5 Chapter Assessment

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Ch.5 Newton's 2nd Law of Motion

Concept Summary Force & Acceleration

An object accelerates—changes speed and/or direction—when a net force acts on it.

- The acceleration of an object is directly proportional to the net force acting on it.
- The acceleration of an object is inversely proportional to the mass of the object.
- Acceleration equals net force divided by mass.
- Acceleration is in the same direction as the net force.

When an object moves with constant velocity while an applied force acts on it, an equal and opposite force, usually friction, must also act to balance the applied force.

The application of a force over an area produces pressure.

- When the force is perpendicular to the surface area, the pressure equals the force divided by the area over which it acts.

The acceleration of all objects in free fall is the same, regardless of their mass.

- When air resistance is present, a falling object accelerates only until it reaches its terminal speed.
- At terminal speed, the force of air resistance balances the force of gravity.

Key Terms

air resistance (5.4)
fluid (5.4)
free-body diagram (5.4)
inversely (5.2)
Newton's second law (5.3)
pascal (5.5)
pressure (5.5)
terminal speed (5.7)
terminal velocity (5.7)

Review Questions *Check Concepts*

1. Distinguish between the relationship that defines acceleration and the relationship that states how it is produced. (5.1)
2. What is meant by the net force that acts on an object? (5.1)
3. Suppose a cart is being moved by a certain net force. If the net force is doubled, by how much does the cart's acceleration change? (5.1)
4. Suppose a cart is being moved by a certain net force. If a load is dumped into the cart so its mass is doubled, by how much does the acceleration change? (5.2)
5. Distinguish between the concepts *directly proportional* and *inversely proportional.* Support your statement with examples. (5.1–5.2)
6. State Newton's second law in words and then in the form of an equation. (5.3)
7. How much force does a 20 000-kg rocket develop to accelerate 1 m/s^2? (5.3)
8. What is the cause of friction, and in what direction does it act with respect to the motion of a sliding object? (5.4)
9. If the force of friction acting on a sliding crate is 100 N, how much force must be applied to maintain a constant velocity? What will be the net force acting on the crate? What will be the acceleration? (5.4)
10. Distinguish between force and pressure. (5.5)
11. Which produces more pressure on the ground, a person standing up or the same person lying down? (5.5)
12. The force of gravity is twice as great on a 2-kg rock as on a 1-kg rock. Why does the 2-kg rock not fall with twice the acceleration? (5.6)
13. Why do a coin and a feather in a vacuum tube fall with the same acceleration? (5.7)

14. Why do a coin and a feather fall with different accelerations in the presence of air? (5.7)

15. How much air resistance acts on a 100-N bag of nails that falls at its terminal speed? (5.7)

16. How do the air resistance and the weight of a falling object compare when terminal speed is reached? (5.7)

17. All other things being equal, why does a heavy sky diver have a terminal speed greater than a light sky diver? What can be done so that the terminal speeds are equal? (5.7)

18. What is the net force acting on a 25-N freely falling object? What is the net force when the object encounters 15 N of air resistance? When it falls fast enough to encounter 25 N of air resistance? (5.6–5.7)

Plug and Chug *Use Equations*

19. Calculate the acceleration of a 2000-kg, single-engine airplane just before takeoff when the thrust of its engine is 500 N.

20. Calculate the acceleration of a 300 000-kg jumbo jet just before takeoff when the thrust for each of its four engines is 30 000 N.

21. **a.** Calculate the acceleration if you push with a 20-N horizontal force on a 2-kg block on a horizontal friction-free air table.

    b. What acceleration occurs if the friction force is 4 N?

22. Calculate the horizontal force that must be applied to a 1-kg puck to make it accelerate on a horizontal friction-free air table with the same acceleration it would have if it were dropped and fell freely.

23. Calculate the horizontal force that must be applied to produce an acceleration of 1.8 *g* for a 1.2-kg puck on a horizontal friction-free air table.

Think and Explain *Think Critically*

24. What is the difference between saying that one quantity is proportional to another and saying it is equal to another?

25. If an object has no acceleration, can you conclude that no forces are exerted on it? Explain and draw a free-body diagram to illustrate an example.

26. What is the acceleration of a rock at the top of its trajectory when thrown straight upward? Explain whether or not the answer is zero by using the equation $a = F/m$ as a guide to your thinking.

27. A rocket fired from its launching pad not only picks up speed, but its acceleration also increases significantly as firing continues. Why is this so? (*Hint:* About 90% of the mass of a newly launched rocket is fuel.)

28. If you push horizontally on your book with a force of 1 N to make the book slide at constant velocity, how much is the force of friction on the book?

29. When blocking in football, why does a defending lineman often attempt to get his body under that of his opponent and push upward? What effect does this have on the friction force between the opposing lineman's feet and the ground?

30. Why does a sharp knife cut better than a dull knife?

31. An aircraft gains speed during takeoff due to the constant thrust of its engines. When is the acceleration during takeoff greatest—at the beginning of the run along the runway or just before the aircraft lifts into the air? Think, then explain.

32. As a sky diver falls faster and faster through the air (before reaching terminal speed), does the net force on her increase, decrease, or remain unchanged? Does her acceleration increase, decrease, or remain unchanged? Defend your answers.

33. After she jumps, a sky diver reaches terminal speed after 10 seconds. Does she gain more speed during the first second of fall or the ninth second of fall? Compared with the first second of fall, does she fall a greater or a lesser distance during the ninth second?

34. A regular tennis ball and another one filled with sand are dropped at the same time from the top of a high building. Your friend says that even though air resistance is present, both balls should hit the ground at the same time because they are the same size and "plow through" the same amount of air. What do you say?

Think and Solve

Develop Problem-Solving Skills

35. If a 1-N net force accelerates a 1-kg mass at $1 m/s^2$, what is the acceleration caused by a net force of 2 N on a 2-kg mass?

36. What is the acceleration of a 747 jumbo jet, mass 30 000 kg, in takeoff when the thrust for each of its four engines is 30 000 N?

37. A certain force applied to a 2-kg mass accelerates the mass at $3 m/s^2$. How much acceleration will the same force produce on a 4-kg mass?

38. A horizontal force of 100 N is required to push a crate across a factory floor at a constant speed. What is the net force acting on the crate? What is the force of friction acting on the crate?

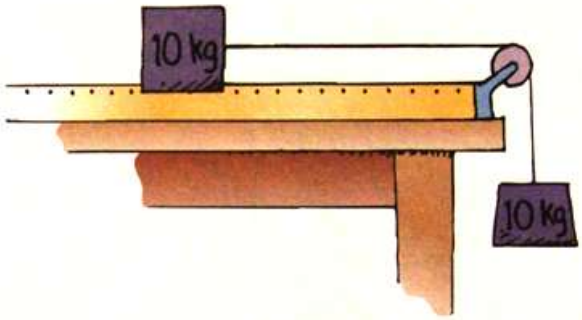
39. If a four-engine jet accelerates down the runway at $2 m/s^2$ and one of the jet engines fails, how much acceleration will the other three produce?

40. What will be the acceleration of a sky diver when air resistance is half the weight of the sky diver?

41. If a loaded truck that can accelerate at $1 m/s^2$ loses its load and has three-fourths of the original mass, what acceleration can it attain from the same driving force?

42. An occupant of a car has a chance of surviving a crash if the deceleration during the crash is not more than 30 *g*. Calculate the force on a 70-kg person decelerating at this rate.

43. A 10-kg mass on a horizontal friction-free air track is accelerated by a string attached to another 10-kg mass hanging vertically from a pulley as shown. What is the force due to gravity in newtons of the hanging 10-kg mass? What is the acceleration of the system of both masses?



44. Suppose the masses described in the preceding problem are 1 kg and 100 kg, respectively. Compare the accelerations when they are interchanged, that is, for the case where the 1-kg mass dangles over the pulley, and then for the case where the 100-kg mass dangles over the pulley. What does this indicate about the maximum acceleration of such a system of masses?

Activity *Performance Assessment*

45. When you drop two balls of different weights from the same height, you will see that for low speeds, they practically fall together. What happens if you let them roll together down the same inclined plane? If each is suspended from the same length string, made into a pendulum, and then displaced through the same angle, determine whether they swing back and forth in unison.

More Problem-Solving Practice
Appendix F