CHAPTER 4 Review

REFLECTING ON CHAPTER 4

- Inertia is the natural tendency of an object to remain at rest or in uniform motion.
- The amount of inertia depends on the amount of mass of an object.
- The force of gravity acting on an object near a celestial object, such as Earth, is called weight. An object's weight is given by $\vec{F}_g = m\vec{g}$.
- The normal force acts perpendicular to the plane of the surfaces in contact.
- The force of friction is the product of the *coefficient* of friction between the contact surfaces and the *normal force* pressing the objects together ($F_f = \mu F_N$). The force of friction always acts in a direction to oppose motion. The coefficient of friction, μ, is dependent on the types of materials in contact.
- Application of the standard model of friction assumes that
  - **(a)** the force of friction is independent of area of contact
  - **(b)** the force of friction is proportional to the normal force
  - **(c)** the force of friction is independent of the velocity of motion
- Free body diagrams represent all forces *acting on* one object (and only those forces).
- Forces that the object exerts on other objects are *not* shown in a free body diagram.
- The object is represented as a single dot and an arrow is used to represent each force *acting on* the object.
- The direction of each force arrow represents the direction of the force and the arrow's relative length provides information about the magnitude of the force.

Knowledge and Understanding

1. Identify and provide examples of what physicists consider to be the two "natural" types of motion.

2. What is the term used to describe the tendency for objects to have differing amounts of "persistence" in maintaining their natural motion?

3. What concept is used to quantify the inertia of an object?

4. A small stuffed animal hangs from the rear view mirror of a car turning a corner. Sketch the position of the stuffed animal relative to the mirror during the turn as seen by a passenger. Explain the reason for the perceived movement of the stuffed animal.

5. Astronauts working outside of the space shuttle in Earth orbit are able to move large satellites. One astronaut referred to the satellites not as heavy, but as massive. Explain the astronaut's comment.

6. You are a passenger in a car that is driving on the highway at 100 km/h. Explain, in terms of inertia, what happens to you if the driver brakes suddenly?

7. Consider the motion of an object. State Aristotle's, Buridan's, and Galileo's understanding of what is now termed inertia.

8. If an object's mass resists any change in its motion, how, then, does the motion of a mass change?

9. Compare inertial mass and gravitational mass, giving similarities and differences.

10. Why do physicists, who take pride in precise, unambiguous terminology, usually speak just of "mass" rather than distinguishing between inertial and gravitational mass?

11. If gold were sold by weight, at which of the two locations would you prefer to buy it: At a location on the equator at sea level, or at the North Pole at sea level? If it were sold by mass, where would you prefer to buy it? Explain.

12. Assume that a friend who has not yet taken a physics course makes the following statement: "My new backpacking tent is really light. It only weighs 5.3 kg." Explain why the statement is incorrect and restate it correctly.
13. Explain Galileo's reasoning when he proposed that all objects will fall to Earth with the same acceleration.
14. What causes the value of g, the acceleration due to gravity, to vary from place to place on Earth's surface?
15. Explain the difference between static friction and kinetic friction.
16. How do you determine the direction of the force of surface friction?
17. What factors affect the force of surface friction under ideal conditions?
18. Describe how the normal force acting between a block and a board changes when the board-block combination are (a) horizontal and (b) at an angle to the horizontal.

Inquiry

19. Imagine that you are in a closed freight car on an ultra modern, magnetically levitated railroad. The car runs so smoothly that you cannot feel any effects of the motion at a constant velocity. Design an experiment that would reveal any change in the freight car's motion. Be able to distinguish whether the train was speeding up, slowing down, or turning.
20. Design and carry out an experiment in which you demonstrate the linear relationship between the force of friction and the normal force. Perform the experiment with several different pairs of surfaces. Show the relationship in the form of a graph. In each case, determine the coefficient of friction from the graph.
21. If it is winter time, design and carry out an experiment to test the success of different kinds of wax in reducing friction on snow skis.

Communication

22. Use a labeled diagram to show the principal forces acting on a car that is slowly braking as it moves towards a stop light. The length of the force vectors should represent their magnitude. Make reference to this diagram to explain why accidents occur when the road is covered with ice.
23. Draw a free-body diagram of a diver being lowered into the water from a hovering helicopter to make a sea rescue. His downward speed is decreasing. Label all forces and show them with correct scale lengths.
24. Describe three benefits of using free-body diagrams in engineering problems involving the design of bridges.

Making Connections

25. Car tires are designed to optimize the amount of friction between the tire surface and the road. If there is too little friction, the car will be difficult to control. Too much friction will reduce the quality of the car's performance and fuel efficiency.
    - **(a)** List the different types of road conditions under which cars are operated. Research the different types of tread designs that have been developed to respond to these conditions. Explain how the different designs are intended to increase or decrease the coefficient of friction between a car's tires and the road.
    - **(b)** Compare the positive and negative factors of using "all-season" tires rather than changing car tires to suit the season (for example, changing to special winter tires). Do a cost analysis of the two systems and recommend your choice for the climatic conditions in your own community.

Problems for Understanding

26. What is the mass of a sack of potatoes that weighs 1.10×10^2 N?
27. If you weigh 541 N on Earth, how much would you weigh on the Moon? on Mars?
28. How much would a 4.6 kg rock weigh on Jupiter?
29. A spring scale has been calibrated to report in units of mass when used on Earth's surface. What would be the percent error in the results if the scale was then used on Mars?
30. You must push with a force of 401 N in order to slide a 47 kg overstuffed chair across the carpet at a constant velocity. What is the coefficient of friction between the chair and the carpet?
31. You are pushing a wooden crate across a wood floor at a constant velocity. If you are exerting a force of 385 N, what is the mass of the crate?
32. You are pushing horizontally on a 3.0 kg block of wood, pressing it against a wall. If the coefficient of static friction between the block of wood and the wall is 0.60, how much force must you exert on the block to prevent it from sliding down?
33. A force of 457 N is required to slide a block of rubber across dry concrete. By how much would the required force be reduced if you sprayed the concrete with water before sliding the rubber across it?
34. You are helping a friend push a piano across the floor. It has a mass of 450 kg.
    - **(a)** Calculate the normal force supporting the piano.
    - **(b)** If the coefficient of static friction between the floor and the piano is 0.35, calculate the minimum amount of force needed to start the piano moving.
    - **(c)** Once the piano is moving, a horizontal force of 1.1×10^3 N is necessary to keep it moving at a constant speed. Determine the coefficient of kinetic friction.
35. Draw a free-body diagram to show the magnitude of the forces acting in the following situations:
    - **(a)** A person on a scooter uses one of her feet to accelerate forward.
    - **(b)** The person glides briefly at a constant speed.
    - **(c)** She slows down as she continues to glide.