HOMEWORK ASSIGNMENTS

SOLUTIONS TO CHAPTER 1

EXERCISES

2. (a) This is a scientific hypothesis, for there is a test for wrongness. For example, you can extract chlorophyll from grass and note its color.
(b) This statement is without a means of proving it wrong and is not a scientific hypothesis. It is speculation.
(c) This is a scientific hypothesis. It could be proved wrong, for example, by showing tides that do not correspond to the position of the Moon.

4. To publicly change your mind about your ideas is a sign of strength rather than a sign of weakness. It takes more courage to change your ideas when confronted with counter evidence than to hold fast to your ideas. If a person’s ideas and view of the world are no different after a lifetime of varied experience, then that person was either miraculously blessed with unusual wisdom at an early age, or learned nothing. The latter is more likely. Education is learning that which you don’t yet know about. It would be arrogant to think you know it all in the later stages of your education, and stupid to think so at the beginning of your education.

6. The Sun’s radius is approximately $7 \times 10^8$ m. The distance between the Earth and Moon is about $4 \times 10^8$ m. So the Sun’s radius is much larger, nearly twice the distance between the Earth and Moon. The Earth and Moon at their present distance from each other would easily fit inside the Sun. The Sun is really big—surprisingly big!

8. Yes, there is a geometric connection between the two ratios. As the sketch shows, they are approximately equal.

\[
\frac{\text{Pole shadow}}{\text{Pole height}} = \frac{\text{Alexandria – Syene distance}}{\text{Earth radius}}
\]

From this pair of ratios, given the distance between Alexandria and Syene, the radius of the Earth can be calculated!

10. Yes, for many examples abound in such areas as music, architecture, painting, poetry, and even an eloquent thought. This list is nearly endless.

SOLUTIONS TO CHAPTER 2

EXERCISES

2. Copernicus and others of his day thought an enormous force would have to continuously push the Earth to keep it in motion. He was unfamiliar with the concept of inertia, and didn’t realize that once a body is in motion, no force is needed to keep it moving (assuming no friction).

4. Galileo demolished the notion that a moving body requires a force to keep it moving. He showed a force is needed to change motion, not to keep a body moving, so long as friction was negligible.
10. If Tim pulls the cloth upward, even slightly, it will tend to lift the dishes, which will disrupt the demonstration to show the dishes remaining at rest. The cloth should move horizontally for the dishes to remain at rest.

14. In a car at rest your head tends to stay at rest. When the car is rear-ended, the car lurches forward and you and your head also move forward. Without headrest your body tends to leave your head behind. Hence a neck injury.

20. The maximum resultant occurs when the forces are parallel in the same direction—32 N. The minimum occurs when they oppose each other—8 N.

26. You can say that no net force acts on a body at rest, but there may be any number of forces that act to produce a zero net force. When the net force is zero, the body is in static equilibrium.

30. 800 N; The pulley simply changes the direction of the applied force.

34. No, the normal force would be the same whether the book was on slippery ice or sandpaper. Friction plays no role unless the book slides or tends to slide along the table surface.

38. Friction on the cart has to be 200 N, opposite to your 200-N pull.

46. The coin is moving along with you when you toss it. While in the air it maintains this forward motion, so the coin lands in your hand. If the train slows while the coin is in the air, it will land in front of you. If the train makes a turn while the coin is in the air, it will land off to the side of you. The coin continues in its horizontal motion, in accord with the law of inertia.

CHAPTER 2 PROBLEMS

2. 800 N on one scale, 400 N on the other. (2x + x = 1200 N; 3x = 1200 N; x = \frac{1200 N}{3} = 400 N.)

4. From the equilibrium rule, \( \Sigma F = 0 \), the upward forces are 800 N + tension in the right scale. This sum must equal the downward forces 500 N + 400 N + 400 N. Arithmetic shows the reading on the right scale is 500 N.

SOLUTIONS TO CHAPTER 3

EXERCISES

10. “The dragster rounded the curve at a constant speed of 100 km/h.” Constant velocity means not only constant speed but constant direction. A car rounding a curve changes its direction of motion.
12. Emily is correct. Jacob is describing speed. Acceleration is the time rate of change in speed—"how fast you get fast," as Emily asserts.

14. Any object moving in a circle or along a curve is changing velocity (accelerating) even if its speed is constant, because direction is changing. Something with constant velocity has both constant direction and constant speed, so there is no example of motion with constant velocity and varying speed.

16. An object moving in a circular path at constant speed is a simple example of acceleration at constant speed because its velocity is changing direction. No example can be given for the second case, for constant velocity means zero acceleration. You can't have a nonzero acceleration while having a constant velocity. There are no examples of things that accelerate while not accelerating.

22. The greater change in speeds occurs for (30 km/h – 25 km/h = 5 km/h) which is greater than (100 km/h – 96 km/h = 4 km/h). So for the same time, the slower one has the greater acceleration.

24. Free fall is defined as falling only under the influence of gravity, with no air resistance or other non-gravitational forces. So your friend should omit "free" and say something like, "Air resistance is more effective in slowing a falling feather than a falling coin."

26. Distance readings would indicate greater distances fallen in successive seconds. During each successive second the object falls faster and covers greater distance.

32. If air drag is not a factor, its acceleration is the same 10 m/s² regardless of its initial velocity. Thrown downward, its velocity will be greater, but not its acceleration.

36. Time (in seconds) | Velocity (in meters/second) | Distance (in meters)
---|---|---
0 | 0 | 0
1 | 10 | 5
2 | 20 | 20
3 | 30 | 45
4 | 40 | 80
5 | 50 | 125
6 | 60 | 180
7 | 70 | 245
8 | 80 | 320
9 | 90 | 405
10 | 100 | 500

42. How you respond may or may not agree with the author’s response: There are few pure examples in physics, for most real situations involve a combination of effects. There is usually a "first order" effect that is basic to the situation, but then there are 2nd, 3rd, and even 4th or more order effects that interact also. If we begin our study of some concept by considering all effects together before we have studied their contributions separately, understanding is likely to be difficult. To have a better understanding of what is going on, we strip a situation of all but the first order effect, and then examine that. When we have a good grip on that, then we proceed to investigate the other effects for a fuller understanding. Consider Kepler, for example, who made the stunning discovery that planets move in elliptical paths. Now we know that they don’t quite move in perfect ellipses because each planet affects the motion of every other one. But if Kepler had been stopped by these second-order effects, he would not have made
his groundbreaking discovery. Similarly, if Galileo hadn’t been able to free his thinking from real-world friction he may not have made his great discoveries in mechanics.

44. As water falls it picks up speed. Since the same amount of water issues from the faucet each second, it stretches out as distance increases. It becomes thinner just as taffy that is stretched gets thinner the more it is stretched. When the water is stretched too far, it breaks up into droplets.

CHAPTER 3 PROBLEMS

2. (a) The velocity of the ball at the top of its vertical trajectory is instantaneously zero.  
(b) One second before reaching its top, its velocity is 10 m/s.  
(c) The amount of change in velocity is 10 m/s during this 1-second interval (or any other 1-second interval).  
(d) One second after reaching its top, its velocity is −10 m/s—equal in magnitude but oppositely directed to its value 1 second before reaching the top.  
(e) The amount of change in velocity during this (or any) 1-second interval is 10 m/s.  
(f) In 2 seconds, the amount of change in velocity, from 10 m/s up to 10 m/s down, is 20 m/s (not zero!).  
(g) The acceleration of the ball is 10 m/s² before reaching the top, when reaching the top, and after reaching the top. In all cases acceleration is downward, toward the Earth.

4. \[ a = \frac{\text{change in velocity}}{\text{time interval}} = \frac{25 \text{ m/s} - 0}{10 \text{ s}} = 2.5 \text{ m/s}^2 \]

6. (a) \[ t = \frac{d}{\vec{v} \cdot \vec{a}} = \frac{d}{\vec{v}} = \frac{L}{\left(\frac{v_f + v_i}{2}\right)} = \frac{2L}{v} \]

(b) \[ t = \frac{2L}{v} = \frac{2(1.4 \text{ m})}{15.0 \text{ m/s}} = 0.19 \text{ s} \]

SOLUTIONS TO CHAPTER 4

EXERCISES

6. 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.

8. 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 = \[ mg = (400 \text{ kg})(10 \text{ m/s}^2) = 4000 \text{ N} \]

10. When carrying a heavy load there is more mass involved; more 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.

14. Ten kilograms weighs about 100 N on the Earth (weight = \( mg = 10 \text{ kg} \times 10 \text{ m/s}^2 = 100 \text{ N} \) or 98 N if \( g = 9.8 \text{ m/s}^2 \) is used). On the Moon, weight would be \( \frac{1}{6} \) of 100 N = 16.7 N (or 16.3 N if \( g = 9.8 \text{ m/s}^2 \) is used). The mass would be 10 kg everywhere.

16. The change of weight is the change of mass times \( g \), so when mass changes by 2 kg, weight changes by about 20 N.

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

19. Friction 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.

24. 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.

26. Note that 30 N pulls 3 blocks. To pull 2 blocks then requires a 20-N pull, which is the tension in the rope between the second and third block. 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.)

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

32. 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.

34. 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, but 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 and you have the acceleration of free fall. That is, \( a = \frac{F_{\text{net}}}{m} = \frac{mg}{m} = g \).
38. When held at rest the upward support force equals the gravitational force on the apple and the net force is zero. When 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 air resistance builds up to 1 N.)

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

58. 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!

60. Open-ended.

CHAPTER 4 PROBLEMS

2. Katelyn’s mass is \( \frac{500 \text{ N}}{10 \text{ N/kg}} = 50 \text{ kg} \). Her weight in lb; \( 50 \text{ kg} \times \frac{2.2 \text{ lb}}{\text{kg}} = 110 \text{ lb} \).

4. The acceleration of each is the same: \( a = \frac{F}{m} = \frac{2 \text{ N}}{2 \text{ kg}} = \frac{1 \text{ N}}{1 \text{ kg}} = 1 \text{ m/s}^2 \). (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.)

6. (a) \( a = \frac{\Delta v}{\Delta t} = \frac{9.0 \text{ m/s}}{0.2 \text{ s}} = 45 \text{ m/s}^2 \)
   (b) \( F = ma = (100 \text{ kg})(45 \text{ m/s}^2) = 4500 \text{ N} \)

SOLUTIONS TO CHAPTER 5

EXERCISES

2. In accord with Newton’s third law, Steve and Gretchen are touching each other. One may initiate the touch, but the physical interaction can’t occur without contact between both Steve and Gretchen. Indeed, you cannot touch without being touched!

6. (a) Action; Earth pulls you downward. Reaction; you pull Earth upward.
   (b) Action; you touch tutor’s back. Reaction; your tutor’s back touches you.
   (c) Action; wave hits shore. Reaction; shore hits wave.

8. In accord with Newton’s first law, your body tends to remain in uniform motion. When the airplane accelerates, the seat pushes you forward. In accord with Newton’s third law, you simultaneously push backward against the seat.
12. The billions of force pairs are internal to the book, and exert no net force on the book. An external net force is necessary to accelerate the book.

16. The forces must be equal and opposite because they are the only forces acting on the person, who obviously is not accelerating. Note that the pair of forces do not comprise an action-reaction pair, however, for they act on the same body. The downward force, the man’s weight, Earth pulls down on man, has the reaction man pulls up on Earth, not the floor pushing up on him. And the upward force of the floor on the man has the reaction of man against the floor, not the interaction between the man and Earth. (If you find this confusing, you may take solace in the fact that Newton himself had trouble applying his 3rd law to certain situations. Apply the rule, A on B reacts to B on A, as in Figure 5.7.)

20. The forces do not cancel because they act on different things—one acts on the horse, and the other acts on the wagon. It’s true that the wagon pulls back on the horse, and this prevents the horse from running as fast as it could without the attached wagon. But the force acting on the wagon (the pull by the horse minus friction) divided by the mass of the wagon, produces the acceleration of the wagon. To accelerate, the horse must push against the ground with more force than it exerts on the wagon and the wagon exerts on it. So tell the horse to push backward on the ground.

24. In accord with Newton’s 3rd law, the force on each will be of the same magnitude. But the effect of the force (acceleration) will be different for each because of the different mass. The more massive truck undergoes less change in motion than the Civic.

28. No. The net force on the rope is zero, meaning tension is the same on both ends, in accord with Newton’s third law.

38. By the parallelogram rule, the tension is less than 50 N.

42. The other interaction is between the stone and the ground on which it rests. The stone pushes down on the ground surface, say action, and the reaction is the ground pushing up on the stone. This upward force on the stone is called the normal force.

44. (a) As shown.

(b) Yes.
(c) Because the stone is in equilibrium.

48. (a) Weight and normal force only.
(b) As shown.
50. Tension would be the same if one end of the rope were tied to a tree. If two horses pull in the same
direction, tension in the rope (and in the strongman) is doubled.

CHAPTER 5 PROBLEMS

2. The wall pushes on you with 40 N.
\[ a = \frac{F}{m} = \frac{40 \text{ N}}{80 \text{ kg}} = 0.5 \text{ m/s}^2 \]

4. \[ a = \frac{F}{m} \], where \( F = \sqrt{(3.0 \text{ N})^2 + (4.0 \text{ N})^2} = 5 \text{ N} \). So \[ a = \frac{F}{m} = \frac{5 \text{ N}}{2.0 \text{ kg}} = 2.5 \text{ m/s}^2 \].

6. (a) \( V = \sqrt{(3.0 \text{ km/h})^2 + (4.0 \text{ km/h})^2} = 5 \text{ km/h} \)
(b) To reach a destination directly across the river, paddle upstream at an angle that is more than 45
degrees to the straight-across direction. The resultant velocity will be less than 4 km/h. [Exact
calculation shows that the angle should be about 49 degrees to the straight-across direction (41 degrees
to the shore), giving a resultant velocity of 2.6 km/h across the river.]

SOLUTIONS TO CHAPTER 6

EXERCISES

12. The impulse required to stop the heavy truck is considerably more than the impulse required to stop a
skateboard moving with the same speed. The force required to stop either, however, depends on the time
during which it is applied. Stopping the skateboard in a split second results in a certain force. Apply less
than this amount of force on the moving truck and given enough time, the truck will come to a halt.

18. The momentum of recoil of the world is 10 kg·m/s. Again, this is not apparent because the mass of the
Earth is so enormous that its recoil velocity is imperceptible. (If the masses of Earth and person were
equal, both would move at equal speeds in opposite directions.)

24. The internal force of the brake brings the wheel to rest. But the wheel, after all, is attached to the tire
which makes contact with the road surface. It is the force of the road on the tires that stops the car.

28. If no momentum is imparted to the ball, no oppositely directed momentum will be imparted to the
thrower. Going through the motions of throwing has no net effect. If at the beginning of the throw you
begin recoiling backward, at the end of the throw when you stop the motion of your arm and hold onto
the ball, you stop moving too. Your position may change a little, but you end up at rest. No momentum
given to the ball means no recoil momentum gained by you.
32. Both recoiling carts have the same amount of momentum. So the cart with twice the mass will have half the speed of the less massive cart. That is, \(2m \left(\frac{v}{2}\right) = mv\).

36. For the system comprised of only the ball, momentum changes, and is therefore not conserved. But for the larger system of (ball + Earth), momentum is conserved for the impulses acting are internal impulses. The change of momentum of the ball is equal and opposite to the change of momentum of the recoiling Earth.

40. This exercise is similar to the previous one. If we consider Bronco to be the system, then a net force acts and momentum changes. In this case, momentum is not conserved. If, however we consider the system to be Bronco and the world (including the air), then all the forces that act are internal forces and momentum is conserved. Momentum is conserved only in systems not subject to external forces.

46. By Newton’s 3rd law, the force on the bug is equal in magnitude and opposite in direction to the force on the car windshield. The rest is logic: Since the time of impact is the same for both, the amount of impulse is the same for both, which means they both undergo the same change in momentum. The change in momentum of the bug is evident because of its large change in speed. The same change in momentum of the considerably more massive car is not evident, for the change in speed is correspondingly very small. Nevertheless, the magnitude of \(m\Delta V\) for the bug is equal to \(M\Delta v\) for the car!

50. In terms of force: When Freddy lands on the skateboard it is brought up to the skateboard’s speed. This means a horizontal force provided by the board acts on the sand. By action-reaction, Freddy exerts a force on the board in the opposite direction—which slows the skateboard. In terms of momentum conservation: Since no external forces act in the horizontal direction, the momentum after the skateboard catches Freddy is equal to the momentum before. Since mass is added, velocity must decrease.

52. Momentum conservation is being violated. The momentum of the boat before the hero lands on it will be the same as the momentum of boat + hero after. The boat will slow down. If, for example, the masses of the hero and boat were the same, the boat should be slowed to half speed; \(mv_{\text{before}} = 2m \left(\frac{v}{2}\right)_{\text{after}}\). From an impulse-momentum point of view, when the hero makes contact with the boat, he is moved along with the boat by a friction force between his feet and the boat surface. The equal and opposite friction force on the boat surface provides the impulse that slows the boat. (Here we consider only horizontal forces and horizontal component of momentum.)

56. Impulse is greater for reflection, which is in effect, bouncing. The vanes therefore recoil more from the silvered sides. The vanes in the sketch therefore rotate clockwise as viewed from above. (This rotation is superseded by a counter rotation when air is present, which is the case for most radiometers. The black surface absorbs radiation and is heated, which warms the nearby air. The surface is pushed away from the warmed air resulting in a recoil that spins the vanes counterclockwise.)

60. Agree with the first friend because after the collision the bowling ball will have a greater momentum than the golf ball. Note that before collision the momentum of the system of two balls is all in the moving golf ball. Call this +1 unit. Then after collision the momentum of the rebounding golf ball is nearly −1 unit. The momentum (not the speed) of the bowling ball will have to be nearly +2 units. Why? Because only then is momentum conserved. Momentum before is +1 unit: momentum after is \((+2 + 1) = +1\).

CHAPTER 6 PROBLEMS
2. From $Ft = \Delta mv$; $F = \frac{\Delta mv}{t} = \frac{(1000 \text{ kg})(20 \text{ m/s})}{10 \text{ s}} = 2000 \text{ N}$.

4. From the conservation of momentum,

Momentum$_{\text{dog}} = \text{momentum}_{\text{Judy} + \text{dog}}$

$(15 \text{ kg})(3.0 \text{ m/s}) = (40.0 \text{ kg} + 15 \text{ kg})v$

$45 \text{ kg} \cdot \text{m/s} = (55 \text{ kg})v$

$v = \frac{45 \text{ kg} \cdot \text{m/s}}{55 \text{ kg}} = 0.8 \text{ m/s}$

6. Let $m$ be the mass of the freight car, and $4m$ the mass of the diesel engine, and $v$ the speed after both have coupled together. Before collision, the total momentum is due only to the diesel engine, $4m(5 \text{ km/h})$, because the momentum of the freight car is 0. After collision, the combined mass is $(4m + m)$, and combined momentum is $(4m + m)v$. By the conservation of momentum equation:

$\text{Momentum}_{\text{before}} = \text{Momentum}_{\text{after}}$

$4m(5 \text{ km/h}) + 0 = (4m + m)v$

$20m \cdot \text{km/h} = (5m)v$

$v = \frac{(20m \cdot \text{km/h})}{5m} = 4 \text{ km/h}$

(Note that you don’t have to know $m$ to solve the problem.)

8. By momentum conservation, asteroid mass $\times 800 \text{ m/s} = \text{Superman's mass} \times v$.

Since asteroid’s mass is 1000 times Superman’s, $(1000m)(800 \text{ m/s}) = mv$.

$800,000m \cdot \text{m/s} = mv$

$v = \frac{800,000m \cdot \text{m/s}}{m} = 800,000 \text{ m/s}. \text{ This is nearly 2 million miles per hour!}$

10. (a) From $Ft = \Delta p = mv$; $F = \frac{mv}{t}$.

(b) $F = \frac{mv}{t} = \frac{(1 \text{ kg})(2 \text{ m/s})}{0.2 \text{ s}} = 10 \text{ kg} \cdot \text{m/s}^2 = 10 \text{ N}$

SOLUTIONS TO CHAPTER 7

EXERCISES

6. Work done by each is the same, for they reach the same height. The one who climbs in 30 s uses more power because work is done in a shorter time.

10. Agree, because speed itself is relative to the frame of reference (Chapter 3). Hence $\frac{1}{2}mv^2$ is also relative to a frame of reference.

14. Without the use of a pole, the KE of running horizontally cannot easily be transformed to gravitational PE. But bending a pole stores elastic PE in the pole, which can be transformed to gravitational PE. Hence the greater heights reached by vaulters with very elastic poles.
18. In accord with the theorem, once moving, no work is done on the satellite (because the gravitational force has no component parallel to motion), so no change in energy occurs. Hence the satellite cruises at a constant speed.

22. The string tension is everywhere perpendicular to the bob’s direction of motion, which means there is no component of tension along the bob’s path, and therefore no work done by the tension. The force of gravity, on the other hand, has a component along the direction of motion everywhere except at the bottom of the swing, and does work, which changes the bob’s KE.

26. When a Superball hits the floor some of its energy is transformed to heat. This means it will have less kinetic energy after the bounce than just before and will not reach its original level.

30. Both will have the same speed. This is easier to see here because both balls convert the same PE to KE. (Think energy when solving motion problems!)

32. Except for the very center of the plane, the force of gravity acts at an angle to the plane, with a component of gravitational force along the plane—along the block’s path. Hence the block goes somewhat against gravity when moving away from the central position, and moves somewhat with gravity when coming back. As the object slides farther out on the plane, it is effectively traveling “upward” against Earth’s gravity, and slows down. It finally comes to rest and then slides back and the process repeats itself. The block slides back and forth along the plane. From a flat-Earth point of view the situation is equivalent to that shown in the sketch.

38. Your friend may not realize that mass itself is congealed energy, so you tell your friend that much more energy in its congealed form is put into the reactor than is taken out from the reactor. About 1% of the mass that undergoes fission is converted to energy of other forms.

40. When we speak of work done, we must understand work done on what, by what. Work is done on the car by applied forces that originate in the engine. The work done by the road in reacting to the backward push of the tires is equal to the product of the applied force and the distance moved, not the net force that involves air resistance and other friction forces. When doing work, we think of applied force; when considering acceleration, we think of net force. Actually, the frictional forces of the internal mechanisms in the car, and to some extent the road itself are doing negative work on the car. The zero total work explains why the car’s speed doesn’t change.

42. The ball strikes the ground with the same speed, whether thrown upward or downward. The ball starts with the same energy at the same place, so they will have the same energy when they reach the ground. This means they will strike with the same speed. This is assuming negligible air resistance, for if air resistance is a factor, then the ball thrown upward will lose more energy to the air in its longer path and strike with somewhat less speed. Another way to look at this is to consider Figure 3.8 back on page 43; in the absence of air resistance, the ball thrown upward will return to its starting level with the same speed as the ball thrown downward. Both hit the ground at the same speed (but at different times).

46. If an object has KE, then it must have momentum—for it is moving. But it can have potential energy without being in motion, and therefore without having momentum. And every object has “energy of being”—stated in the celebrated equation $E = mc^2$. So whether an object moves or not, it has some form
of energy. If it has KE, then with respect to the frame of reference in which its KE is measured, it also has momentum.

52. Yes, if we’re talking about only you, which would mean your speed is zero. But a system of two or more objects can have zero net momentum, yet have substantial total KE.

56. There is more to the “swinging balls” problem than momentum conservation, which is why the problem wasn’t posed in the previous chapter. Momentum is certainly conserved if two balls strike with momentum $2mv$ and one ball pops out with momentum $m(2v)$. That is, $2mv = m2v$. We must also consider KE. Two balls would strike with $2(\frac{1}{2}mv^2) = mv^2$. The single ball popping out with twice the speed would carry away twice as much energy as was put in: $\frac{1}{2}m(2v)^2 = \frac{1}{2}m(4v^2) = 2mv^2$. This is clearly a conservation of energy no-no!

60. The rate at which energy can be supplied is more central to consumers than the amount of energy that may be available, so “power crisis” more accurately describes a short-term situation where demand exceeds supply. (In the long term, the world may be facing an energy crisis when supplies of fuel are insufficient to meet demand.)

64. As world population continues to increase, energy production must also increase to provide decent standards of living. Without peace, cooperation, and security, global-scale energy production likely decreases rather than increases.

CHAPTER 7 PROBLEMS

2. (a) You do $F \times d = 100 \text{ N} \times 10 \text{ m} = 1000 \text{ J}$ of work.
   (b) Because of friction, net work on the crate is less. $\Delta KE = \text{net work} = \text{net force} \times \text{distance} = (100 \text{ N} - 70 \text{ N})(10 \text{ m}) = 300 \text{ J}$
   (c) So the rest, 700 J, goes into heating the crate and floor.

4. PE + KE = Total E; KE = 10,000 J – 1000 J = 9000 J.

6. Your input work is 50 J, so $200 \text{ N} \times b = 50 \text{ J}$. $b = \frac{50 \text{ J}}{200 \text{ N}} = 0.25 \text{ m}$

8. $(F \times d)_{\text{in}} = (F \times d)_{\text{out}}$
   $(100 \text{ N} \times 10 \text{ cm})_{\text{in}} = (? \times 1 \text{ cm})_{\text{out}}$
   $? = \frac{(100 \text{ N} \times 10 \text{ cm})_{\text{in}}}{(1 \text{ cm})_{\text{out}}} = 1000 \text{ N}$

So we see that the output force and weight held is 1000 N (or less if the efficiency is less than 100%).

10. The initial PE of the banana is transformed to KE as it falls. When the banana is about to hit the water, all of its initial PE becomes KE. From $\text{PE}_0 = \text{KE}_0$, $mg_b = \frac{1}{2}mv^2$; $v^2 = \frac{2mgb}{m} = 2gb$; $v = \sqrt{2gb}$