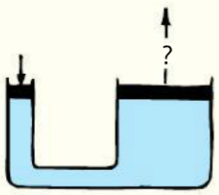
THINK AND SOLVE (MATHEMATICAL APPLICATION)

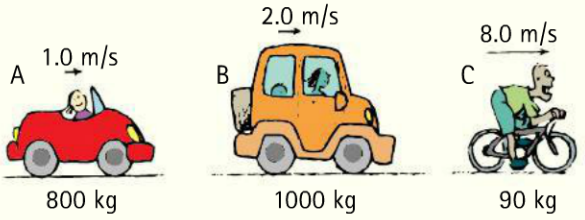
41. The second floor of a house is 6 m above the street level. How much work is required to lift a 300-kg refrigerator to the second-story level?
42. (a) How much work is done when you push a crate horizontally with 100 N across a 10-m factory floor? (b) If the force of friction on the crate is a steady 70 N, show that the KE gained by the crate is 300 J. (c) Show that 700 J is turned into heat.
43. This question is typical on some driver's license exams: A car that was moving at 50 km/h skids 15 m with locked brakes. How far will the car skid with locked brakes if it was moving at 150 km/h?
44. Belly-flop Bernie dives from atop a tall flagpole into a swimming pool below. His potential energy at the top is 10,000 J (relative to the surface of the pool). What is his kinetic energy when his potential energy is reduced to 1000 J?
45. Nellie Newton applies a force of 50 N to the end of a lever, which is moved a certain distance. If the other end of the lever moves one-third as far, show that the force it exerts is 150 N.
46. Consider an ideal pulley system. If you pull one end of the rope 1 m downward with a 50-N force, show that you can lift a 200-N load one-quarter of a meter high.
47. In raising a 5000-N piano with a pulley system, the workers note that for every 2 m of rope pulled downward, the piano rises 0.2 m. Ideally, show that 500 N is required to lift the piano.
48. In the hydraulic machine shown, you observe that when the small piston is pushed down 10 cm, the large piston is raised 1 cm. If the small piston is pushed down with a force of 100 N, what is the most weight that the large piston can support?



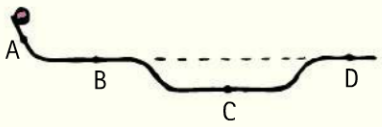
49. How many watts of power do you expend when you exert a force of 50 N that moves a crate 8 m in a time interval of 4 s?
50. Emily holds a banana of mass m over the edge of a bridge of height h. She drops the banana and it falls to the river below. Use conservation of energy to show that the speed of the banana just before hitting the water is $v = \sqrt{2gh}$.

THINK AND RANK (ANALYSIS)

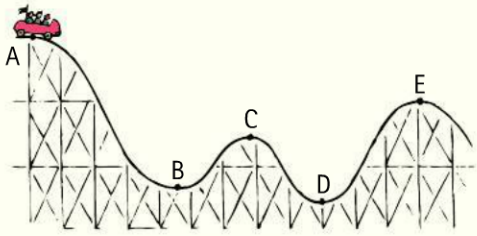
51. The mass and speed of the three vehicles, A, B, and C, are shown. Rank them from greatest to least for the following:
    a. Momentum
    b. Kinetic energy
    c. Work done to bring them up to their respective speeds from rest



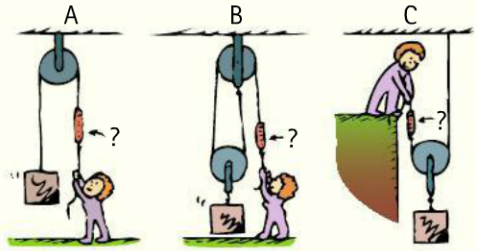
52. A ball is released from rest at the left of the metal track shown here. Assume it has only enough friction to roll, but not to lessen its speed. Rank these quantities from greatest to least at each point:
    a. Momentum
    b. KE
    c. PE



53. The roller coaster ride starts from rest at point A. Rank these quantities from greatest to least at each point:
    a. Speed
    b. KE
    c. PE



54. Rank the scale readings from highest to lowest. (Ignore friction.)



THINK AND EXPLAIN (SYNTHESIS)

55. Why is it easier to stop a lightly loaded truck than a heavier one that has equal speed?
56. Why do you do no work on a 25-kg backpack when you walk a horizontal distance of 100 m?
57. If your friend pushes a lawnmower four times as far as you do while exerting only half the force, which one of you does more work? How much more?
58. Why does one get tired pushing against a stationary wall when no work is done on the wall?
59. Which requires more work: stretching a strong spring a certain distance or stretching a weak spring the same distance? Defend your answer.
60. Two people who weigh the same climb a flight of stairs. The first person climbs the stairs in 30 s, and the second person climbs them in 40 s. Which person does more work? Which uses more power?
61. In determining the potential energy of Tenny's drawn bow (see Figure 7.10), would it be an underestimate or an overestimate to multiply the force with which she holds the arrow in its drawn position by the distance she pulls it back? Why do we say the work done is *average* force $\times$ distance?
62. When a rifle with a longer barrel is fired, the force of expanding gases acts on the bullet for a longer distance. What effect does this have on the velocity of the emerging bullet? (Do you see why long-range cannons have such long barrels?)
63. Your friend says that the kinetic energy of an object depends on the reference frame of the observer. Explain why you agree or disagree.
64. You and a flight attendant toss a ball back and forth in an airplane in flight. Does the KE of the ball depend on the speed of the airplane? Carefully explain.
65. You watch your friend take off in a jet plane, and you comment on the kinetic energy she has acquired. But she says she experiences no such increase in kinetic energy. Who is correct?
66. When a jumbo jet slows and descends on the approach to landing, there is a decrease in both its kinetic and potential energy. Where does this energy go?
67. Explain how "elastic potential energy" dramatically changed the sport of pole vaulting when flexible fiberglass poles replaced stiffer wooden poles.
68. At what point in its motion is the KE of a pendulum bob at a maximum? At what point is its PE at a maximum? When its KE is at half its maximum value, how much PE does it have relative to its PE at the center of the swing?
69. A physics instructor demonstrates energy conservation by releasing a heavy pendulum bob, as shown in the sketch, and allowing it to swing to and fro. What would happen if, in his exuberance, he gave the bob a slight shove as it left his nose? Explain.

70. Does the International Space Station have gravitational PE? KE? Explain.
71. What does the work–energy theorem say about the speed of a satellite in circular orbit?
72. A moving hammer hits a nail and drives it into a wall. If the hammer hits the nail with twice the speed, how much deeper will the nail be driven? If the hammer hits with three times the speed?
73. Why does the force of gravity do no work on (a) a bowling ball rolling along a bowling alley and (b) a satellite in circular orbit about Earth?
74. Why does the force of gravity do work on a car that rolls down a hill but no work when it rolls along a level part of the road?
75. Does the string that supports a pendulum bob do work on the bob as its swings to and fro? Does the force of gravity do any work on the bob?
76. A crate is pulled across a horizontal floor by a rope. At the same time, the crate pulls back on the rope, in accord with Newton's third law. Does the work done on the crate by the rope then equal zero? Explain.
77. On a playground slide, a child has potential energy that decreases by 1000 J while her kinetic energy increases by 900 J. What other form of energy is involved, and how much?
78. Someone who wants to sell you a Superball claims that it will bounce to a height greater than the height from which it is dropped. Can this be?
79. Why can't a Superball released from rest reach its original height when it bounces from a rigid floor?
80. Consider a ball thrown straight up in the air. At what position is its kinetic energy at a maximum? Where is its gravitational potential energy at a maximum?
81. Discuss the design of the roller coaster shown in the sketch in terms of the conservation of energy.

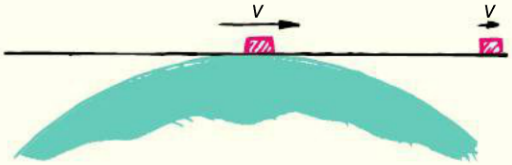
82. Suppose that you and two classmates are discussing the design of a roller coaster. One classmate says that each summit must be lower than the preceding one. Your other classmate says this is nonsense, for as long as the first one is the highest, it doesn't matter what height the others are. What do you say?
83. When the girl in Figure 7.17 jacks up a car, how can applying so little force produce sufficient force to raise the car?
84. What famous equation by Albert Einstein describes the relationship between mass and energy?
85. When the mass of a moving object is doubled with no change in speed, by what factor is its momentum changed? By what factor is its kinetic energy changed?

86. When the velocity of an object is doubled, by what factor is its momentum changed? By what factor is its kinetic energy changed?
87. Which, if either, has greater momentum: a 1-kg ball moving at 2 m/s or a 2-kg ball moving at 1 m/s? Which has greater kinetic energy?
88. A car has the same kinetic energy when traveling north as when it turns around and travels south. Is the momentum of the car the same in both cases?
89. If an object's KE is zero, what is its momentum?
90. If your momentum is zero, is your kinetic energy necessarily zero also?
91. If two objects have equal kinetic energies, do they necessarily have the same momentum? Defend your answer.
92. Two lumps of clay with equal and opposite momenta have a head-on collision and come to rest. Is momentum conserved? Is kinetic energy conserved? Why are your answers the same or different?
93. Scissors for cutting paper have long blades and short handles, whereas metal-cutting shears have long handles and short blades. Bolt cutters have very long handles and very short blades. Why is this so?
94. An inefficient machine is said to "waste energy." Does this mean that energy is actually lost? Explain.
95. If an automobile were to have a 100%-efficient engine, transferring all of the fuel's energy to work, would the engine be warm to your touch? Would its exhaust heat the surrounding air? Would it make any noise? Would it vibrate? Would any of its fuel go unused?
96. Your friend says that one way to improve air quality in a city is to have traffic lights synchronized so that motorists can travel long distances at constant speed. What physics principle supports this claim?
97. The energy we require to live comes from the chemically stored potential energy in food, which is transformed into other energy forms during the metabolism process. What happens to a person whose combined work and heat output is less than the energy consumed? What happens when the person's work and heat output is greater than the energy consumed? Can an undernourished person perform extra work without extra food? Defend your answers.

THINK AND DISCUSS (EVALUATION)

98. Discuss whether or not, once used, energy can be regenerated. Is your reasoning consistent with the common term *renewable energy*?
99. Discuss what international peace, cooperation, and security have to do with addressing the world's energy needs.
100. Consider the identical balls released from rest on tracks A and B, as shown. When they reach the right ends of the tracks, which will have the greater speed? Why is this question easier to answer than the similar one (Think and Discuss 95) in Chapter 3?

101. Does a car burn more gasoline when its lights are turned on? Does the overall consumption of gasoline depend on whether or not the engine is running while the lights are on? Discuss this, and defend your answer.
102. Suppose an object is set sliding, with a speed less than escape velocity, on an infinite frictionless plane in contact with the surface of Earth, as shown. Describe its motion. (Will it slide forever at a constant velocity? Will it slide to a stop? In what way will its energy changes be similar to that of a pendulum?)



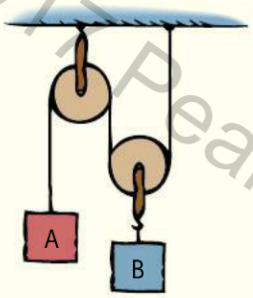
103. The Sun puts out twice as much solar energy in 2 hours as it does in 1 hour. But the solar *power* of the Sun is the same from one hour to the next. Distinguish between the terms *solar energy* and *solar power*.
104. If a golf ball and a Ping-Pong ball both move with the same kinetic energy, can you say which has the greater speed? Explain in terms of the definition of KE. Similarly, in a gaseous mixture of heavy molecules and light molecules with the same average KE, can you say which have the greater speed?
105. Running a car's air conditioner usually increases fuel consumption. But, at certain speeds, a car with its windows open and with the air conditioner turned off can consume more fuel. Discuss and explain.
106. Discuss why one should even bother to use a machine if it cannot multiply work input to achieve greater work output. What, then, is the use of a machine?
107. You tell your friend that no machine can possibly put out more energy than is put into it, and your friend states that a nuclear reactor puts out more energy than is put into it. What is your response?
108. This may seem like an easy question for a physics type to answer: With what force does a rock that weighs 10 N strike the ground if it is dropped from a rest position 10 m high? In fact, the question cannot be answered unless you know more. Discuss why this is so.
109. Your discussion partner is confused about ideas discussed in Chapter 4 that seem to contradict ideas discussed in this chapter. For example, in Chapter 4, we learned that the net force is zero for a car traveling along a level road at constant velocity, but in this chapter, we learned that work is done in such a case. Your discussion

friend asks, "How can work be done when the net force equals zero?" Discuss your explanation.

110. In the absence of air resistance, a ball thrown vertically upward with a certain initial KE will return to its original level with the same KE. When air resistance is a factor affecting the ball, will it return to its original level with the same, less, or more KE? Does your answer contradict the law of energy conservation?

111. You're on a rooftop and you throw one ball downward to the ground below and another upward. The second ball, after rising, falls and also strikes the ground below. If air resistance can be ignored, and if your downward and upward initial speeds are the same, how will the speeds of the balls compare upon striking the ground? (Use the idea of energy conservation to arrive at your answer.)

112. In the pulley system shown, block A has a mass of 10 kg and is suspended precariously at rest. Assume that the pulleys and string are massless and there is no friction. No friction means that the tension in one part of the supporting string is the same as at any other part. Discuss why the mass of block B is 20 kg.



113. Going uphill, the gasoline engine in a gasoline–electric hybrid car provides 75 horsepower while the total power propelling the car is 90 horsepower. Burning gasoline provides the 75 horsepower. Discuss what provides the other 15 horsepower.

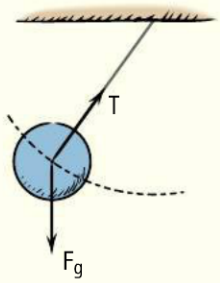
114. When a driver applies the brakes to keep a car going downhill at constant speed and constant kinetic energy, the potential energy of the car decreases. Where does this energy go? In contrast, discuss where most of it goes with a hybrid vehicle.

115. Does the KE of a car change more when it goes from 10 to 20 km/h or when it goes from 20 to 30 km/h?

116. Can something have energy without having momentum? Explain. Can something have momentum without having energy? Discuss and defend your answer.

117. No work is done by gravity on a bowling ball that is resting or moving on a bowling alley because the force of gravity on the ball acts perpendicular to the surface. But on an incline, the force of gravity has a vector component parallel to the alley, as in B. How does this component account for (a) the acceleration of the ball and (b) the work done on the ball to change its kinetic energy?

118. Consider a bob attached by a string, a simple pendulum, that swings to and fro. (a) Why doesn't the tension force in the string do work on the pendulum? (b) Explain, however, why the force due to gravity on the pendulum at nearly every point *does* do work on the pendulum. (c) What is the single position of the pendulum where "no work by gravity" occurs?



119. Consider a satellite in a circular orbit above Earth's surface. In Chapter 10 we will learn that the force of gravity changes only the direction of motion of a satellite in circular motion (and keeps it in a circle); it does NOT change the satellite's speed. Work done on the satellite by the gravitational force is zero. What is your explanation?

120. Consider the swinging-balls apparatus. If two balls are lifted and released, momentum is conserved as two balls pop out the other side with the same speed as the released balls at impact. But momentum would also be conserved if one ball popped out at twice the speed. Discuss why this never happens. (And explain why this exercise is in Chapter 7 rather than in Chapter 6.)

121. To combat wasteful habits, we often speak of "conserving energy," by which we mean turning off lights and hot water when they are not being used and keeping thermostats at a moderate level. In this chapter, we also speak of "energy conservation." Discuss and distinguish between these two phrases.

122. When an electric company can't meet its customers' demand for electricity on a hot summer day, should the problem be called an "energy crisis" or a "power crisis"? Discuss.