.

61. In the equation $W = Fd\cos\theta$, what is the angle θ?

62. The general equation for work is $W = Fd\cos\theta$. For what angle is the work $W = Fd$? For what angle is the work $W = -Fd$?

63. Your favorite uncle makes this statement: "A force that is always perpendicular to the velocity of a particle does no work on the particle." Is this statement true or false? If it is true, state why. If it is false, give a counterexample.

64. Triple Choice The International Space Station orbits the Earth in an approximately circular orbit at a height of $h = 375$ km above the Earth's surface. In one complete orbit, is the work done by Earth's gravity on the space station positive, negative, or zero? Explain.

65. Triple Choice A pendulum bob swings from point A to point B along the circular arc indicated in **Figure 6.10**. **(a)** Is the work done on the bob by gravity positive, negative, or zero? Explain. **(b)** Is the work done on the bob by the string positive, negative, or zero? Explain.

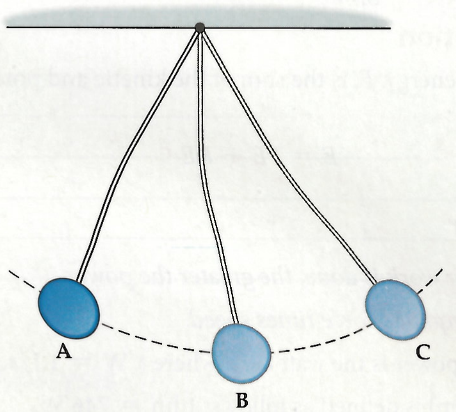

Figure 6.10

66. Triple Choice A pendulum bob swings from point B to point C along the circular arc indicated in Figure 6.10. **(a)** Is the work done on the bob by gravity positive, negative, or zero? Explain. **(b)** Is the work done on the bob by the string positive, negative, or zero? Explain.

Problem Solving

67. A dog lifts a 0.75-kg bone straight up through a distance of 0.11 m. How much work was done by the dog?

68. A weightlifter does 9.8 J of work while lifting a weight straight upward through a distance of 0.12 m. What was the force exerted by the weightlifter?

69. You do 13 J of work as you lift a 35-N pail of water. Through what height did you lift the pail?

70. You push a book 0.45 m across a desk with a 5.2-N force that is at an angle of 21° below the horizontal. How much work did you do on the book?

71. You pick up a 3.4-kg can of paint from the ground and lift it to a height of 1.8 m. **(a)** How much work do you do on the can of paint? **(b)** You hold the can stationary for half a minute, waiting for a friend on a ladder to take it. How much work do you do during this time? **(c)** Your friend decides not to use the paint, so you lower it back to the ground. How much work do you do on the can as you lower it?

72. Think & Calculate A tow rope, parallel to the water, pulls a water skier directly behind a boat with constant velocity for a distance of 65 m before the skier falls. The tension in the rope is 120 N. **(a)** Is the work done on the skier by the rope positive, negative, or zero? Explain. **(b)** Calculate the work done by the rope on the skier.

73. Think & Calculate In Problem 72, **(a)** is the work done on the boat by the rope positive, negative, or zero? Explain. **(b)** Calculate the work done by the rope on the boat.

74. A child pulls a friend in a little red wagon. If the child pulls with a force of 16 N for 12 m and the handle of the wagon is inclined at an angle of 25° above the horizontal, how much work does the child do on the wagon?

75. A 51-kg packing crate is pulled across a rough floor with a rope that is at an angle of 43° above the horizontal. If the tension in the rope is 120 N, how much work is done on the crate to move it 18 m?

76. Water skiers often ride to one side of the center line of a boat, as shown in **Figure 6.11**. In this case the boat is traveling at 15 m/s, and the tension in the rope is 75 N. If the boat does 2500 J of work on the skier in 42 m, what is the angle θ between the tow rope and the center line of the boat?

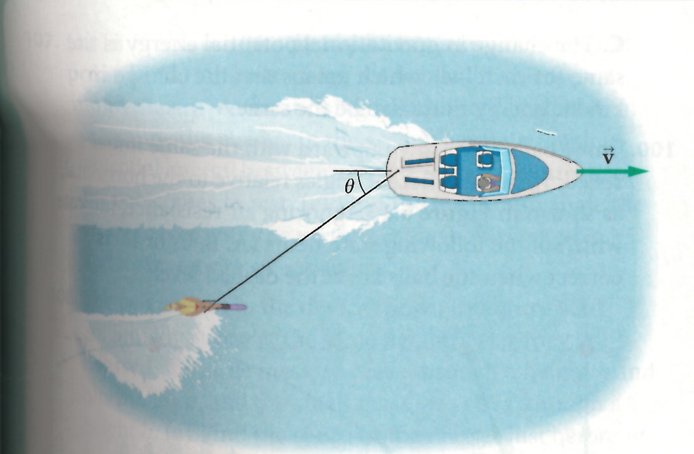

Figure 6.11

6.2 Work and Energy

Conceptual Questions

77. A package rests on the floor of an elevator that is rising with constant speed. The elevator exerts an upward force on the package and thus does positive work on it. Why doesn't the kinetic energy of the package increase?

78. An object moves with constant velocity. Is it safe to conclude that no force acts on the object? Why, or why not?

79. **Rank** Four joggers have the following masses and speeds:

Jogger	Mass	Speed
A	m	v
B	$m/2$	$3v$
C	$3m$	$v/2$
D	$4m$	$v/2$

Rank the joggers in order of increasing kinetic energy. Indicate ties where appropriate.

80. Is it possible for the kinetic energy of an object to be negative? Explain.

81. **Predict & Explain** The work required to accelerate a car from 0 to 50 km/h is W. **(a)** Is the work required to accelerate the car from 50 km/h to 150 km/h equal to $2W$, $3W$, $8W$, or $9W$? **(b)** Choose the *best* explanation from among the following:

A. The work to accelerate the car depends on the speed squared.

B. The final speed is three times the speed that was produced by the work W.

C. The increase in speed from 50 km/h to 150 km/h is twice the increase in speed from 0 to 50 km/h.

82. **Predict & Explain** Ball 1 is dropped to the ground from rest. Ball 2 is thrown to the ground with an initial downward speed. Assuming that the balls have the same mass and are released from the same height, is the change in gravitational potential energy of ball 1 greater than, less than, or equal to the change in gravitational potential energy of ball 2? **(b)** Choose the *best* explanation from among the following:

A. Ball 2 has the greater total energy, and therefore more of its energy can go into gravitational potential energy.

B. The gravitational potential energy depends only on the mass of the ball and its initial height above the ground.

C. All of the initial energy of ball 1 is gravitational potential energy.

83. **Triple Choice** Referring to Figure 6.10, is the gravitational potential energy of the bob at point C greater than, less than, or equal to the gravitational potential energy at **(a)** point A and **(b)** point B? Explain.

84. **Triple Choice** The potential energy of a stretched spring is positive. Is the potential energy of a compressed spring positive, negative, or zero? Explain.

Problem Solving

85. ***Skylab*'s Reentry** When NASA's *Skylab* reentered the Earth's atmosphere on July 11, 1979, it broke into a myriad of pieces. One of the largest fragments was a 1770-kg lead-lined film vault, and it landed with an estimated speed of 120 m/s. What was the kinetic energy of the film vault when it landed?

86. A 7.3-kg bowling ball is placed on a shelf 1.7 m above the floor. What is its gravitational potential energy?

87. A 0.15-kg baseball has a kinetic energy of 18 J. What is its speed?

88. The gravitational potential energy of a 0.12-kg bird in a tree is 6.6 J. What is the height of the bird above the ground?

89. A spring with a spring constant of 92 N/m is compressed by 2.8 cm. How much potential energy is stored in the spring?

90. A force of 27 N stretches a given spring by 4.4 cm. How much potential energy is stored in the spring when it is compressed 3.5 cm?

91. A spring that is stretched 2.6 cm stores a potential energy of 0.053 J. What is the spring constant of this spring?

92. **Think & Calculate** A 1100-kg car is coasting on a horizontal road with a speed of 19 m/s. After passing over an unpaved, sandy stretch 32 m long, the car's speed has decreased to 12 m/s. **(a)** Was the net work done on the car positive, negative, or zero? Explain. **(b)** Find the magnitude of the average net force on the car in the sandy section of the road.

93. A 65-kg bicyclist rides his 8.8-kg bicycle with a speed of 14 m/s. **(a)** How much work must be done by the brakes to bring the bike and rider to a stop? **(b)** What is the magnitude of the braking force if the bicycle comes to rest in 3.5 m?

94. After hitting a long fly ball that goes over the right fielder's head and lands in the outfield, a batter decides to keep going past second base and try for third base. The 62-kg player begins sliding 3.4 m from the base with a speed of 4.5 m/s. **(a)** If the player comes to rest at third base, how much work was done on the player by friction with the ground? **(b)** What was the coefficient of kinetic friction between the player and the ground?

95. An object has a speed of 3.5 m/s and a kinetic energy of 14 J at $t = 0$. At $t = 5.0$ s the object has a speed of 4.7 m/s. **(a)** What is the mass of the object? **(b)** What is the kinetic energy of the object at $t = 5.0$ s? **(c)** How much work was done on the object between $t = 0$ and $t = 5.0$ s?

96. A 0.33-kg pendulum bob is attached to a string 1.2 m long. What is the change in the gravitational potential energy of the system as the bob swings from point A to point B in **Figure 6.12**?

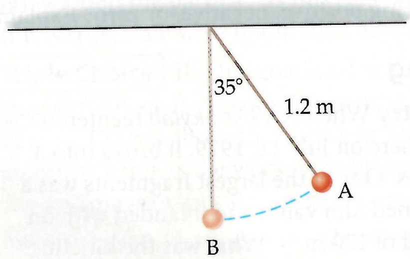

Figure 6.12

6.3 Conservation of Energy

Conceptual Questions

97. An object moves with no friction or air resistance. Initially, its kinetic energy is 10 J, and its gravitational potential energy is 20 J. What is its kinetic energy when its potential energy has decreased to 15 J? What is its potential energy when its kinetic energy has decreased to 5 J?

98. An object moves with no friction or air resistance. Initially, its kinetic energy is 10 J, and its gravitational potential energy is 30 J. What is the greatest potential energy possible for this object? What is the greatest kinetic energy possible for this object?

99. **Predict & Explain** You throw a ball upward and let it fall to the ground. Your friend drops an identical ball straight down to the ground from the same height. **(a)** Is the change in kinetic energy (from just after the ball is released until just before it hits the ground) of your ball greater than, less than, or equal to the change in kinetic energy of your friend's ball? **(b)** Choose the *best* explanation from among the following:

A. Your friend's ball converts all of its initial energy into kinetic energy.

B. Your ball is in the air longer, which results in a greater change in kinetic energy.

C. The change in gravitational potential energy is the same for each ball, which means that the change in kinetic energy must also be the same.

100. Three balls are thrown upward with the same initial speed, v_i, but at different angles relative to the horizontal, as shown in **Figure 6.13**. Ignoring air resistance, indicate which of the following statements (A, B, C, or D) is correct when the balls are at the dashed level?

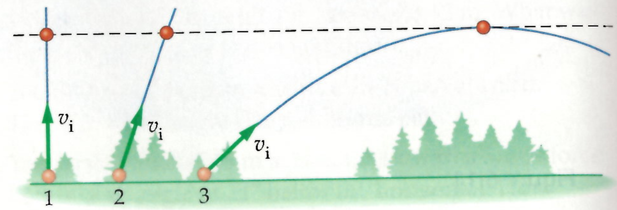

Figure 6.13

A. Ball 3 has the lowest speed.

B. Ball 1 has the lowest speed.

C. All three balls have the same speed.

D. The speed of the balls depends on their mass.

Problem Solving

101. A player passes a 0.600-kg basketball down court for a fast break. The ball leaves the player's hands with a speed of 8.30 m/s and slows down to 7.10 m/s at its highest point. Ignoring air resistance, how high above the release point is the ball when it is at its maximum height?

102. A 5.76-kg rock is dropped and allowed to fall freely. Find the initial kinetic energy, the final kinetic energy, and the change in kinetic energy for **(a)** the first 2.00 m of fall and **(b)** the second 2.00 m of fall.

103. A 0.26-kg rock is thrown vertically upward from the top of a cliff that is 32 m high. When it hits the ground at the base of the cliff, the rock has a speed of 29 m/s. Assuming that air resistance can be ignored, find **(a)** the initial speed of the rock and **(b)** the greatest height of the rock as measured from the base of the cliff.

104. A block with a mass of 3.7 kg slides with a speed of 2.2 m/s on a frictionless surface. The block runs into a stationary spring and compresses it a certain distance before coming to rest. What is the compression distance, given that the spring has a spring constant of 3200 N/m?

105. A 1.3-kg block is pushed up against a stationary spring, compressing it a distance of 4.2 cm. When the block is released, the spring pushes it away across a frictionless, horizontal surface. What is the speed of the block, given that the spring constant of the spring is 1400 N/m?

106. Suppose the pendulum bob in Figure 6.12 has a mass of 0.33 kg and is moving to the right at point B with a speed of 2.4 m/s. Air resistance is negligible. **(a)** What is the change in the system's gravitational potential energy when the bob reaches point A? **(b)** What is the speed of the bob at point A?

107. (a) In Problem 106, what is the bob's kinetic energy at point B? **(b)** At some point the bob will come to rest momentarily. Without doing an additional calculation, determine the change in the system's gravitational potential energy between point B and the point where the bob comes to rest. **(c)** Find the maximum angle the string makes with the vertical as the bob swings back and forth. Ignore air resistance.

108. The two masses in the device shown in **Figure 6.14** are initially at rest at the same height. After they are released, the large mass, m_2, falls through a height h and hits the floor, and the small mass, m_1, rises through a height h. **(a)** Find the speed of the masses just before m_2 lands, giving your answer in terms of m_1, m_2, g, and h. Assume that the ropes and pulley have negligible mass and that friction can be ignored. **(b)** Evaluate your answer to part (a) for the case where $h = 1.2$ m, $m_1 = 3.7$ kg, and $m_2 = 4.1$ kg.

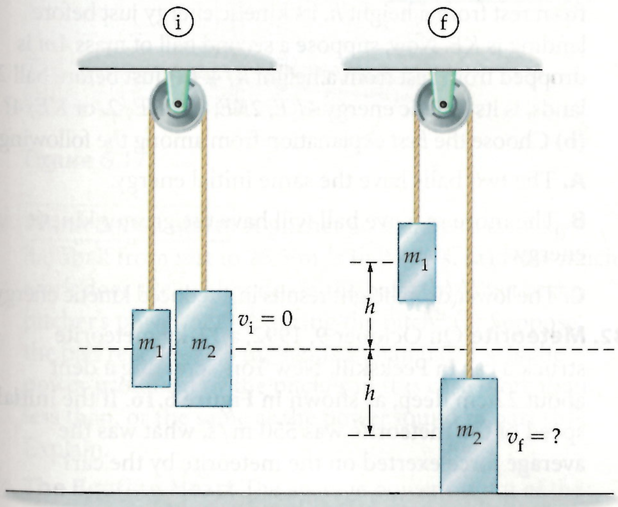

Figure 6.14

6.4 Power

Conceptual Questions

109. Engine 1 produces twice the power of engine 2. If it takes engine 1 the time T to do the work W, how long does it take engine 2 to do the same work? Explain.

110. Engine 1 produces twice the power of engine 2. If it takes engine 1 the time T to do the work W, how long does it take engine 2 to do the work $3W$? Explain.

111. **Rank** Four forces do the following amounts of work in the indicated times:

Force	Work	Time
A	5 J	10 s
B	3 J	5 s
C	6 J	18 s
D	25 J	125 s

Rank these forces in order of increasing power produced. Indicate ties where appropriate.

112. **Rank** Four forces do the following amounts of work and produce the indicated powers:

Force	Work	Power
A	40 J	80 W
B	35 J	5 W
C	75 J	25 W
D	60 J	30 W

Rank these forces in order of increasing time required to do the work. Indicate ties where appropriate.

Problem Solving

113. How many joules of energy are in a kilowatt-hour?

114. **The Power You Produce** Estimate the power you produce as you walk leisurely up a flight of stairs. Give your answer in both watts and horsepower (1 hp = 746 W).

115. As you lift an 88-N box straight upward, you produce a power of 72 W. What is the speed of the box?

116. In order to keep a leaking ship from sinking, it is necessary to pump 12 kg of water each second from below deck 2.1 m upward and over the side. What is the minimum horsepower motor that can be used to save the ship (1 hp = 746 W)?

117. **Human-Powered Flight** Human-powered aircraft require a pilot to pedal, as on a bicycle, and to produce a sustained power output of about 0.30 hp (1 hp = 746 W). The *Gossamer Albatross* flew across the English Channel on June 12, 1979, in 2 h 49 min. **(a)** How much energy did the pilot expend during the flight? **(b)** How many candy bars (280 Cal per bar) would the pilot have to consume to be "fueled up" for the flight? Note that a nutritional calorie (1 Cal) is equivalent to 1000 calories (1000 cal) as defined in physics. In addition, the conversion factor between calories and joules is as follows: 1 Cal = 1000 cal = 1 kcal = 4186 J.

118. **Think & Calculate** A grandfather clock is powered by the descent of a 4.35-kg weight. **(a)** If the weight descends through a distance of 0.760 m in 3.25 days, how much power does it deliver to the clock? **(b)** To increase the power delivered to the clock, should the time it takes for the mass to descend be increased or decreased? Explain.

Mixed Review

119. To get out of bed in the morning, do you have to do work? Explain.

120. A leaf falls to the ground with constant speed. Is $PE_i + KE_i$ for this system greater than, less than, or equal to $PE_f + KE_f$? Explain.

121. A ball is dropped from rest. Which of the three graphs (A, B, or C) in **Figure 6.15** corresponds to **(a)** the potential energy, **(b)** the kinetic energy, and **(c)** the total mechanical energy for the ball as it falls to the ground? Assume that the system is ideal, with no form of friction.

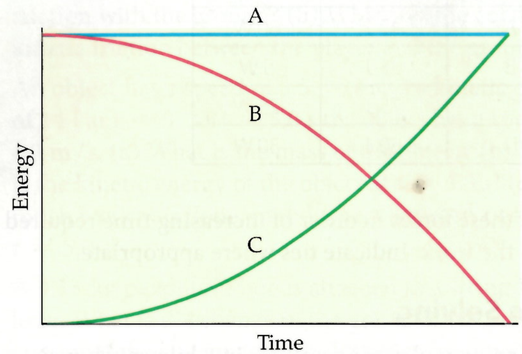

Figure 6.15

122. A spring has a spring constant of 310 N/m. Plot the potential energy for this spring when it is stretched by 1.0 cm, 2.0 cm, 3.0 cm, and 4.0 cm. Draw a curve that goes through your plotted points.

123. A small motor runs a lift that raises a load of bricks weighing 836 N to a height of 10.7 m in 23.2 s. Assuming that the bricks are lifted with constant speed, what is the minimum power the motor must produce?

124. Brain Power The human brain uses about 22 W of power under normal conditions (though more power may be required during exams!). How long can one Snickers bar (see Problem 117) power the normally functioning brain?

125. The Atmos Clock The Atmos clock (the so-called perpetual motion clock) gets its name from the fact that it runs off pressure variations in the atmosphere, which drive a bellows containing a mixture of gas and liquid ethyl chloride. Because the power to drive these clocks is so limited, they have to be very efficient. In fact, a single 60.0-W lightbulb could power 240 million Atmos clocks simultaneously. Find the amount of energy, in joules, required to run an Atmos clock for 1 day.

126. You push a 67-kg box across a floor, where the coefficient of kinetic friction is $\mu_k = 0.55$. The force you exert is horizontal. How much power is needed to push the box at a speed of 0.50 m/s?

127. Think & Calculate To clean a floor, a janitor pushes on a mop handle with a force of 43 N. **(a)** If the mop handle is at an angle of 55° above the horizontal, how much work is required to push the mop 0.50 m? **(b)** If the angle the mop handle makes with the horizontal is increased to 65°, does the work done by the janitor increase, decrease, or stay the same? Explain.

128. A small airplane tows a glider at constant speed and altitude. If the plane does 2.00×10^5 J of work to tow the glider 145 m and the tension in the tow rope is 2560 N, what is the angle between the tow rope and the horizontal?

129. Cookie Power To make a batch of cookies, you mix half a bag of chocolate chips into a bowl of cookie dough, exerting a 21-N force on the stirring spoon. Assume that your force is always in the direction of motion of the spoon. **(a)** What power is needed to move the spoon at a speed of 0.23 m/s? **(b)** How much work do you do if you stir the mixture for 1.5 min?

130. A particle moves without friction. At point A the particle has a kinetic energy of 12 J; at point B the particle is momentarily at rest, and the potential energy of the system is 25 J; at point C the potential energy of the system is 5 J. **(a)** What is the potential energy of the system when the particle is at point A? **(b)** What is the kinetic energy of the particle at point C?

131. Predict & Explain When a ball of mass m is dropped from rest from a height h, its kinetic energy just before landing is KE. Now, suppose a second ball of mass $4m$ is dropped from rest from a height $h/4$. **(a)** Just before ball 2 lands, is its kinetic energy $4KE$, $2KE$, KE, $KE/2$, or $KE/4$? **(b)** Choose the *best* explanation from among the following:

A. The two balls have the same initial energy.

B. The more massive ball will have the greater kinetic energy.

C. The lower drop height results in a reduced kinetic energy.

132. Meteorite On October 9, 1992, a 12-kg meteorite struck a car in Peekskill, New York, creating a dent about 22 cm deep, as shown in **Figure 6.16**. If the initial speed of the meteorite was 550 m/s, what was the average force exerted on the meteorite by the car?

Figure 6.16 An interplanetary fender-bender.

133. **(a)** At what rate must you lift a 3.6-kg container of milk (1 gallon) if the power output of your arm is to be 22 W? **(b)** How long does it take to lift the milk container through a distance of 1.0 m at this rate?

134. Catapult Launcher A catapult launcher on an aircraft carrier accelerates a jet from rest to 72 m/s. The work done by the catapult during the launch is 7.6×10^7 J. **(a)** What is the mass of the jet? **(b)** If the jet is in contact with the catapult for 2.0 s, what is the power output of the catapult?

135. The water skier in Figure 6.11 is at an angle of 35° with respect to the center line of the boat and is being pulled at a constant speed of 14 m/s. **(a)** If the tension in the tow rope is 90.0 N, how much work does the rope do on the skier in 10.0 s? **(b)** How much work does the resistive force of water do on the skier in the same time?

136. Calculate the power output of a 1.8-g spider as it walks up a windowpane at 2.3 cm/s. The spider walks on a path that is at 25° to the vertical, as illustrated in **Figure 6.17.**

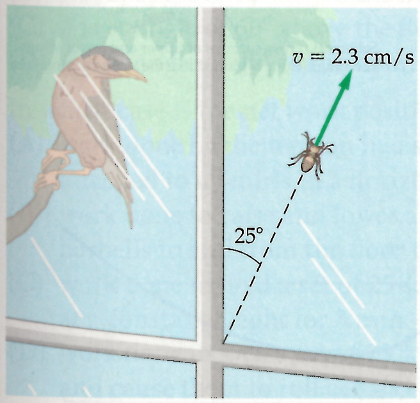

Figure 6.17

137. Think & Calculate A pitcher accelerates a 0.14-kg hardball from rest to 25.5 m/s in 0.075 s. **(a)** How much work does the pitcher do on the ball? **(b)** What is the pitcher's power output during the pitch? **(c)** Suppose the ball reaches 25.5 m/s in less than 0.075 s. Is the power produced by the pitcher in this case more than, less than, or the same as the power found in part (b)? Explain.

138. The Beating Heart The average power output of the human heart is 1.33 W. **(a)** How much energy does the heart produce in a day? **(b)** Compare the energy found in part (a) with the energy required to walk up a flight of stairs. Estimate the height a person could attain on a set of stairs using nothing more than the daily energy produced by the heart.

139. Think & Calculate A sled slides without friction down a small, ice-covered hill. If the sled starts from rest at the top of the hill, its speed at the bottom is 7.50 m/s. **(a)** On a second run, the sled starts with a speed of 1.50 m/s at the top. When it reaches the bottom of the hill, is its speed 9.00 m/s, more than 9.00 m/s, or less than 9.00 m/s? Explain. **(b)** Find the speed of the sled at the bottom of the hill after the second run.

140. An 1865-kg airplane starts at rest on an airport runway at sea level. What is the change in mechanical energy of the airplane if it climbs to a cruising altitude of 2420 m and maintains a constant speed of 96.5 m/s?

141. The water slide shown in **Figure 6.18** ends at a height of 1.50 m above the pool. If the person starts from rest at point A and lands in the water at point B, what is the height h of the water slide? (Assume that the water slide is frictionless.)

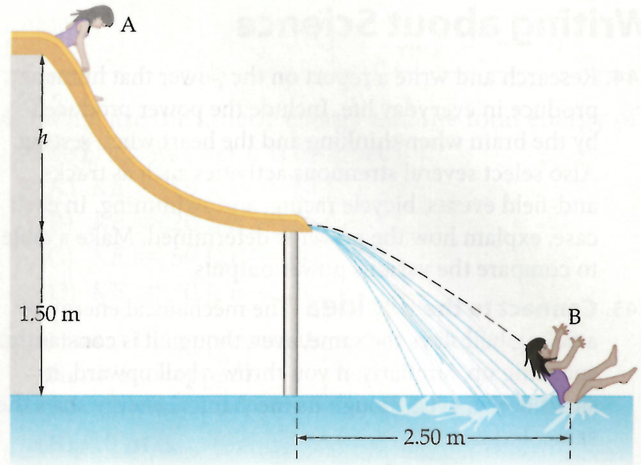

Figure 6.18

142. A skateboarder starts at point A in **Figure 6.19** and rises to a height of 2.64 m above the top of the ramp at point B. What was the skateboarder's initial speed at point A?

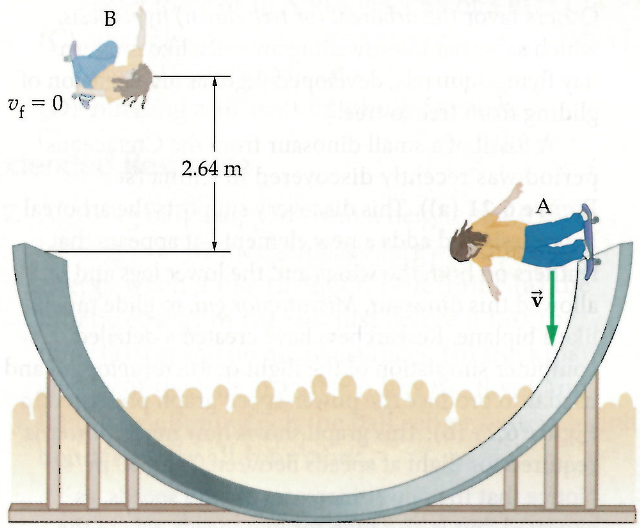

Figure 6.19

143. A 1.9-kg block slides down a frictionless ramp, as shown in **Figure 6.20**. The top of the ramp is 1.5 m above the ground; the bottom of the ramp is 0.25 m above the ground. The block leaves the ramp moving horizontally, and lands a horizontal distance d away. Find the distance d.

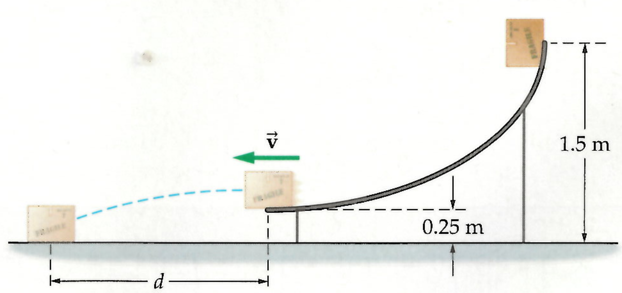

Figure 6.20