

# APPENDIX I

## Additional Problems

### The Science of Physics

1. Mt. Waialeale in Hawaii gets  $1.168 \times 10^3$  cm of rainfall on average per year. Express this quantity in meters.
2. An acre is equal to about  $4.0469 \times 10^3$  m<sup>2</sup>. Express this area in square kilometers.
3. A group drinks about  $6.4 \times 10^4$  cm<sup>3</sup> of water per person per year. Express this in cubic meters.
4. The largest stone jar on the Plain of Jars in Laos has a mass of  $6.0 \times 10^3$  kg. Express this mass in milligrams.
5. Half of a sample of the radioactive isotope beryllium-8 decays in  $6.7 \times 10^{-17}$  s. Express this time in picoseconds.

### Motion in One Dimension

6. The fastest airplane is the Lockheed SR-71. If an SR-71 flies 15.0 km west in 15.3 s, what is its average velocity in kilometers per hour?
7. Except for a 22.0 min rest stop, Emily drives with a constant velocity of 89.5 km/h, north. How long does the trip take if Emily's average velocity is 77.8 km/h, north?
8. A spaceship accelerates uniformly for 1220 km. How much time is required for the spaceship to increase its speed from 11.1 km/s to 11.7 km/s?
9. A polar bear initially running at 4.0 m/s accelerates uniformly for 18 s. If the bear travels 135 m in this time, what is its maximum speed?
10. A walrus accelerates from 7.0 km/h to 34.5 km/h over a distance of 95 m. What is the magnitude of the walrus's acceleration?
11. A snail can move about 4.0 m in 5.0 min. What is the average speed of the snail?
12. A crate is accelerated at  $0.035 \text{ m/s}^2$  for 28.0 s along a conveyor belt. If the crate's initial speed is 0.76 m/s, what is its final speed?
13. A person throws a ball vertically and catches it after 5.10 s. What is the ball's initial velocity?
14. A bicyclist accelerates  $-0.870 \text{ m/s}^2$  during a 3.80 s interval. What is the change in the velocity of the bicyclist and bicycle?
15. A hockey puck slides 55.0 m in 1.25 s with a uniform acceleration. If the puck's final speed is 43.2 m/s, what was its initial speed?
16. A small rocket launched from rest travels 12.4 m upward in 2.0 s. What is the rocket's net acceleration?
17. A jet slows uniformly from 153 km/h to 0 km/h over 42.0 m. What is the jet's acceleration?
18. A softball thrown straight up at 17.5 m/s is caught 3.60 s later. How high does the ball rise?
19. A child, starting from rest, sleds down a snow-covered slope in 5.50 s. If the child's final speed is 14.0 m/s, what is the length of the slope?
20. A skydiver opens her parachute and drifts down for 34.0 s with a constant velocity of 6.50 m/s. What is the skydiver's displacement?
21. In a race, a tortoise runs at 10.0 cm/s, and a hare runs at 200.0 cm/s. Both start at the same time, but the hare stops to rest for 2.00 min. The tortoise wins by 20.0 cm. At what time does the tortoise cross the finish line?
22. What is the length of the race in problem 21?
23. The cable pulling an elevator upward at 12.5 m/s breaks. How long does it take for the elevator to come to rest?
24. A disk is uniformly accelerated from rest for 0.910 s over 7.19 km. What is its final speed?
25. A tiger accelerates  $3.0 \text{ m/s}^2$  for 4.1 s to reach a final speed of 55.0 km/h. What was its initial speed in kilometers per hour?
26. A shark accelerates uniformly from 2.8 km/h to 32.0 km/h in 1.5 s. How large is its acceleration?
27. The 1903 Wright flyer was accelerated at  $4.88 \text{ m/s}^2$  along a track that was 18.3 m long. How long did it take to accelerate the flyer from rest?
28. A drag racer starts at rest and reaches a speed of 386.0 km/h with an average acceleration of  $16.5 \text{ m/s}^2$ . How long does this acceleration take?
29. A hummingbird accelerates at  $-9.20 \text{ m/s}^2$  such that its velocity changes from +50.0 km/h to 0 km/h. What is its displacement?
30. A train backs up from an initial velocity of  $-4.0 \text{ m/s}$  and an average acceleration of  $-0.27 \text{ m/s}^2$ . What is the train's velocity after 17 s?
31. A cross-country skier skiing with an initial velocity of +4.42 m/s slows uniformly at  $-0.75 \text{ m/s}^2$ . How long does it take the skier to stop?

32. What is the skier's displacement in problem 31?
33. A speedboat uniformly increases its speed from 25 m/s west to 35 m/s west. How long does it take the boat to travel 250 m west?
34. A ship accelerates at  $-7.6 \times 10^{-2} \text{ m/s}^2$  so that it comes to rest at the dock 255 m away in 82.0 s. What is the ship's initial speed?
35. A student skates downhill with an average acceleration of  $0.85 \text{ m/s}^2$ . Her initial speed is 4.5 m/s, and her final speed is 10.8 m/s. How long does she take to skate down the hill?
36. A wrench dropped from a tall building is caught in a safety net when the wrench has a velocity of  $-49.5 \text{ m/s}$ . How far did it fall?
37. A rocket sled comes to a complete stop from a speed of 320 km/h in 0.18 s. What is the sled's average acceleration?
38. A racehorse uniformly accelerates  $7.56 \text{ m/s}^2$ , reaching its final speed after running 19.0 m. If the horse starts at rest, what is its final speed?
39. An arrow is shot upward at a speed of 85.1 m/s. How long does the archer have to move from the launching spot before the arrow returns to Earth?
40. A handball strikes a wall with a forward speed of 13.7 m/s and bounces back with a speed of 11.5 m/s. If the ball changes velocity in 0.021 s, what is the handball's average acceleration?
41. A ball accelerates at  $6.1 \text{ m/s}^2$  from 1.8 m/s to 9.4 m/s. How far does the ball travel?
42. A small sandbag is dropped from rest from a hovering hot-air balloon. After 2.0 s, what is the sandbag's displacement below the balloon?
43. A hippopotamus accelerates at  $0.678 \text{ m/s}^2$  until it reaches a speed of 8.33 m/s. If the hippopotamus runs 46.3 m, what was its initial speed?
44. A ball is hit upward with a speed of 7.5 m/s. How long does the ball take to reach maximum height?
45. A surface probe on the planet Mercury falls 17.6 m downward from a ledge. If free-fall acceleration near Mercury is  $-3.70 \text{ m/s}^2$ , what is the probe's velocity when it reaches the ground?
47. Find the displacement direction in problem 46.
48. A train travels 478 km southwest along a straight stretch. If the train is displaced south by 42 km, what is the train's displacement to the west?
49. Find the displacement direction in problem 48.
50. A ship's total displacement is 7400 km at  $26^\circ$  south of west. If the ship sails 3200 km south, what is the western component of its journey?
51. The distance from an observer on a plain to the top of a nearby mountain is 5.3 km at  $8.4^\circ$  above the horizontal. How tall is the mountain?
52. A skyrocket travels 113 m at an angle of  $82.4^\circ$  with respect to the ground and toward the south. What is the rocket's horizontal displacement?
53. A hot-air balloon descends with a velocity of 55 km/h at an angle of  $37^\circ$  below the horizontal. What is the vertical velocity of the balloon?
54. A stretch of road extends 55 km at  $37^\circ$  north of east and then continues for 66 km due east. What is a driver's resultant displacement along this road?
55. A driver travels 4.1 km west, 17.3 km north, and finally 1.2 km at an angle of  $24.6^\circ$  west of north. What is the driver's displacement?
56. A tornado picks up a car and hurls it horizontally 125 m with a speed of 90.0 m/s. How long does it take the car to reach the ground?
57. A squirrel knocks a nut horizontally at a speed of 10.0 cm/s. If the nut lands at a horizontal distance of 18.6 cm, how high up is the squirrel?
58. A flare is fired at an angle of  $35^\circ$  to the ground at an initial speed of 250 m/s. How long does it take for the flare to reach its maximum altitude?
59. A football kicked with an initial speed of 23.1 m/s reaches a maximum height of 16.9 m. At what angle was the ball kicked?
60. A bird flies north at 58.0 km/h relative to the wind. The wind is blowing at 55.0 km/h south relative to Earth. How long will it take the bird to fly 1.4 km relative to Earth?
61. A racecar moving at 286 km/h is 0.750 km behind a car moving at 252 km/h. How long will it take the faster car to catch up to the slower car?
62. A helicopter flies 165 m horizontally and then moves downward to land 45 m below. What is the helicopter's resultant displacement?
63. A toy parachute floats 13.0 m downward. If the parachute travels 9.0 m horizontally, what is the resultant displacement?
46. A plane moves 599 m northeast along a runway. If the northern component of this displacement is 89 m, how large is the eastern component?

## Two-Dimensional Motion and Vectors

64. A billiard ball travels 2.7 m at an angle of  $13^\circ$  with respect to the long side of the table. What are the components of the ball's displacement?
65. A golf ball has a velocity of 1.20 m/s at  $14.0^\circ$  east of north. What are the velocity components?
66. A tiger leaps with an initial velocity of 55.0 km/h at an angle of  $13.0^\circ$  with respect to the horizontal. What are the components of the tiger's velocity?
67. A tramway extends 3.88 km up a mountain from a station 0.8 km above sea level. If the horizontal displacement is 3.45 km, how far above sea level is the mountain peak?
68. A bullet travels 850 m, ricochets, and moves another 640 m at an angle of  $36^\circ$  from its previous forward motion. What is the bullet's resultant displacement?
69. A bird flies 46 km at  $15^\circ$  south of east, then 22 km at  $13^\circ$  east of south, and finally 14 km at  $14^\circ$  west of south. What is the bird's displacement?
70. A ball is kicked with a horizontal speed of 9.37 m/s off the top of a mountain. The ball moves 85.0 m horizontally before hitting the ground. How tall is the mountain?
71. A ball is kicked with a horizontal speed of 1.50 m/s from a height of  $2.50 \times 10^2$  m. What is its horizontal displacement when it hits the ground?
72. What is the velocity of the ball in problem 71 when it reaches the ground?
73. A shingle slides off a roof at a speed of 2.0 m/s and an angle of  $30.0^\circ$  below the horizontal. How long does it take the shingle to fall 45 m?
74. A ball is thrown with an initial speed of 10.0 m/s and an angle of  $37.0^\circ$  above the horizontal. What are the vertical and horizontal components of the ball's displacement after 2.5 s?
75. A rocket moves north at 55.0 km/h with respect to the air. It encounters a wind from  $17.0^\circ$  north of west at 40.0 km/h with respect to Earth. What is the rocket's velocity with respect to Earth?
76. How far to the north and west does the rocket in problem 75 travel after 15.0 min?
77. A cable car travels  $2.00 \times 10^2$  m on level ground, then  $3.00 \times 10^2$  m at an incline of  $3.0^\circ$ , and then  $2.00 \times 10^2$  m at an incline of  $8.8^\circ$ . What is the final displacement of the cable car?
78. A hurricane moves 790 km at  $18^\circ$  north of west, then due west for 150 km, then north for 470 km, and finally  $15^\circ$  east of north for 240 km. What is the hurricane's resultant displacement?
79. What is the range of an arrow shot horizontally at 85.3 m/s from 1.50 m above the ground?
80. A drop of water in a fountain takes 0.50 s to travel 1.5 m horizontally. The water is projected upward at an angle of  $33^\circ$ . What is the drop's initial speed?
81. A golf ball is hit up a  $41.0^\circ$  ramp to travel 4.46 m horizontally and 0.35 m below the edge of the ramp. What is the ball's initial speed?
82. A flare is fired with a velocity of 87 km/h west from a car traveling 145 km/h north. With respect to Earth, what is the flare's resultant displacement 0.45 s after being launched?
83. A sailboat travels south at 12.0 km/h with respect to the water against a current  $15.0^\circ$  south of east at 4.0 km/h. What is the boat's velocity?

## Forces and the Laws of Motion

84. A boat exerts a  $9.5 \times 10^4$  N force  $15.0^\circ$  north of west on a barge. Another exerts a  $7.5 \times 10^4$  N force north. What direction is the barge moved?
85. A shopper exerts a force on a cart of 76 N at an angle of  $40.0^\circ$  below the horizontal. How much force pushes the cart in the forward direction?
86. How much force pushes the cart in problem 85 against the floor?
87. What are the magnitudes of the largest and smallest net forces that can be produced by combining a force of 6.0 N and a force of 8.0 N?
88. A buoyant force of 790 N lifts a 214 kg sinking boat. What is the boat's net acceleration?
89. A house is lifted by a net force of 2850 N and moves from rest to an upward speed of 15 cm/s in 5.0 s. What is the mass of the house?
90. An 8.0 kg bag is lifted 20.0 cm in 0.50 s. If it is initially at rest, what is the net force on the bag?
91. A 90.0 kg skier glides at constant speed down a  $17.0^\circ$  slope. Find the frictional force on the skier.
92. A snowboarder slides down a  $5.0^\circ$  slope at a constant speed. What is the coefficient of kinetic friction between the snow and the board?
93. A 2.00 kg block is in equilibrium on a  $36.0^\circ$  incline. What is the normal force on the block?
94. A  $1.8 \times 10^3$  kg car is parked on a hill on a  $15.0^\circ$  incline. A  $1.25 \times 10^4$  N frictional force holds the car in place. Find the coefficient of static friction.

95. The coefficient of kinetic friction between a jar slid across a table and the table is 0.20. What is the magnitude of the jar's acceleration?
96. A force of 5.0 N to the left causes a 1.35 kg book to have a net acceleration of  $0.76 \text{ m/s}^2$  to the left. What is the frictional force on the book?
97. A child pulls a toy by exerting a force of 15.0 N at an angle of  $55.0^\circ$  with respect to the floor. What are the components of the force?
98. A car is pulled by three forces: 600.0 N to the north, 750.0 N to the east, and 675 N at  $30.0^\circ$  south of east. What direction does the car move?
99. Suppose a catcher exerts a force of  $-65.0 \text{ N}$  to stop a baseball with a mass of 0.145 kg. What is the ball's net acceleration as it is being caught?
100. A 2.0 kg fish pulled upward by a fisherman rises 1.9 m in 2.4 s, starting from rest. What is the net force on the fish during this interval?
101. An 18.0 N force pulls a cart against a 15.0 N frictional force. The speed of the cart increases 1.0 m/s every 5.0 s. What is the cart's mass?
102. A 47 kg sled carries a 33 kg load. The coefficient of kinetic friction between the sled and snow is 0.075. What is the magnitude of the frictional force on the sled as it moves up a hill with a  $15^\circ$  incline?
103. Ice blocks slide with an acceleration of  $1.22 \text{ m/s}^2$  down a chute at an angle of  $12.0^\circ$  below the horizontal. What is the coefficient of kinetic friction between the ice and the chute?
104. A 1760 N force pulls a 266 kg load up a  $17^\circ$  incline. What is the coefficient of static friction between the load and the incline?
105. A  $4.26 \times 10^7 \text{ N}$  force pulls a ship at a constant speed along a dry dock. The coefficient of kinetic friction between the ship and dry dock is 0.25. Find the normal force exerted on the ship.
106. If the incline of the dry dock in problem 105 is  $10.0^\circ$ , what is the ship's mass?
107. A 65.0 kg skier is pulled up an  $18.0^\circ$  slope by a force of  $2.50 \times 10^2 \text{ N}$ . If the net acceleration uphill is  $0.44 \text{ m/s}^2$ , what is the frictional force between the skis and the snow?
108. Four forces are acting on a hot-air balloon:  $F_1 = 2280.0 \text{ N}$  up,  $F_2 = 2250.0 \text{ N}$  down,  $F_3 = 85.0 \text{ N}$  west, and  $F_4 = 12.0 \text{ N}$  east. What is the direction of the net external force on the balloon?
109. A traffic signal is supported by two cables, each of which makes an angle of  $40.0^\circ$  with the vertical. If each cable can exert a maximum force of  $7.50 \times 10^2 \text{ N}$ , what is the largest weight they can support?
110. A certain cable of an elevator is designed to exert a force of  $4.5 \times 10^4 \text{ N}$ . If the maximum acceleration that a loaded car can withstand is  $3.5 \text{ m/s}^2$ , what is the combined mass of the car and its contents?
111. A frictional force of 2400 N keeps a crate of machine parts from sliding down a ramp with an incline of  $30.0^\circ$ . The coefficient of static friction between the box and the ramp is 0.20. What is the normal force of the ramp on the box?
112. Find the mass of the crate in problem 111.
113. A  $5.1 \times 10^2 \text{ kg}$  bundle of bricks is pulled up a ramp at an incline of  $14^\circ$  to a construction site. The force needed to move the bricks up the ramp is  $4.1 \times 10^3 \text{ N}$ . What is the coefficient of static friction between the bricks and the ramp?

## Work and Energy

114. If  $2.13 \times 10^6 \text{ J}$  of work must be done on a roller-coaster car to move it  $3.00 \times 10^2 \text{ m}$ , how large is the net force acting on the car?
115. A force of 715 N is applied to a roller-coaster car to push it horizontally. If  $2.72 \times 10^4 \text{ J}$  of work is done on the car, how far has it been pushed?
116. In 0.181 s, through a distance of 8.05 m, a test pilot's speed decreases from 88.9 m/s to 0 m/s. If the pilot's mass is 70.0 kg, how much work is done against his body?
117. What is the kinetic energy of a disk with a mass of 0.20 g and a speed of 15.8 km/s?
118. A  $9.00 \times 10^2 \text{ kg}$  walrus is swimming at a speed of 35.0 km/h. What is its kinetic energy?
119. A golf ball with a mass of 47.0 g has a kinetic energy of 1433 J. What is the ball's speed?
120. A turtle, swimming at 9.78 m/s, has a kinetic energy of  $6.08 \times 10^4 \text{ J}$ . What is the turtle's mass?
121. A 50.0 kg parachutist is falling at a speed of 47.00 m/s when her parachute opens. Her speed upon landing is 5.00 m/s. How much work is done by the air to reduce the parachutist's speed?
122. An 1100 kg car accelerates from 48.0 km/h to 59.0 km/h over 100.0 m. What was the magnitude of the net force acting on it?

123. What is the gravitational potential energy of a 64.0 kg person at 5334 m above sea level?
124. A spring has a force constant of 550 N/m. What is the elastic potential energy stored in the spring when the spring is compressed 1.2 cm?
125. What is the kinetic energy of a 0.500 g raindrop that falls 0.250 km? Ignore air resistance.
126. A 50.0 g projectile is fired upward at  $3.00 \times 10^2$  m/s and lands at 89.0 m/s. How much mechanical energy is lost to air resistance?
127. How long does it take for  $4.5 \times 10^6$  J of work to be done by a 380.3 kW engine?
128. A ship's engine has a power output of 13.0 MW. How much work can it do in 15.0 min?
129. A catcher picks up a baseball from the ground with a net upward force of  $7.25 \times 10^{-2}$  N so that  $4.35 \times 10^{-2}$  J of net work is done. How far is the ball lifted?
130. A crane does  $1.31 \times 10^3$  J of net work when lifting cement 76.2 m. How large is the net force doing this work?
131. A girl exerts a force of 35.0 N at an angle of  $20.0^\circ$  to the horizontal to move a wagon 15.0 m along a level path. What is the net work done on it if a frictional force of 24.0 N is present?
132. The *Queen Mary* had a mass of  $7.5 \times 10^7$  kg and a top cruising speed of 57 km/h. What was the kinetic energy of the ship at that speed?
133. How fast is a 55.0 kg skydiver falling when her kinetic energy is  $7.81 \times 10^4$  J?
134. A hockey puck with an initial speed of 8.0 m/s coasts 45 m to a stop. If the force of friction on the puck is 0.12 N, what is the puck's mass?
135. How far does a  $1.30 \times 10^4$  kg jet travel if it is slowed from  $2.40 \times 10^2$  km/h to 0 km/h by an acceleration of  $-30.8$  m/s<sup>2</sup>?
136. An automobile is raised 7.0 m, resulting in an increase in gravitational potential energy of  $6.6 \times 10^4$  J. What is the automobile's mass?
137. A spring in a pogo stick has a force constant of  $1.5 \times 10^4$  N/m. How far is the spring compressed when its elastic potential energy is 120 J?
138. A 100.0 g arrow is pulled back 30.0 cm against a bowstring. The bowstring's force constant is 1250 N/m. At what speed will the arrow leave the bow?
139. A ball falls 3.0 m down a vertical pipe, the end of which bends horizontally. How fast does the ball leave the pipe if no energy is lost to friction?
140. A spacecraft's engines do  $1.4 \times 10^{13}$  J of work in 8.5 min. What is the power output of these engines?
141. A runner exerts a force of 334 N against the ground while using 2100 W of power. How long does it take him to run a distance of 50.0 m?
142. A high-speed boat has four 300.0 kW motors. How much work is done in 25 s by the motors?
143. A 92 N force pushes an 18 kg box of books, initially at rest, 7.6 m across a floor. The coefficient of kinetic friction between the floor and the box is 0.35. What is the final kinetic energy of the box of books?
144. A guardrail can be bent by 5.00 cm and then restore its shape. What is its force constant if struck by a car with  $1.09 \times 10^4$  J of kinetic energy?
145. A 25.0 kg trunk strikes the ground with a speed of 12.5 m/s. If no energy is lost from air resistance, what is the height from which the trunk fell?
146. Sliding a 5.0 kg stone up a frictionless ramp with a  $25.0^\circ$  incline increases its gravitational potential energy by  $2.4 \times 10^2$  J. How long is the ramp?
147. A constant  $4.00 \times 10^2$  N force moves a  $2.00 \times 10^2$  kg iceboat 0.90 km. Frictional force is negligible, and the boat starts at rest. Find the boat's final speed.
148. A 50.0 kg circus clown jumps from a platform into a net 1.00 m above the ground. The net is stretched 0.65 m and has a force constant of  $3.4 \times 10^4$  N/m. What is the height of the platform?

## Momentum and Collisions

149. If a 50.0 kg cheetah, initially at rest, runs 274 m north in 8.65 s, what is its momentum?
150. If a  $1.46 \times 10^5$  kg whale has a momentum of  $9.73 \times 10^5$  kg•m/s to the south, what is its velocity?
151. A star has a momentum of  $8.62 \times 10^{36}$  kg•m/s and a speed of 255 km/s. What is its mass?
152. A 5.00 g projectile has a velocity of 255 m/s right. Find the force to stop this projectile in 1.45 s.
153. How long does it take a 0.17 kg hockey puck to decrease its speed by 9.0 m/s if the coefficient of kinetic friction is 0.050?

154. A 705 kg racecar driven by a 65 kg driver moves with a velocity of 382 km/h right. Find the force to bring the car and driver to a stop in 12.0 s.
155. Find the stopping distance in problem 154.
156. A 50.0 g shell fired from a 3.00 kg rifle has a speed of 400.0 m/s. With what velocity does the rifle recoil in the opposite direction?
157. A twig at rest in a pond moves with a speed of 0.40 cm/s opposite a 2.5 g snail, which has a speed of 1.2 cm/s. What is the mass of the twig?
158. A 25.0 kg sled holding a 42.0 kg child has a speed of 3.50 m/s. They collide with and pick up a snowman, initially at rest. The resulting speed of the snowman, sled, and child is 2.90 m/s. What is the snowman's mass?
159. An 8500 kg railway car moves right at 4.5 m/s, and a 9800 kg railway car moves left at 3.9 m/s. The cars collide and stick together. What is the final velocity of the system?
160. What is the change in kinetic energy for the two railway cars in problem 159?
161. A 55 g clay ball moving at 1.5 m/s collides with a 55 g clay ball at rest. By what percentage does the kinetic energy change after the inelastic collision?
162. A 45 g golf ball collides elastically with an identical ball at rest and stops. If the second ball's final speed is 3.0 m/s, what was the first ball's initial speed?
163. A  $5.00 \times 10^2$  kg racehorse gallops with a momentum of  $8.22 \times 10^3$  kg•m/s to the west. What is the horse's velocity?
164. A  $3.0 \times 10^7$  kg ship collides elastically with a  $2.5 \times 10^7$  kg ship moving north at 4.0 km/h. After the collision, the first ship moves north at 3.1 km/h, and the second ship moves south at 6.9 km/h. Find the unknown velocity.
165. A high-speed train has a mass of  $7.10 \times 10^5$  kg and moves at a speed of 270.0 km/h. What is the magnitude of the train's momentum?
166. A bird with a speed of 50.0 km/h has a momentum of magnitude of 0.278 kg•m/s. What is the bird's mass?
167. A 75 N force pulls a child and sled initially at rest down a snowy hill. If the combined mass of the sled and child is 55 kg, what is their speed after 7.5 s?
168. A student exerts a net force of -1.5 N over a period of 0.25 s to bring a falling 60.0 g egg to a stop. What is the egg's initial speed?
169. A  $1.1 \times 10^3$  kg walrus starts swimming east from rest and reaches a velocity of 9.7 m/s in 19 s. What is the net force acting on the walrus?
170. A 12.0 kg wagon at rest is pulled by a 15.0 N force at an angle of  $20.0^\circ$  above the horizontal. If an 11.0 N frictional force resists the forward force, how long will the wagon take to reach a speed of 4.50 m/s?
171. A 42 g meteoroid moving forward at  $7.82 \times 10^3$  m/s collides with a spacecraft. What force is needed to stop the meteoroid in  $1.0 \times 10^{-6}$  s?
172. A 455 kg polar bear slides for 12.2 s across the ice. If the coefficient of kinetic friction between the bear and the ice is 0.071, what is the change in the bear's momentum as it comes to a stop?
173. How far does the bear in problem 172 slide?
174. How long will it take a  $-1.26 \times 10^4$  N force to stop a  $2.30 \times 10^3$  kg truck moving at a speed of 22.2 m/s?
175. A 63 kg skater at rest catches a sandbag moving north at 5.4 m/s. The skater and bag then move north at 1.5 m/s. Find the sandbag's mass.
176. A  $1.36 \times 10^4$  kg barge is loaded with  $8.4 \times 10^3$  kg of coal. What was the unloaded barge's speed if the loaded barge has a speed of 1.3 m/s?
177. A 1292 kg automobile moves east at 88.0 km/h. If all forces remain constant, what is the car's velocity if its mass is reduced to 1255 kg?
178. A 68 kg student steps into a 68 kg boat at rest, causing both to move west at a speed of 0.85 m/s. What was the student's initial velocity?
179. A 1400 kg automobile, heading north at 45 km/h, collides inelastically with a 2500 kg truck traveling east at 33 km/h. What is the vehicles' final velocity?
180. An artist throws 1.3 kg of paint onto a 4.5 kg canvas at rest. The paint-covered canvas slides backward at 0.83 m/s. What is the change in the kinetic energy of the paint and canvas?
181. Find the change in kinetic energy if a 0.650 kg fish leaping to the right at 15.0 m/s collides inelastically with a 0.950 kg fish leaping to the left at 13.5 m/s.
182. A 10.0 kg cart moving at 6.0 m/s hits a 2.5 kg cart moving at 3.0 m/s in the opposite direction. Find the carts' final speed after an inelastic collision.
183. A ball, thrown right at 6.00 m/s, hits a 1.25 kg panel at rest and then bounces back at 4.90 m/s. The panel moves right at 1.09 m/s. Find the ball's mass.

- 184.** A 2150 kg car, moving east at 10.0 m/s, collides and joins with a 3250 kg car. The cars move east together at 5.22 m/s. What is the 3250 kg car's initial velocity?
- 185.** Find the change in kinetic energy in problem 184.
- 186.** A 15.0 g toy car moving to the right at 20.0 cm/s collides elastically with a 20.0 g toy car moving left at 30.0 cm/s. The 15.0 g car then moves left at 37.1 cm/s. Find the 20.0 g car's final velocity.
- 187.** A remora swimming right at 5.0 m/s attaches to a 150.0 kg shark moving left at 7.00 m/s. Both move left at 6.25 m/s. Find the remora's mass.
- 188.** A  $6.5 \times 10^{12}$  kg comet, moving at 420 m/s, catches up to and collides inelastically with a  $1.50 \times 10^{13}$  kg comet moving at 250 m/s. Find the change in the comets' kinetic energy.
- 189.** A 7.00 kg ball moves east at 2.00 m/s, collides with a 7.00 kg ball at rest, and then moves  $30.0^\circ$  north of east at 1.73 m/s. What is the second ball's final velocity?
- 190.** A 2.0 kg block moving at 8.0 m/s on a frictionless surface collides elastically with a block at rest. The first block moves in the same direction at 2.0 m/s. What is the second block's mass?

## Circular Motion and Gravitation

- 191.** A pebble that is 3.81 m from the eye of a tornado has a tangential speed of 124 m/s. What is the magnitude of the pebble's centripetal acceleration?
- 192.** A racecar speeds along a curve with a tangential speed of 75.0 m/s. The centripetal acceleration on the car is  $22.0 \text{ m/s}^2$ . Find the radius of the curve.
- 193.** A subject in a large centrifuge has a radius of 8.9 m and a centripetal acceleration of  $20g$  ( $g = 9.81 \text{ m/s}^2$ ). What is the tangential speed of the subject?
- 194.** A 1250 kg automobile with a tangential speed of 48.0 km/h follows a circular road that has a radius of 35.0 m. How large is the centripetal force?
- 195.** A rock in a sling is 0.40 m from the axis of rotation and has a tangential speed of 6.0 m/s. What is the rock's mass if the centripetal force is  $8.00 \times 10^2 \text{ N}$ ?
- 196.** A  $7.55 \times 10^{13}$  kg comet orbits the sun with a speed of 0.173 km/s. If the centripetal force on the comet is 505 N, how far is it from the sun?
- 197.** A  $2.05 \times 10^8$  kg asteroid has an orbit with a 7378 km radius. The centripetal force on the asteroid is  $3.00 \times 10^9 \text{ N}$ . Find the asteroid's tangential speed.
- 198.** Find the gravitational force between a 0.500 kg mass and a  $2.50 \times 10^{12}$  kg mountain that is 10.0 km away.
- 199.** The gravitational force between Ganymede and Jupiter is  $1.636 \times 10^{22} \text{ N}$ . Jupiter's mass is  $1.90 \times 10^{27} \text{ kg}$ , and the distance between the two bodies is  $1.071 \times 10^6 \text{ km}$ . What is Ganymede's mass?
- 200.** At the sun's surface, the gravitational force on 1.00 kg is 274 N. The sun's mass is  $1.99 \times 10^{30} \text{ kg}$ . If the sun is assumed spherical, what is the sun's radius?
- 201.** At the surface of a red giant star, the gravitational force on 1.00 kg is only  $2.19 \times 10^{-3} \text{ N}$ . If its mass equals  $3.98 \times 10^{31} \text{ kg}$ , what is the star's radius?
- 202.** Uranus has a mass of  $8.6 \times 10^{25} \text{ kg}$ . The mean distance between the centers of the planet and its moon Miranda is  $1.3 \times 10^5 \text{ km}$ . If the orbit is circular, what is Miranda's period in hours?
- 203.** What is the tangential speed in problem 202?
- 204.** The rod connected halfway along the 0.660 m radius of a wheel exerts a  $2.27 \times 10^5 \text{ N}$  force. How large is the maximum torque?
- 205.** A golfer exerts a torque of  $0.46 \text{ N}\cdot\text{m}$  on a golf club. If the club exerts a force of 0.53 N on a stationary golf ball, what is the length of the club?
- 206.** What is the orbital radius of the Martian moon Deimos if it orbits  $6.42 \times 10^{23} \text{ kg}$  Mars in 30.3 h?
- 207.** A  $4.00 \times 10^2 \text{ N}\cdot\text{m}$  torque is produced, applying a force 1.60 m from the fulcrum and at an angle of  $80.0^\circ$  to the lever. How large is the force?
- 208.** A customer 11 m from the center of a revolving restaurant has a speed of  $1.92 \times 10^{-2} \text{ m/s}$ . How large a centripetal acceleration acts on the customer?
- 209.** A toy train on a circular track has a tangential speed of 0.35 m/s and a centripetal acceleration of  $0.29 \text{ m/s}^2$ . What is the radius of the track?
- 210.** A person against the inner wall of a hollow cylinder with a 150 m radius feels a centripetal acceleration of  $9.81 \text{ m/s}^2$ . Find the cylinder's tangential speed.
- 211.** The tangential speed of 0.20 kg toy carts is 5.6 m/s when they are 0.25 m from a turning shaft. How large is the centripetal force on the carts?

212. A 1250 kg car on a curve with a 35.0 m radius has a centripetal force from friction and gravity of  $8.07 \times 10^3$  N. What is the car's tangential speed?
213. Two wrestlers,  $2.50 \times 10^{-2}$  m apart, exert a  $2.77 \times 10^{-3}$  N gravitational force on each other. One has a mass of 157 kg. What is the other's mass?
214. A  $1.81 \times 10^5$  kg blue whale is 1.5 m from a  $2.04 \times 10^4$  kg whale shark. What is the gravitational force between them?
215. Triton's orbit around Neptune has a radius of  $3.56 \times 10^5$  km. Neptune's mass is  $1.03 \times 10^{26}$  kg. What is Triton's period?
216. Find the tangential speed in problem 215.
217. A moon orbits a  $1.0 \times 10^{26}$  kg planet in 365 days. What is the radius of the moon's orbit?
218. What force is required to produce a  $1.4 \text{ N}\cdot\text{m}$  torque when applied to a door at a  $60.0^\circ$  angle and 0.40 m from the hinge?
219. What is the maximum torque that the force in problem 218 can exert?
220. A worker hanging  $65.0^\circ$  from the blade of a windmill exerts an  $8.25 \times 10^3 \text{ N}\cdot\text{m}$  torque. If the worker weighs 587 N, what is the blade's length?

## Fluid Mechanics

221. A cube of volume  $1.00 \text{ m}^3$  floats in gasoline, which has a density of  $675 \text{ kg/m}^3$ . How large a buoyant force acts on the cube?
222. A cube 10.0 cm on each side has a density of  $2.053 \times 10^4 \text{ kg/m}^3$ . Its apparent weight in fresh water is 192 N. Find the buoyant force.
223. A  $1.47 \times 10^6$  kg steel hull has a base that is  $2.50 \times 10^3 \text{ m}^2$  in area. If it is placed in sea water ( $\rho = 1.025 \times 10^3 \text{ kg/m}^3$ ), how deep does the hull sink?
224. What size force will open a door of area  $1.54 \text{ m}^2$  if the net pressure on the door is  $1.013 \times 10^3 \text{ Pa}$ ?
225. Gas at a pressure of  $1.50 \times 10^6 \text{ Pa}$  exerts a force of  $1.22 \times 10^4 \text{ N}$  on the upper surface of a piston. What is the piston's upper surface area?
226. In a barometer, the mercury column's weight equals the force from air pressure on the mercury's surface. Mercury's density is  $13.6 \times 10^3 \text{ kg/m}^3$ . What is the air's pressure if the column is 760 mm high?
227. A cube of osmium with a volume of  $166 \text{ cm}^3$  is placed in fresh water. The cube's apparent weight is 35.0 N. What is the density of osmium?
228. A block of ebony with a volume of  $2.5 \times 10^{-3} \text{ m}^3$  is placed in fresh water. If the apparent weight of the block is 7.4 N, what is the density of ebony?
229. One piston of a hydraulic lift holds  $1.40 \times 10^3 \text{ kg}$ . The other holds an ice block ( $\rho = 917 \text{ kg/m}^3$ ) that is 0.076 m thick. Find the first piston's area.
230. A hydraulic-lift piston raises a  $4.45 \times 10^4 \text{ N}$  weight by 448 m. How large is the force on the other piston if it is pushed 8.00 m downward?
231. A platinum flute with a density of  $21.5 \text{ g/cm}^3$  is submerged in fresh water. If its apparent weight is 40.2 N, what is the flute's mass?

## Heat

232. Surface temperature on Mercury ranges from 463 K during the day to 93 K at night. Express this temperature range in degrees Celsius.
233. Solve problem 233 for degrees Fahrenheit.
234. The temperature in Fort Assiniboine, Montana, went from  $-5^\circ\text{F}$  to  $+37^\circ\text{F}$  on January 19, 1892. Calculate this change in temperature in kelvins.
235. An acorn falls 9.5 m, absorbing 0.85 of its initial potential energy. If 1200 J/kg will raise the acorn's temperature  $1.0^\circ\text{C}$ , what is its temperature increase?
236. A bicyclist on level ground brakes from 13.4 m/s to 0 m/s. What is the cyclist's and bicycle's mass if the increase in internal energy is 5836 J?
237. A 61.4 kg roller skater on level ground brakes from 20.5 m/s to 0 m/s. What is the total change in the internal energy of the system?
238. A 0.225 kg tin can ( $c_p = 2.2 \times 10^3 \text{ J/kg}\cdot^\circ\text{C}$ ) is cooled in water, to which it transfers  $3.9 \times 10^4 \text{ J}$  of energy. By how much does the can's temperature change?
239. What mass of bismuth ( $c_p = 121 \text{ J/kg}\cdot^\circ\text{C}$ ) increases temperature by  $5.0^\circ\text{C}$  when 25 J is added by heat?
240. Placing a 0.250 kg pot in 1.00 kg of water raises the water's temperature  $1.00^\circ\text{C}$ . The pot's temperature drops  $17.5^\circ\text{C}$ . Find the pot's specific heat capacity.
241. Lavas at Kilauea in Hawaii have temperatures of  $2192^\circ\text{F}$ . Express this quantity in degrees Celsius.
242. The present temperature of the background radiation in the universe is 2.7 K. What is this temperature in degrees Celsius?

243. The human body cannot survive at a temperature of  $42^{\circ}\text{C}$  for very long. Express this quantity in kelvins.
244. Two sticks rubbed together gain  $2.15 \times 10^4 \text{ J}$  from kinetic energy and lose 33 percent of it to the air. How much does the sticks' internal energy change?
245. A stone falls 561.7 m. When the stone lands, the internal energy of the ground and the stone increases by 105 J. What is the stone's mass?
246. A 2.5 kg block of ice at  $0.0^{\circ}\text{C}$  slows on a level floor from 5.7 m/s to 0 m/s. If  $3.3 \times 10^5 \text{ J}$  causes 1.0 kg of ice to melt, how much of the ice melts?
247. Placing a 3.0 kg skillet in 5.0 kg of water raises the water's temperature  $2.25^{\circ}\text{C}$  and lowers the skillet's temperature  $29.6^{\circ}\text{C}$ . Find the skillet's specific heat.
248. Air has a specific heat of  $1.0 \times 10^3 \text{ J/kg}\cdot^{\circ}\text{C}$ . If air's temperature increases  $55^{\circ}\text{C}$  when  $45 \times 10^6 \text{ J}$  is added to it by heat, what is the air's mass?
249. A 0.23 kg tantalum part has a specific heat capacity of  $140 \text{ J/kg}\cdot^{\circ}\text{C}$ . By how much does the part's temperature change if it gives up  $3.0 \times 10^4 \text{ J}$  as heat?
258. Find the efficiency of an engine that receives 571 J as heat and loses 463 J as heat per cycle.
259. A  $5.4 \times 10^{-4} \text{ m}^3$  increase in steam's volume does 1.3 J of work on a piston. What is the pressure?
260. A pressure of 655 kPa does 393 J of work inflating a bike tire. Find the change in volume.
261. An engine's internal energy changes from 8093 J to  $2.0920 \times 10^4 \text{ J}$ . If 6932 J is added as heat, how much work is done on or by the system?
262. Steam expands from a geyser to do 192 kJ of work. If the system's internal energy increases by 786 kJ, how much energy is transferred as heat?
263. If 632 kJ is added to a boiler and 102 kJ of work is done as steam escapes from a safety valve, what is the net change in the system's internal energy?
264. A power plant with an efficiency of 0.35 percent requires  $7.37 \times 10^8 \text{ J}$  of energy as heat. How much work is done by the power plant?
265. An engine with an efficiency of 0.11 does 1150 J of work. How much energy is taken in as heat?
266. A test engine performs 128 J of work and receives 581 J of energy as heat. What is the engine's efficiency?

## Thermodynamics

250. A volume of air increases  $0.227 \text{ m}^3$  at a net pressure of  $2.07 \times 10^7 \text{ Pa}$ . How much work is done on the air?
251. The air in a hot-air balloon does  $3.29 \times 10^6 \text{ J}$  of work, increasing the balloon's volume by  $2190 \text{ m}^3$ . What is the net pressure in the balloon?
252. Filling a fire extinguisher with nitrogen gas at a net pressure of 25.0 kPa requires 472.5 J of work on the gas. Find the change in the gas's volume.
253. The internal energy of air in a closed car rises 873 J. How much heat energy is transferred to the air?
254. A system's initial internal energy increases from 39 J to 163 J. If 114 J of heat is added to the system, how much work is done on the system?
255. A gas does 623 J of work on its surroundings when 867 J is added to the gas as heat. What is the change in the internal energy of the gas?
256. An engine with an efficiency of 0.29 takes in 693 J as heat. How much work does the engine do?
257. An engine with an efficiency of 0.19 does 998 J of work. How much energy is taken in by heat?

## Vibrations and Waves

267. A scale with a spring constant of 420 N/m is compressed 4.3 cm. What is the spring force?
268. A 669 N weight attached to a giant spring stretches it 6.5 cm. What is the spring constant?
269. An archer applies a force of 52 N on a bowstring with a spring constant of 490 N/m. What is the bowstring's displacement?
270. On Mercury, a pendulum 1.14 m long would have a 3.55 s period. Calculate  $a_g$  for Mercury.
271. Find the length of a pendulum that oscillates with a frequency of 2.5 Hz.
272. Calculate the period of a 6.200 m long pendulum in Oslo, Norway, where  $a_g = 9.819 \text{ m/s}^2$ .
273. Find the pendulum's frequency in problem 272.
274. A 24 kg child jumps on a trampoline with a spring constant of 364 N/m. What is the oscillation period?
275. A 32 N weight oscillates with a 0.42 s period when on a spring scale. Find the spring constant.

276. Find the mass of a ball that oscillates at a period of 0.079 s on a spring with a constant of 63 N/m.
277. A dolphin hears a 280 kHz sound with a wavelength of 0.51 cm. What is the wave's speed?
278. If a sound wave with a frequency of 20.0 Hz has a speed of 331 m/s, what is its wavelength?
279. A sound wave has a speed of  $2.42 \times 10^4$  m/s and a wavelength of 1.1 m. Find the wave's frequency.
280. An elastic string with a spring constant of 65 N/m is stretched 15 cm and released. What is the spring force exerted by the string?
281. The spring in a seat compresses 7.2 cm under a 620 N weight. What is the spring constant?
282. A 3.0 kg mass is hung from a spring with a spring constant of 36 N/m. Find the displacement.
283. Calculate the period of a 2.500 m long pendulum in Quito, Ecuador, where  $a_g = 9.780$  m/s<sup>2</sup>.
284. How long is a pendulum with a frequency of 0.50 Hz?
285. A tractor seat supported by a spring with a spring constant of  $2.03 \times 10^3$  N/m oscillates at a frequency of 0.79 Hz. What is the mass on the spring?
286. An 87 N tree branch oscillates with a period of 0.64 s. What is the branch's spring constant?
287. What is the oscillation period for an 8.2 kg baby in a seat that has a spring constant of 221 N/m?
288. An organ creates a sound with a speed of 331 m/s and a wavelength of 10.6 m. Find the frequency.
289. What is the speed of an earthquake S-wave with a  $2.3 \times 10^4$  m wavelength and a 0.065 Hz frequency?

## Sound

290. What is the distance from a sound with  $5.88 \times 10^{-5}$  W power if its intensity is  $3.9 \times 10^{-6}$  W/m<sup>2</sup>?
291. Sound waves from a stereo have a power output of 3.5 W at 0.50 m. What is the sound's intensity?
292. What is a vacuum cleaner's power output if the sound's intensity 1.5 m away is  $4.5 \times 10^{-4}$  W/m<sup>2</sup>?
293. Waves travel at 499 m/s on a 0.850 m long cello string. Find the string's fundamental frequency.
294. A mandolin string's first harmonic is 392 Hz. How long is the string if the wave speed on it is 329 m/s?
295. A 1.53 m long pipe that is closed on one end has a seventh harmonic frequency of 466.2 Hz. What is the speed of the waves in the pipe?
296. A pipe open at both ends has a fundamental frequency of 125 Hz. If the pipe is 1.32 m long, what is the speed of the waves in the pipe?
297. Traffic has a power output of  $1.57 \times 10^{-3}$  W. At what distance is the intensity  $5.20 \times 10^{-3}$  W/m<sup>2</sup>?
298. If a mosquito's buzzing has an intensity of  $9.3 \times 10^{-8}$  W/m<sup>2</sup> at a distance of 0.21 m, how much sound power does the mosquito generate?
299. A note from a flute (a pipe with a closed end) has a first harmonic of 392.0 Hz. How long is the flute if the sound's speed is 331 m/s?
300. An organ pipe open at both ends has a first harmonic of 370.0 Hz when the speed of sound is 331 m/s. What is the length of this pipe?

## Light and Reflection

301. A  $7.6270 \times 10^8$  Hz radio wave has a wavelength of 39.296 cm. What is this wave's speed?
302. An x-ray's wavelength is 3.2 nm. Using the speed of light in a vacuum, calculate the frequency of the x-ray.
303. What is the wavelength of ultraviolet light with a frequency of  $9.5 \times 10^{14}$  Hz?
304. A concave mirror has a focal length of 17 cm. Where must a 2.7 cm tall coin be placed for its image to appear 23 cm in front of the mirror's surface?
305. How tall is the coin's image in problem 304?
306. A concave mirror's focal length is 9.50 cm. A 3.0 cm tall pin appears to be 15.5 cm in front of the mirror. How far from the mirror is the pin?
307. How tall is the pin's image in problem 306?
308. A convex mirror's magnification is 0.11. Suppose you are 1.75 m tall. How tall is your image?
309. How far in front of the mirror in problem 308 are you if your image is 42 cm behind the mirror?
310. A mirror's focal length is -12 cm. What is the object distance if an image forms 9.00 cm behind the surface of the mirror?
311. What is the magnification in problem 310?
312. A metal bowl is like a concave spherical mirror. You are 35 cm in front of the bowl and see an image at 42 cm. What is the bowl's focal length?