Answers and Solutions for Chapter 4

Reading Check Questions

1. No. The net force acting on the object must double for its acceleration to double.
2. Your push and the force of friction have the same magnitude.
3. Friction is caused by the irregularities in the surfaces in mutual contact. Seemingly smooth surfaces also have microscopic irregularities.
4. Once moving, your push has the same magnitude as the force of friction.
5. This is because static friction is greater than sliding friction for the same object. Therefore, more force is required to get the object moving initially to overcome static friction; once the object is in motion, only sliding friction needs to be overcome.
6. The force of friction does not depend upon the area of contact for sliding bodies.
7. Yes. Fluid friction does vary with speed.
8. Mass is a measure of the inertia of a material object. Weight is dependent on acceleration due to gravity, or '*g*', as well.
9. mass; weight.
10. kilogram; newton.
11. 2 × 9.8 = 19.6 newtons
12. The weight of a 1-kg brick is about 10 newtons.
13. Breaking of the top string is due mainly to the ball's weight.
14. Breaking of the lower string is due mainly to the ball's mass.
15. The body with a higher mass will accelerate less since acceleration is inversely proportional to mass.
16. Acceleration, Force, and Mass.
17. No. Weight is proportional to mass, but not *equal* to mass.
18. The net force is also quadrupled.
19. The acceleration decreases to one-third.
20. The acceleration will be unchanged.
21. The speed of the object reduces.
22. In free fall, the only force acting on an object is the force of gravity.
23. The ratio of force to mass is *g*.
24. The ratio of force to mass for both is the same, *g*.
25. The net force is 10 N.
26. The net force is 6 N; zero.
27. The force of air drag increases with an increase in the speed of a falling object.
28. Acceleration is zero.
29. The heavier parachutist should be given a parachute with a proportionately higher frontal area.
30. The faster one encounters greater air resistance.

Think and Do

31. Relate how Newton followed Galileo, and so on.

32. The coin hits the ground first; when crumpled, both fall in nearly the same time; from an elevated starting point, the coin hits first. That's because it has less frontal area.

33. When the paper is on top of the dropped book, no air resistance acts on the paper because the book shields it from the air. So the paper and book fall with the same acceleration!

34. In all three kinds of motion they move in unison, in accord with $a = F/m$.

35. The spool will roll to the right! There is an angle at which it will not roll but slide. Any angle larger will roll the spool to the left. But pulled horizontally it rolls in the direction of the pull.

Plug and Chug

36. Weight = (100 kg)(10 N/kg) = 1000 N.

37. Weight = (2000 kg)(10 N/kg) = 20,000 N.

38. Weight = (2.5 kg)(10 N/kg) = 25 N; (25 N)(2.2 lb/kg)(10 N/1 kg) = 550 N.

39. (1 N)(1 kg/10 N) = 0.1 kg; (0.1 kg)(2.2 lb/1 kg) = 0.22 lb.

40. N to kg; (700 N)(1 kg/10 N) = 70 kg.

41. $a = F_{net}/m$ = (500 N)/(2000 kg) = 0.25 N/kg = 0.25 m/s^2.

42. $a = F_{net}/m$ = (120,000 N)/(300,000 kg) = 0.4 N/kg = 0.4 m/s^2.

43. $a = F_{net}/m$ = 200 N/40 kg = 5 N/kg = 5 m/s^2.

44. $a = \Delta v/\Delta t$ = (6.0 m/s)/(1.2 m/s^2) = 5.0 m/s^2.

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45. a **= F_{net}/m = (15 N)/(3.0 kg) = 5.0 N/kg = 5.0 m/s^2.**

46. a **= F_{net}/m = (10 N)/(1 kg) = 10 N/kg = 10 m/s^2.**

47. $F_{net} = ma$ = (12 kg)(7.0 m/s^2) = 84 kg·m/s^2 = 84 N.

Think and Solve

48. (1 N)(1 lb/4.45 N) = 0.225 lb.

49. Jess's mass is (700N)/(10N/kg) = 70 kg. Her weight in pounds, (70 kg)(2.2 lb/kg) = 154 lb.

50. The acceleration of each is the same: $a = F/m$ = 2 N/2 kg = 1 N/1 kg = 1 m/s^2. (Incidentally, from the definition that 1 N = 1 kg·m/s^2, you can see that 1 N/kg is the same as 1 m/s^2.)

51. For the jet: $a = F/m$ = 2(30,000 N)/(30,000 kg) = 2 m/s^2.

52. (a) a = Δv/Δt = (9.0 m/s)/(0.2 s) = 45 m/s^2. (b) $F = ma$ = (100 kg)(45 m/s^2) = 4500 N.

53. (a) The force on the bus is Ma. New acceleration = same force/new mass = $Ma/(M+M/5) = 5Ma/(5M+M)$ $= 5Ma/6M = (5/6)a$.
(b) New acceleration = $(5/6)a$ = (5/6)(1.2 m/s^2) = 1.0 m/s^2.

Think and Rank

54**.** a. D, A=B=C; b. A=C, B=D
55. C, B, A
56. a. A=B=C; b. C, A, B
57. a. C, A, B; b. B, A, C

Think and Explain

58. The force you exert on the ball ceases as soon as contact with your hand ceases.

59. Yes, if the ball slows down, a force opposite to its motion is acting—likely air resistance and friction between the ball and alley.

60. Constant velocity means zero acceleration, so yes, no net force acts on the motorcycle. But when moving at constant acceleration there is a net force acting on it.

61. No, inertia involves mass, not weight.

62. Items like apples weigh less on the Moon, so there are more apples in a 1-pound bag of apples there. Mass is another matter, for the same quantity of apples are in 1-kg bag on the Earth as on the Moon.

63. Buy by weight in Denver because the acceleration of gravity is less in Denver than in Death Valley. Buying by mass would be the same amount in both locations.

64. Shake the boxes. The box that offers the greater resistance to acceleration is the more massive box, the one containing the sand.

65. When you carry a heavy load there is more mass involved and a greater tendency to remain moving. If a load in your hand moves toward a wall, its tendency is to remain moving when contact is made. This

tends to squash your hand if it's between the load and the wall—an unfortunate example of Newton's first law in action.

66. Mass is a measure of the amount of material in something, not gravitational pull that depends on its location. So although the weight of the astronaut may change with location, mass does not.

67. A massive cleaver is more effective in chopping vegetables because its greater mass contributes to greater tendency to keep moving as the cleaver chops the food.

68. Neither the mass nor the weight of a junked car changes when it is crushed. What does change is its volume, not to be confused with mass and weight.

69. Ten kilograms weighs about 100 N on the Earth (weight = mg = 10 kg $\times$ 10 m/s^2 = 100 N, or 98 N if g = 9.8 m/s^2 is used). On the Moon the weight is 1/6 of 100 N = 16.7 N (or 16 N if g = 9.8 m/s^2 is used). The mass is 10 kg everywhere.

70. The scale reading will increase during the throw. Your upward force on the heavy object is transmitted to the scale.

71. The change of weight is the change of mass times *g,* so when mass changes by 2 kg, weight changes by about 20 N.

72. One kg of mass weighs 2.2 pounds at the Earth's surface. If you weigh 100 pounds, for example, your mass is (100 lb)/(2.2 kg/lb) = 45 kg. Your weight in newtons, using the relationship weight = mg, is then (45 kg)(10 N/kg) = 450 N. On the Moon, your weight will be lower since acceleration due to gravity is lower on the Moon. Your mass, however, will remain unchanged.

73. A 1-kg mass weighs 10 N, so 30 kg weigh 300 N. The bag can safely hold 30 kg of apples—if you don't pick it up too quickly.

74. Since the crate remains at rest, the net force on it is zero, which means the force of friction by the floor on the crate will be equal and opposite to your applied force.

75. The second law states the relationship between force and acceleration. If there is no net force, there is no acceleration—which is what Newton's first law states. So Newton's first law is consistent with the second law, and can be considered to be a special case of the second law.

76. Acceleration (slowing the car) is opposite to velocity (direction car moves).

77. Agree. Acceleration (slowing the car) is opposite to velocity (the direction the car is moving).

78. Acceleration is the ratio force/mass (Newton's second law), which in free fall is just weight/mass = $mg/m = g$. Since weight is proportional to mass, the ratio weight/mass is the same whatever the weight of a body.

79. Lifting the opponent decreases the force with which the ground supports him, and correspondingly decreases the force of friction he can muster. The reduced friction limits the opponent's effectiveness.

80. The forces acting horizontally are the driving force provided by friction between the tires and the road, and resistive forces—mainly air resistance. These forces cancel and the car is in dynamic equilibrium with a net force of zero.

81. (a) No. Air resistance is also acting. Free fall means free of all forces other than that due to gravity. A falling object may experience air resistance; a freely falling object experiences only the force due to gravity. (b) Yes. Although getting no closer to the Earth, the satellite is falling (more about this in Chapter 10).

82. The velocity of the ascending coin decreases while its acceleration remains constant (in the absence of air resistance).

83. The only force on a tossed coin, except for air resistance, is mg. So the same mg acts on the coin at all points in its trajectory.

84. The acceleration at the top or anywhere else in free fall is g, 10 m/s^2, downward. The velocity of the rock is momentarily zero while the rate of change of velocity is still present. Or better, by Newton's 2[nd] law, the force of gravity acts at the top as elsewhere; divide this net force by the mass for the acceleration of free fall. That is, $a = F_{net}/m = mg/m = g$.

85. You explain the distinction between an applied force and a net force. It would be correct to say no *net* force acts on a car at rest.

86. When driving at constant velocity, the zero net force on the car results from the driving force that your engine supplies against the friction drag force. You continue to apply a driving force to offset the drag force that otherwise would slow the car.

87. When the apple is held at rest the upward support force equals the gravitational force on the apple and the net force is zero. When the apple is released, the upward support force is no longer there and the net force is the gravitational force, 1 N. (If the apple falls fast enough for air resistance to be important, then the net force will be less than 1 N, and eventually can reach zero if the air resistance builds up to 1 N.)

88. High-speed grains of sand grazing the Earth's atmosphere burn up because of friction against the air.

89. Both forces have the same magnitude. This is easier to understand if you visualize the parachutist at rest in a strong updraft—static equilibrium. Whether equilibrium is static or dynamic, the net force is zero.

90. When anything falls at constant velocity, air resistance and gravitational force are equal in magnitude. Raindrops are merely one example.

91. When a parachutist opens her chute she slows down. That means she accelerates upward.

92. There are usually two terminal speeds, one before the parachute opens, which is faster, and one after, which is slower. The difference has mainly to do with the different areas presented to the air in falling. The large area presented by the open chute results in a slower terminal speed, slow enough for a safe landing.

93. Just before a falling body attains terminal velocity, there is still a downward acceleration because gravitational force is still greater than air resistance. When the air resistance builds up to equal the gravitational force, terminal velocity is reached. Then air resistance is equal and opposite to gravitational force.

94. The terminal speed attained by the falling cat is the same whether it falls from 50 stories or 20 stories. Once terminal speed is reached, falling extra distance does not affect the speed. (The low terminal velocities of small creatures enables them to fall without harm from heights that would kill larger creatures.)

95. The sphere will be in equilibrium when it reaches terminal speed—which occurs when the gravitational force on it is balanced by an equal and opposite force of fluid drag.

96. Air resistance is not really negligible for so high a drop, so the heavier ball does strike the ground first. (This idea is shown in Figure 4.16.) But although a twice-as-heavy ball strikes first, it falls only a little faster, and not twice as fast, which is what followers of Aristotle believed. Galileo recognized that the small difference is due to air friction, and both would fall together when air friction is negligible.

97. The heavier tennis ball will strike the ground first for the same reason the heavier parachutist in Figure 4.15 strikes the ground first. Note that although the air resistance on the heavier ball is smaller relative to the ball's weight, it is actually greater than the air resistance that acts on the other ball. Why? Because the heavier ball falls faster, and air resistance is greater at greater speed.

98. Air resistance decreases the speed of a moving object. Hence the ball has less than its initial speed when it returns to the level from which it was thrown. The effect is easy to see for a feather projected upward by a slingshot. No way will it return to its starting point with its initial speed!

99. The ball rises in less time than it falls. If we exaggerate the circumstance and considering the feather example in the preceding answer, the time for the feather to flutter from its maximum altitude is clearly

longer than the time it took to attain that altitude. The same is true for the not-so-obvious case of the ball.

100. Open-ended.

Think and Discuss

101. Yes, as illustrated by a ball thrown vertically into the air. Its velocity is initially upward, and finally downward, all the while accelerating at a constant downward *g*.

102. Neither a stick of dynamite nor anything else "contains" force. We will see later that a stick of dynamite contains *energy*, which is capable of producing forces when an interaction of some kind occurs.

103. No. An object can move in a curve only when a force acts. With no force its path would be a straight line.

104. The only force that acts on a dropped rock on the Moon is the gravitational force between the rock and the Moon because there is no air and therefore no air drag on the rock.

105. A dieting person seeks to lose mass. Interestingly, a person can lose weight by simply being farther from the center of the Earth, at the top of a mountain, for example.

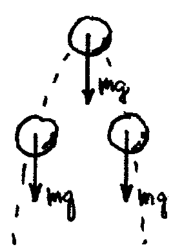
106. Friction between the crate and the truck-bed is the force that keeps the crate picking up the same amount of speed as the truck. With no friction, the accelerating truck would leave the crate behind.

107. Note that 30 N pulls three blocks. To pull two blocks then requires a 20-N pull, which is the tension in the rope between the second and third block. The tension in the rope that pulls only the third block is therefore 10 N. (Note that the net force on the first block,
30 N – 20 N = 10 N, is the force needed to accelerate that block, having one-third of the total mass.)

108. The *net* force on the wagon, your pull plus friction, is zero. So $\Sigma F = 0$.

109. When you stop suddenly, your velocity changes rapidly, which means a large acceleration of stopping. By Newton's second law, this means the force that acts on you is also large. Experiencing a large force is what hurts you.

110. The force vector *mg* is the same at all locations. Acceleration *g* is therefore the same at all locations also.



111. The force you exert on the ground is greater. The ground must push up on you with a force greater than the downward force of gravity to produce a resulting net force that is upward and that will accelerate you upward.

112. At the top of your jump your acceleration is *g*. Let the equation for acceleration via Newton's second law guide your thinking: $a = F/m = mg/m = g$. If you said zero, you're implying the force of gravity ceases to act at the top of your jump—not so!

113. For a decreasing acceleration the increase in speed becomes smaller each second, but nevertheless, there's greater speed each second than in the preceding second.

114. The net force is *mg* downward, 10 N (or more precisely, 9.8 N).

115. The net force is 10 N – 2 N = 8 N (or more precisely 9.8 N – 2 N = 7.8 N).

116. Agree with your friend. Although acceleration decreases, the ball is nevertheless gaining speed. It will do so until it reaches terminal speed. Only then will it not continue gaining speed.

117. A sheet of paper presents a larger surface area to the air in falling (unless it is falling edge on), and therefore has a lower terminal speed. A wadded piece of paper presents a smaller area and therefore falls faster before reaching terminal speed.

118. In each case the paper reaches terminal speed, which means air resistance equals the weight of the paper. So air resistance will be the same on each! Of course the wadded paper falls faster for air resistance to equal the weight of the paper.

119. For low speeds, accelerations are nearly the same because air drag is small relative to the weights of the falling objects. From a greater height, there is time for air resistance to build up and more noticeably show its effects.

120. Sliding down at constant velocity means acceleration is zero and the net force is zero. This can occur if friction equals the bear's weight, which is 4000 N. Friction = bear's weight = mg = (400 kg)(10 m/ s^2) = 4000 N.

121. Nowhere is her velocity upward. The upward net force on Nellie during the short time that air resistance exceeds the force of gravity produces a momentary upward net force and upward acceleration. This produces a *decrease* in her downward speed, which is nevertheless still downward.