Knowledge

For each question, select the best answer from the four alternatives.

1. What is the value of acceleration due to gravity near Earth's surface? (4.1) K/U
   (a) 9.8 N
   (b) 9.8 m/s
   (c) 9.8 m/s^2
   (d) 9.8 km/h
2. Once a skydiver has accelerated to a constant speed, the skydiver is said to be travelling at
   (a) constant acceleration
   (b) terminal speed
   (c) maximum acceleration
   (d) final speed (4.1) K/U
3. The photo shown in **Figure 1** demonstrates that the ball
   (a) continues to accelerate as it falls
   (b) slows down as it falls
   (c) travels at a constant speed as it falls
   (d) neither speeds up nor slows down as it falls (4.1) K/U

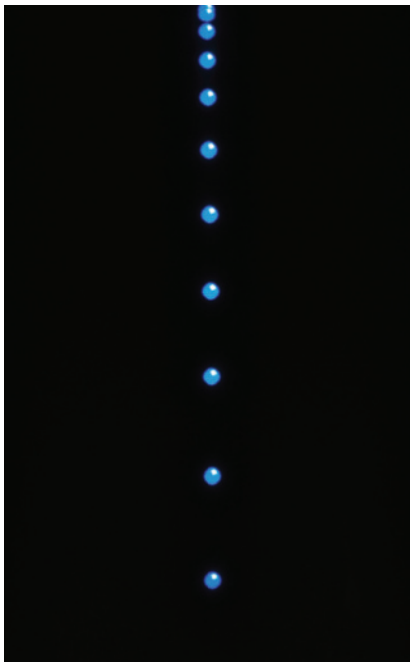

Figure 1

4. An object is said to be in free fall when which of these forces is acting on it alone? (4.1) K/U
   (a) rolling friction
   (b) wind friction
   (c) magnetic force
   (d) gravitational force
5. Compared to an object with a large cross-sectional area, an object with a small cross-sectional area will experience
   (a) less air resistance
   (b) more air resistance
   (c) the same amount of air resistance
   (d) negligible air resistance (4.1) K/U
6. A coin and a feather of equal mass are dropped at the same time. Which will hit the ground first? (4.1) K/U
   (a) the feather
   (b) the coin
   (c) They will hit the ground at the same time.
   (d) Each one has an equal probability of hitting first.
7. The coefficient of friction between two materials is defined by the ratio of the magnitude of the friction force to the magnitude of which other force? (4.2) K/U
   (a) gravitational force
   (b) kinetic force
   (c) static force
   (d) normal force
8. You push on an object, but it does not move. Which force are you unable to overcome? (4.3) K/U
   (a) gravitational force
   (b) kinetic friction
   (c) static friction
   (d) normal force
9. An object is given an initial push, is released, and slides along a surface. While it is sliding, kinetic friction will cause the object to
   (a) maintain its speed
   (b) increase its speed
   (c) decrease its speed
   (d) conserve its speed (4.3) K/U
10. Hydroplaning occurs when the water level in front of the tires is
    (a) too low to pass through the tires' grooves
    (b) low enough for the water to pass through the tires' grooves
    (c) high enough to pass through the tires' grooves
    (d) too high to pass through the tires' grooves (4.4) K/U
11. Which piece of athletic footwear is designed to decrease friction? (4.5) K/U
    (a) running shoes
    (b) baseball cleats
    (c) ice skates
    (d) basketball shoes

Match each statement on the left with the most appropriate description on the right.

12. (a) The skydiver jumps out of the plane.
    (i) Gravity is greater than air resistance.
    (b) The skydiver speeds up while falling.
    (ii) Gravity is less than air resistance.
    (c) The skydiver falls at a constant speed.
    (iii) Gravity is the only force acting on the skydiver.
    (d) The skydiver slows due to the parachute.
    (iv) Gravity is equal to air resistance. (4.1) K/U

Write a short answer to each question.

13. What is the definition of a force field? (4.1) K/U
14. The terms *mass* and *weight* are often used interchangeably in everyday speech. This is incorrect. (4.1) K/U
    (a) Which term represents a force?
    (b) Which term does not depend on gravity?
15. Define static friction in your own words. (4.2) K/U
16. A force large enough to overcome static friction is applied to an object. What type of force replaces static friction after the object begins to move? (4.2) K/U
17. Many people incorrectly assume friction always acts to reduce the net force on an object. Describe how a car's braking system uses friction to increase the net force on a car as it stops. (4.3, 4.4) K/U C
18. (a) In a paragraph, describe the similarities and differences between an antilock braking system and electronic traction control.
    (b) Explain how an electronic stability control system uses both of these as an overall safety system. (4.4) T/I C A

Understanding

19. Two objects of different mass are dropped from the same height. (4.1) T/I
    (a) If they both hit the ground at the same time, which has a larger cross-sectional area?
    (b) If they have the same cross-sectional area, which will hit the ground first?
    (c) Describe what would happen if the objects were dropped in a vacuum (without the presence of air resistance).
20. (a) What two forces act on a ball dropped through the air?
    (b) As the ball is initially dropped, which force is acting more strongly?
    (c) As the ball is moving at terminal speed, what is the relationship between the two forces?
    (d) If the ball has a mass of 25 kg, what must the magnitude of the friction force at terminal speed be? (4.1) T/I
21. **Figure 2** is the graph of a skydiver's acceleration. (4.1) K/U T/I C

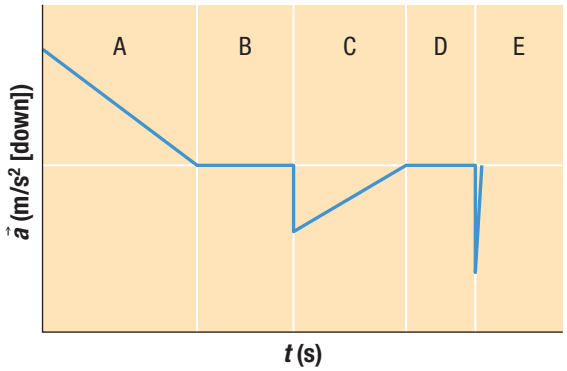

Figure 2

    (a) For each interval of time (A, B, C, D, and E), describe the motion of the skydiver and compare the magnitude of the forces acting on her.
    (b) At which point does the skydiver reach maximum speed?
    (c) At which point is the force of air resistance greatest?
    (d) During which intervals is she travelling at terminal speed?
    (e) Copy Figure 2 into your notebook and plot the skydiver's velocity. You may assume her speed is zero when she leaves the plane.
22. (a) A skydiver slows after the deployment of the parachute. Describe the relationship between air resistance and the gravitational force acting on the skydiver.
    (b) How does this relationship change as the skydiver slows toward terminal speed? (4.1) K/U
23. Compare the magnitudes of the gravitational field strength and the gravitational acceleration at Earth's surface. (4.1) K/U
24. (a) Describe two ways to measure gravitational field strength.
    (b) The force of gravity acting on a 1.50 kg object is 14.67 N. What is the gravitational field strength at that altitude above Earth's surface?
    (c) Is this altitude likely above or below sea level? Explain. (4.1) T/I

25. The weight of an object is measured at three locations: the North Pole, the equator, and the peak of Mount Everest. (4.1) T/I
    (a) Where will the object have the greatest weight?
    (b) Where will the object have the least weight?
    (c) Create a table listing the weight of an object with a mass of 12.687 kg at each of these locations.
26. (a) Define mass.
    (b) How is it possible to change the mass of an object?
    (c) Define weight.
    (d) How is it possible to change the weight of an object, but not change its mass?
    (e) Describe a situation in which the magnitudes of an object's weight and mass are equal. (4.1) K/U
27. (a) Explain why the terms *weightlessness* and *microgravity* are misapplied when discussing astronauts aboard the International Space Station.
    (b) What is the appropriate term to describe the state that makes objects appear to float within the space station? (4.1) K/U
28. A 60.0 kg person is standing on a bathroom scale inside an elevator. The scale is calibrated in newtons. What is the reading on the scale if the elevator is accelerating downward at 1.6 m/s^2? (4.1) T/I
29. To test the forces acting on a person during an amusement park ride, a student sits on a bathroom scale calibrated in kilograms while on the ride. Before the ride starts moving, the reading on the scale is 58 kg. Calculate the reading on the scale when the person is
    (a) moving at a constant velocity of 8.0 m/s [down]
    (b) accelerating at 2.7 m/s^2 [up]
    (c) accelerating at 3.8 m/s^2 [down] (4.1) T/I
30. Describe the difference between static friction and kinetic friction. (4.2) K/U
31. A box, sitting on a horizontal plane, is being pushed by a force that is not able to move the box. (4.2) T/I C
    (a) What forces act on the box?
    (b) Draw a free-body diagram of the box.
    (c) If the mass of the box is 7.5 kg, what is the magnitude of the normal force acting on the box if it is at sea level?
32. An object is being pushed along a horizontal surface with force F_a. Assume the only forces acting on the object in the horizontal direction are F_a and the friction force F_f. (4.2) T/I
    (a) Compare F_a and F_f if the object is slowing.
    (b) Compare F_a and F_f if the object is being pushed at a constant velocity.
    (c) Compare F_a and F_f if the object is speeding up.
33. An object experiences a friction force, F_f, of 6.6 N and a normal force, F_N, of 30.0 N. (4.2) K/U
    (a) What is the coefficient of friction, μ?
    (b) Is the object moving? How do you know?
34. A block of steel weighing 15 N sits on a dry, horizontal steel surface. (4.2) T/I
    (a) Refer to Table 1 on page 170. What force is initially required to make the steel block start sliding across the horizontal surface?
    (b) Once the block has begun sliding, what force is required to maintain the block sliding at a constant speed?
35. Friction occurs between all surfaces we are in contact with in our daily life. (4.2) K/U C
    (a) Describe an example of static friction that you might experience.
    (b) Describe an example of kinetic friction that you might experience.
    (c) Explain how each example of friction either helps something move or stops it from moving.
36. A 4.4 kg object is being pushed along a surface, causing it to accelerate at a rate of 1.5 m/s^2. The coefficient of kinetic friction is 0.25. What is the magnitude of the horizontal force being applied to push the object? (4.3) K/U
37. (a) A couch weighing 620 N is to be pushed to a new location across the room. The coefficient of static friction between the couch and the floor is 0.31. What is the minimum force required to set the couch in motion?
    (b) The coefficient of kinetic friction between the couch and the floor is 0.21. To maintain the couch moving at a constant speed, what force is required? (4.3) T/I
38. At a construction site, one worker passes a brick to another by pushing it across a piece of wood. The brick has a mass of 2.7 kg. The force required to start the brick moving is 18 N. What is the maximum coefficient of static friction between the brick and the wood? (4.3) T/I
39. (a) Rubber is an exception to which concept described for most other materials?
    (b) How does this difference affect the design of car tires? Give an example. (4.4) K/U
40. Explain, with respect to the interactions among the tire, water, and the road, the difference between a car moving at a controllable speed on wet pavement and a car hydroplaning on wet pavement. (4.4) K/U C

41. Car brakes can be broken down into components of a friction problem. Use this analogy to answer the following questions: (4.4) A
    (a) The friction force is applied to which component attached to the wheel?
    (b) The component attached to the wheel experiences a friction force by coming into contact with which other component?
42. Explain how crumple zones in a car's body and frame relate to the force and acceleration experienced by passengers of a vehicle during a collision. (4.4) K/U
43. What embarrassing scenario unfolds when the static friction between a golfer's hand and the golf club is lower than the force of the club's swing, and what do golf club manufacturers do in order to reduce the likelihood of this event? (4.5) A
44. Many applications of physics require a reduction in friction to meet acceptable levels of efficiency for the mechanism to work correctly. Some examples of this are motors, generators, fans, and even vehicles. (4.5) K/U
    (a) What types of bearings have been used for years to facilitate this friction reduction?
    (b) Name a newer type of bearing that reduces friction to negligible levels.
    (c) What are the benefits and tradeoffs of using a magnetic levitation–style bearing?
    (d) What new materials technology allows for both a very low coefficient of friction and a very hard wear surface, and what are some proposed applications for this technology?
45. Two large books are stacked on top of each other on a table (**Figure 3**). The mass of each book is 6.5 kg. Given that the coefficient of static friction between the bottom book and the table is 0.15, what is the lowest the coefficient of static friction between the books can be in order to apply force and move both books? (4.3) T/I

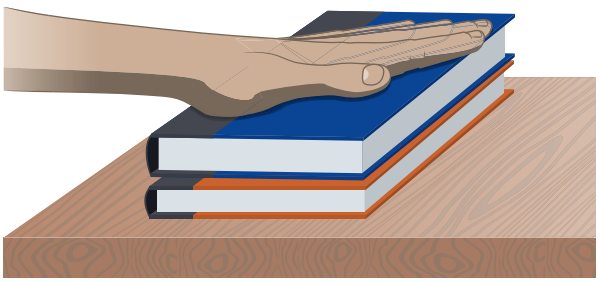

Figure 3

Analysis and Application

46. (a) Using your understanding of gravity and the relationship between force and acceleration, explain why you might feel heavier when an elevator travels upward and lighter when it travels downward.
    (b) Describe another situation in which someone might encounter a similar combination of accelerations to those in an elevator. (4.1) C A
47. Newton used a diagram similar to **Figure 4** to explain how a cannonball could be put into orbit around Earth. Explain how this diagram shows that the cannonball is actually in free fall. Which of the trajectories shown is the fastest? Explain your reasoning. (4.1) T/I A

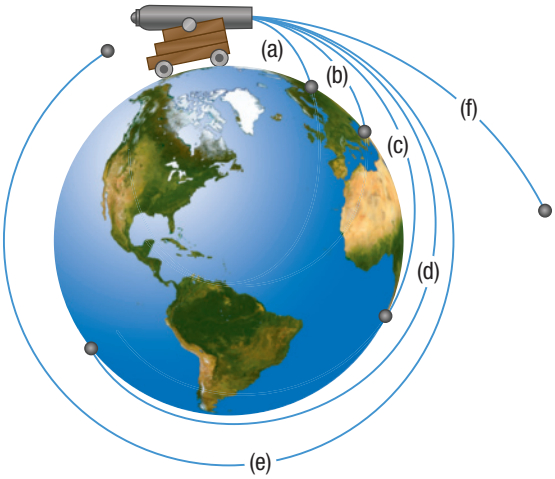

Figure 4

48. Some people think that if a surface is polished to the point where it is very smooth, it can be made virtually frictionless. **Figure 5** shows a metal surface that appears smooth to the unaided eye. Describe what this photograph reveals about friction. (4.2) T/I A

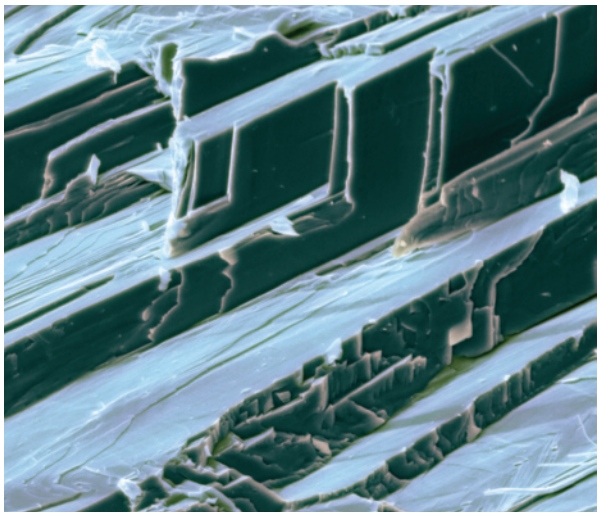

Figure 5

49. A block is pushed across a horizontal surface with a coefficient of kinetic friction of 0.15 by applying a 150 N horizontal force. (4.3) T/I A
    (a) The block accelerates at the rate of 2.53 m/s^2. Find the mass of the block.
    (b) The block slides across a new surface while experiencing the same applied force as before. The block now moves with a constant speed. What is the coefficient of kinetic friction between the block and the new surface?
50. Two sled racing teams use the same sled, but have different dogs and different amounts of equipment. The coefficients of friction are those of steel on ice ($\mu_S = 0.1$, $\mu_K = 0.01$). (4.3) T/I A
    (a) Team 1 pulls a 170 kg sled with 230 N of force and team 2 pulls a 195 kg sled with 250 N of force. Which team will have a quicker start?
    (b) Imagine a situation where each team's dogs are barely able to overcome the force of static friction. When the sleds do start to move, they continue pulling with the same force. How will the accelerations of each sled compare?
51. Sometimes static friction can be used to cause motion instead of impeding it. Running is an example of using static friction to cause motion. Broomball is a game made harder by the small amount of friction available to run, since players are required to wear shoes on ice. (4.3) T/I A
    (a) If a shoe on ice has a coefficient of static friction of 0.05, what is the maximum acceleration a 75 kg broomball player can expect to create?
    (b) If that same player were on a concrete surface, with a coefficient of static friction of 0.85, what acceleration would be possible?
    (c) What would happen to these values if a player of greater mass were on the same surface?
52. Aside from tread depth, describe another factor that might determine the ability of a car's tire to avoid hydroplaning and explain how it could be improved to decrease risk. (4.4) A
53. Most people think solely of the friction reduction capabilities of ice skates. This is only true along the axis parallel with the length of the skate. What would be the consequences of reducing the friction as much as possible along all the axes of an ice skate? (4.5) A

Evaluation

54. Since gravity on Earth is constant and humans have evolved in it and built civilizations around it, one consideration of future space exploration and colonization is adapting to different gravitational environments. The Moon is probably the most accessible possibility for colonization, but it has a lower gravitational field. (4.1) T/I C
    (a) Discuss some advantages and disadvantages of creating an infrastructure in a lower gravitational field. (Consider buildings, transportation, manufacturing, and so on.)
    (b) The human body is also accustomed to Earth's gravity. Discuss some possible effects on the human body of a lower gravitational field.
    (c) What effects might lower gravitational field strength have on human entertainment and sports activities?
55. Humans are affected by gravitational forces other than Earth's. For instance, the Moon exerts a gravitational force that causes the seas to shift in tidal patterns. (4.1) T/I
    (a) If the Moon were closer to Earth, would the tidal shift be greater or lesser? Why?
    (b) If the Moon had less gravitational pull than it does, what would be the effect on Earth's tides?
    (c) Some planets in the Solar System have multiple moons. Describe how Earth having multiple moons might affect the ocean tides.
56. Write a paragraph discussing how coefficients of friction can be determined experimentally. What forces must be measured to do so? What are some variables that can affect results? How could these variables be controlled or documented and accounted for? (4.2) T/I C
57. Friction is commonly a force that needs to be overcome. However, without friction we would not be able to do many of the things we do on a daily basis. Name one thing that would not be possible without friction, and propose an alternative way to accomplish it without being able to rely on friction. (4.2) C A
58. Friction is a very common source of energy loss. Most often, the friction force converts energy into heat. (4.2) K/U T/I C A
    (a) Explain how this friction loss has an impact on the efficiency of a common item (for example, a car, a computer, a refrigerator).
    (b) Describe some of the ways product designers could try to minimize friction in their products.

59. One challenge faced by engineers is predicting the magnitude of the forces their designs will experience in a real-world application. (4.2, 4.3) T/I C A
    (a) Refer to Table 1 on page 170 to explain how an engineer designing the interaction between two parts of greasy steel might encounter this challenge.
    (b) How might engineers overcome this uncertainty?
    (c) Another example of this uncertainty is discussed in this chapter regarding the design of golf clubs. What are some variables that change the forces experienced by a golf club during its use?

Reflect on Your Learning

60. The creation of tools to take advantage of forces is one of the most characteristic distinctions between humans and other animals. K/U T/I C A
    (a) Explain how one of the discussions in this chapter illustrates how humans are capable of taking advantage of forces such as gravity and friction, and explain how that advantage helps make daily life easier.
    (b) Find another example of technology taking advantage of gravity or friction and explain how it works and how it makes life easier.
61. (a) Before you read this chapter's discussion of mass and weight, what was your understanding of these two terms and their relationship to each other? Was that understanding correct? If not, why?
    (b) Explain why using these terms interchangeably must be avoided in the context of physics and science in general. K/U C
62. Air resistance can be both helpful and challenging to overcome. Most of our encounters with air resistance come when we try to move ourselves at high speed, such as for transportation. Write about a situation in which we use air resistance to our advantage and one situation where we have to use technology to overcome the forces we feel due to air resistance in transportation. In what ways had you been introduced to air resistance before reading this chapter? K/U C A
63. Section 4.4 discusses many safety features in automobiles. What safety features were you aware of in cars before reading about those discussed in this chapter? Should your understanding of these safety features allow you or your friends to drive with less care than you would have without knowing about them? Why? A

Research

GO TO NELSON SCIENCE

64. The list of Newton's contributions to science and mathematics is easily as long as anyone else's in history. Research Newton's law of universal gravitation. Write a report describing the law itself, including the mathematical formula describing the gravitational force between two objects. T/I K/U C
65. While it is generally understood that automobile manufacturers are researching ways in which we can use/produce energy more efficiently, many people are unaware of the fact that these manufacturers are also busy developing ways in which we can recover otherwise wasted energy. One of these energy recovery methods is known as regenerative braking. Regenerative braking is a way to recover energy lost in standard friction-based brake systems. Research regenerative braking and write a report about it. You may wish to discuss how regenerative braking works and its current and future applications. T/I K/U C A
66. The idea of a parachute can be shown to have been developed over 500 years ago by none other than Leonardo da Vinci. Research the history of the parachute. Write a short report detailing the timeline of the parachute from the days of da Vinci to the present day. Be sure to discuss any major technological advances or historical milestones. T/I C
67. Guillaume Amontons was the first to publish laws of friction. His laws stated that the friction force is proportional to the normal force acting on the object and independent of the area of contact. Research the life of Guillaume Amontons, noting his other scientific contributions. Write a short biography that highlights significant moments in his personal and public life, along with his major scientific breakthroughs. T/I C
68. Adding to Amontons's laws of friction, Coulomb's friction law stated that the kinetic friction force is independent of sliding velocity. Charles-Augustin de Coulomb is also known for his contributions to the realm of electricity. Research Coulomb's life and write a biography. Be sure to include a discussion of his major scientific contributions and their impact on the scientific community. T/I C
69. Thermal energy is, very often, an unwanted by-product of friction. When thermal energy is the desired effect, however, friction can be a useful way of providing it. This is the case with the development of the friction match. Research the friction match and write a report describing how it works and how it went from an invention to an everyday household object. K/U C