CHAPTER 6 REVIEW

Key Terms

6.1
- force
- system
- environment
- contact force
- long-range force
- force of gravity
- agent
- free-body diagram
- net force
- Newton's second law
- Newton's first law
- inertia
- equilibrium

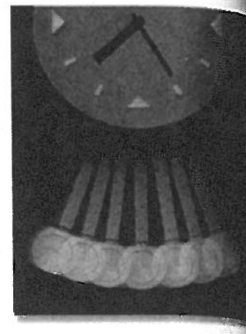
6.2
- apparent weight
- weightlessness
- static friction force
- kinetic friction force
- terminal velocity
- simple harmonic motion
- period
- amplitude
- mechanical resonance

6.3
- interaction pair
- Newton's third law

Summary

6.1 Force and Motion
- An object that experiences a push or a pull has a force exerted on it.
- Forces are vector quantities, having both direction and magnitude.
- Forces may be divided into contact and long-range forces.
- Newton's second law states that the acceleration of a system equals the net force on it divided by its mass.
- Newton's first law states that if, and only if, an object has no net force on it, then its velocity will not change.
- The inertia of an object is its resistance to changing velocity.

6.2 Using Newton's Laws
- The weight of an object depends upon the acceleration due to gravity and the mass of the object.
- An object's apparent weight is what is sensed as a result of contact forces on it.
- The friction force acts when two surfaces touch.
- The friction force is proportional to the force pushing the surfaces together.
- An object undergoes simple harmonic motion if the net restoring force on it is directly proportional to the object's displacement.
- Mechanical resonance can greatly increase the amplitude of simple harmonic motion when a small, periodic force acts on an oscillating object at its natural frequency.



6.3 Interaction Forces
- All forces result from interactions between objects.
- Newton's third law states that the two forces that make up an interaction pair of forces are equal in magnitude but opposite in direction and act on different objects.
- Although there are many different forces, they are all forms of the four fundamental forces.

Reviewing Concepts

Section 6.1

1. A physics book is motionless on the top of a table. If you give it a hard push with your hand, it slides across the table and slowly comes to a stop. Use Newton's laws of motion to answer the following questions.
   a. Why does the book remain motionless before the force of the hand is applied?
   b. Why does the book begin to move when your hand pushes hard enough on it?
   c. Why does the book eventually come to a stop?
   d. Under what conditions would the book remain in motion at constant speed?
2. Why do you have to push harder on the pedals of a single-speed bicycle to start it moving than to keep it moving at a constant velocity?
3. Suppose the acceleration of an object is zero. Does this mean that there are no forces acting on it? Give an example supporting your answer.
4. When a basketball player dribbles a ball, it falls to the floor and bounces up. Is a force required to make it bounce? Why? If a force is needed, what is the agent involved?

Section 6.2

5. Before a sky diver opens his parachute, he may be falling at a velocity higher than the terminal velocity he will have after the parachute opens.
   a. Describe what happens to his velocity as he opens the parachute.
   b. Describe his velocity from after his parachute has been open for a time until he is about to land.
6. What is the difference between the period and the amplitude of a pendulum?
7. When an object is vibrating on a spring and passes through the equilibrium position, there is no net force on it. Why is the velocity not zero at this point? What quantity is zero?

Section 6.3

8. A rock is dropped from a bridge into a valley. Earth pulls on the rock and accelerates it downward. According to Newton's third law, the rock must also be pulling on Earth, yet Earth doesn't seem to accelerate. Explain.
9. All forces can be divided into just four fundamental kinds. Name the fundamental force that best describes the following.
   a. holds the nucleus together
   b. holds molecules together
   c. holds the solar system together

Applying Concepts

10. If you are in a car that is struck from behind, you can receive a serious neck injury called whiplash.
    a. Using Newton's laws of motion, explain what happens to cause the injury.
    b. How does a headrest reduce whiplash?
11. Should astronauts choose pencils with hard or soft lead for making notes in space? Explain.
12. If you find a pendulum clock running slightly fast, how can you adjust it to keep better time?
13. Dragsters often set their tires on fire to soften the rubber and increase the coefficient of friction, μ, to nearly 5.0. What role does friction play in accelerating the dragster?
14. What is the meaning of a coefficient of friction that is greater than 1? How would you measure it?
15. Using the model of friction described in this book, would the friction between the tire and the road be increased by a wide rather than a narrow tire? Explain.
16. From the top of a tall building, you drop two table tennis balls, one filled with air and the other with water. Both experience air resistance as they fall. Which ball reaches terminal velocity first? Do both hit the ground at the same time?
17. It is often said that 1 kg equals 2.2 lb. What does this statement mean? What would be the proper way of making the comparison?
18. Which of the four fundamental forces makes paint cling to a wall? Which force makes adhesive sticky? Which force makes wax stick to a car?
19. According to legend, a horse learned Newton's laws. When the horse was told to pull a cart, it refused, saying that if it pulled the cart forward, according to Newton's third law there would be an equal force backwards. Thus, there would be balanced forces, and, according to Newton's second law, the cart wouldn't accelerate. How would you reason with this horse?

Problems

Section 6.1

LEVEL 1

20. A 873-kg (1930 lb) dragster, starting from rest, attains a speed of 26.3 m/s (58.9 mph) in 0.59 s.
    a. Find the average acceleration of the dragster during this time interval.
    b. What is the magnitude of the average net force on the dragster during this time?
    c. Assume that the driver has a mass of 68 kg. What horizontal force does the seat exert on the driver?
21. The dragster in problem 20 completed the 402.3 m (0.2500 mile) run in 4.936 s. If the car had a constant acceleration, what would be its acceleration and final velocity?
22. After a day of testing race cars, you decide to take your own 1550-kg car onto the test track. While moving down the track at 10.0 m/s, you

uniformly accelerate to 30.0 m/s in 10 s. What is the average net force that you have applied to the car during the 10-s interval?

23. A 65-kg swimmer jumps off a 10.0-m tower.

a. Find the swimmer's velocity on hitting the water.

b. The swimmer comes to a stop 2.0 m below the surface. Find the net force exerted by the water.

LEVEL 2

24. The dragster in problem 21 crossed the finish line going 126.6 m/s (283.1 mph). Does the assumption of constant acceleration hold true? What other piece of evidence could you use to see if the acceleration is constant?

25. A race car has a mass of 710 kg. It starts from rest and travels 40.0 m in 3.0 s. The car is uniformly accelerated during the entire time. What net force is exerted on it?

Section 6.2

LEVEL 1

26. What is your weight in newtons?

27. Your new motorcycle weighs 2450 N. What is its mass in kg?

28. A pendulum has a length of 0.67 m.

a. Find its period.

b. How long would the pendulum have to be to double the period?

29. You place a 7.50-kg television set on a spring scale. If the scale reads 78.4 N, what is the acceleration due to gravity at that location?

30. If you use a horizontal force of 30.0 N to slide a 12.0-kg wooden crate across a floor at a constant velocity, what is the coefficient of kinetic friction between the crate and the floor?

31. A 4500-kg helicopter accelerates upward at 2.0 m/s^2. What lift force is exerted by the air on the propellers?

32. The maximum force a grocery sack can withstand and not rip is 250 N. If 20.0 kg of groceries are lifted from the floor to the table with an acceleration of 5.0 m/s^2, will the sack hold?

33. A force of 40.0 N accelerates a 5.0-kg block at 6.0 m/s^2 along a horizontal surface.

a. How large is the frictional force?

b. What is the coefficient of friction?

34. A 225-kg crate is pushed horizontally with a force of 710 N. If the coefficient of friction is 0.20, calculate the acceleration of the crate.

LEVEL 2

35. You are driving a 2500.0-kg car at a constant speed of 14.0 m/s along an icy, but straight, level road. As you approach an intersection, the traffic light turns red. You slam on the brakes. Your wheels lock, the tires begin skidding, and the car slides to a halt in a distance of 25.0 m. What is the coefficient of kinetic friction between your tires and the icy road?

36. A student stands on a bathroom scale in an elevator at rest on the 64th floor of a building. The scale reads 836 N.

a. As the elevator moves up, the scale reading increases to 936 N, then decreases back to 836 N. Find the acceleration of the elevator.

b. As the elevator approaches the 74th floor, the scale reading drops to 782 N. What is the acceleration of the elevator?

c. Using your results from parts a and b, explain which change in velocity, starting or stopping, would take the longer time.

d. What changes would you expect in the scale readings on the ride back down?

37. A sled of mass 50.0 kg is pulled along flat, snow-covered ground. The static friction coefficient is 0.30, and the kinetic friction coefficient is 0.10.

a. What does the sled weigh?

b. What force will be needed to start the sled moving?

c. What force is needed to keep the sled moving at a constant velocity?

d. Once moving, what total force must be applied to the sled to accelerate it at 3.0 m/s^2?

38. The instruments attached to a weather balloon have a mass of 5.0 kg. The balloon is released and exerts an upward force of 98 N on the instruments.

a. What is the acceleration of the balloon and instruments?
b. After the balloon has accelerated for 10 s, the instruments are released. What is the velocity of the instruments at the moment of their release?
c. What net force acts on the instruments after their release?
d. When does the direction of their velocity first become downward?

Section 6.3

LEVEL 1

39. A 65-kg boy and a 45-kg girl use an elastic rope while engaged in a tug-of-war on an icy, frictionless surface. If the acceleration of the girl toward the boy is 3.0 m/s^2, find the magnitude of the acceleration of the boy toward the girl.

40. As a baseball is being caught, its speed goes from 30.0 m/s to 0.0 m/s in about 0.0050 s. The mass of the baseball is 0.145 kg.
a. What are the baseball's acceleration?
b. What are the magnitude and direction of the force acting on it?
c. What is the magnitude and direction of the force acting on the player who caught it?

LEVEL 2

41. A 2.0-kg mass (m_A) and a 3.0-kg mass (m_B) are attached to a lightweight cord that passes over a frictionless pulley, as shown in **Figure 6–16.**

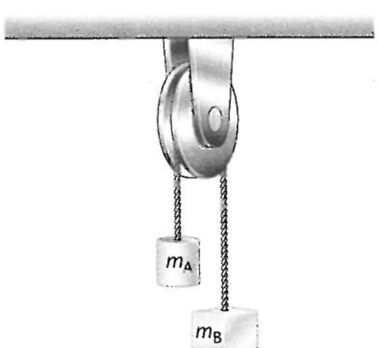


FIGURE 6–16

The hanging masses are free to move. Choose coordinate systems for the two masses with the positive direction up for m_A and down for m_B.
a. Create a pictorial model.
b. Create a physical model with motion and free-body diagrams.
c. Find the acceleration of the smaller mass.

42. Suppose the masses in problem 41 are now 1.00 kg and 4.00 kg. Find the acceleration of the larger mass.

43. Replace the 1.00-kg mass in problem 42 with a 2.00-kg mass. Find the acceleration of the smaller mass.

Critical Thinking Problems

44. The force exerted on a 0.145-kg baseball by a bat changes from 0.0 N to 1.0×10^4 N over 0.0010 s, then drops back to zero in the same amount of time. The baseball was going toward the bat at 25 m/s.
a. Draw a graph of force versus time. What is the average force exerted on the ball by the bat?
b. What is the acceleration of the ball?
c. What is the final velocity of the ball, assuming that it reverses direction?

Going Further

Team Project Using the example problems in this chapter as models, write an example problem to solve the following problem. Include Sketch the Problem, Calculate Your Answer (with a complete strategy), and Check Your Answer.
A driver of a 975-kg car, traveling 25 m/s, puts on the brakes. What is the shortest distance it will take for the car to stop? Assume that the road is concrete and that the frictional force of the road on the tires is constant. Assume that the tires don't slip.

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