KEY (Answers explained on following pages)

Ch. 2

1. A
2. D
3. C
4. C
5. A
6. D
7. C
8. B
9. C
10. E

ch. 3

1. B
2. D
3. A
4. C
5. A
6. E
7. E
8. D
9. D
10. A

ch. 6

1. E
2. B
3. C
4. D
8. A
9. E
10. C
11. D
13. E
15. B
16. B

ch. 4

1. A
2. B
3. B
4. C
5. A
6. D
7. D
8. E
9. E
10. D

ch. 5

1. C
2. C
3. E
4. D
5. B
6. D
7. C
8. E
9. D
10. C

CHAPTER 2 REVIEW QUESTIONS

Section I: Multiple Choice

1. **A** Traveling once around a circular path means that the final position coincides with the initial position. Therefore, the displacement is zero. The average speed, which is *total* distance traveled divided by elapsed time, cannot be zero. Since the velocity changed (because its direction changed), there was a nonzero acceleration. Therefore, only Statement I is true.

2. **D** Section 1 represents a constant positive speed. Section 2 shows an object slowing down, moving in the positive direction. Section 3 represents an object speeding up in the negative direction. Section 4 demonstrates a constant positive speed, and section 5 represents the correct answer: slowing down moving in the negative direction.

3. **C** Statement I is false since a projectile experiencing only the constant acceleration due to gravity can travel in a parabolic trajectory. Statement II is true: Zero acceleration means no change in speed (or direction). Statement III is false: An object whose speed remains constant but whose velocity vector is changing direction is accelerating.

4. **C** The baseball is still under the influence of Earth's gravity. Its acceleration throughout the *entire* flight is constant, equal to g downward.

5. **A** Use Big Five #3 with $v_0 = 0$:

$$x = x_0 + v_0 t + \frac{1}{2}at^2 = \frac{1}{2}at^2 = \frac{1}{2}at^2 \quad \Rightarrow \quad t = \sqrt{\frac{2\Delta x}{a}} = \sqrt{\frac{2(200\text{ m})}{5\text{ m/s}^2}} = 9\text{ s}$$

6. **D** Use Big Five #5 with $v_0 = 0$ (calling *down* the positive direction):

$$v^2 = v_0^2 + 2a(x - x_0) = 2a(x - x_0) \quad \Rightarrow \quad (x - x_0) = \frac{v^2}{2a} = \frac{v^2}{2g} = \frac{(30\text{ m/s})^2}{2(10\text{ m/s}^2)} = 45\text{ m}$$

7. **C** Apply Big Five #3 to the vertical motion, calling *down* the positive direction:

$$\Delta y = v_{0y}t + \frac{1}{2}a_y t^2 = \frac{1}{2}a_y t^2 = \frac{1}{2}gt^2 \quad \Rightarrow \quad t = \sqrt{\frac{2\Delta y}{g}} = \sqrt{\frac{2(80\text{ m})}{10\text{ m/s}^2}} = 4\text{ s}$$

Note that the stone's initial horizontal speed ($v_{0x} = 10$ m/s) is irrelevant.

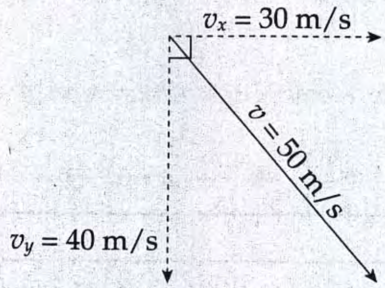
8. **B** First we determine the time required for the ball to reach the top of its parabolic trajectory (which is the time required for the vertical velocity to drop to zero).

$$v_y \overset{\text{set}}{=} 0 \quad \Rightarrow \quad v_{0y} - gt = 0 \quad \Rightarrow \quad t = \frac{v_{0y}}{g}$$

The total flight time is equal to twice this value:

$$t_t = 2t = 2\frac{v_{0y}}{g} = 2\frac{v_0 \sin\theta_0}{g} = \frac{2(10\text{ m/s})\sin 30°}{10\text{ m/s}^2} = 1\text{ s}$$

9. **C** After 4 seconds, the stone's vertical speed has changed by $\Delta v_y = a_y t = (10\ \text{m/s}^2)(4\ \text{s}) = 40\ \text{m/s}$. Since $v_{0y} = 0$, the value of v_y at $t = 4$ is 40 m/s. The horizontal speed does not change. Therefore, when the rock hits the water, its velocity has a horizontal component of 30 m/s and a vertical component of 40 m/s.



By the Pythagorean theorem, the magnitude of the total velocity, v, is 50 m/s.

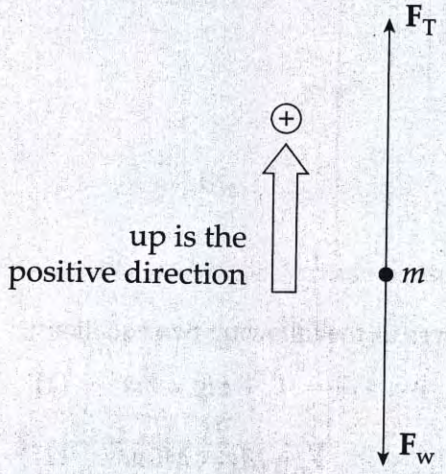
10. **E** Since the acceleration of the projectile is always downward (because it's gravitational acceleration), the vertical speed decreases as the projectile rises and increases as the projectile falls. Statements (A), (B), (C), and (D) are all false.

CHAPTER 3 REVIEW QUESTIONS

SECTION I: MULTIPLE CHOICE

1. **B** Because the person is not accelerating, the net force he feels must be zero. Therefore, the magnitude of the upward normal force from the floor must balance that of the downward gravitational force. Although these two forces have equal magnitudes, they do not form an action/reaction pair because they both act on the same object (namely, the person). The forces in an action/reaction pair always act on different objects.

2. **D** First draw a free-body diagram:



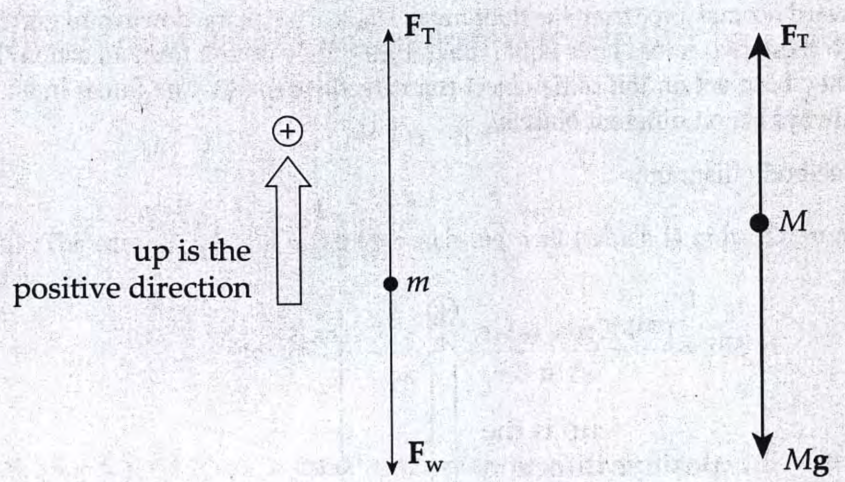
The person exerts a downward force on the scale, and the scale pushes up on the person with an equal (but opposite) force, $\mathbf{F}_N$. Thus, the scale reading is F_N, the magnitude of the normal force. Since $F_N - F_w = ma$, we have $F_N = F_w + ma = (800\text{ N}) + [800\text{ N}/(10\text{ m/s}^2)](5\text{ m/s}^2) = 1200\text{ N}$.

3. **A** The net force that the object feels on the inclined plane is $mg \sin\theta$, the component of the gravitational force that is parallel to the ramp. Since $\sin\theta = (5\text{ m})/(20\text{ m}) = 1/4$, we have $F_{net} = (2\text{ kg})(10\text{ N/kg})(1/4) = 5\text{ N}$.

4. **C** The net force on the block is $F - F_f = F - \mu_k F_N = F - \mu_k F_w = (18\text{ N}) - (0.4)(20\text{ N}) = 10\text{ N}$. Since $F_{net} = ma = (F_w/g)a$, we find that $10\text{ N} = [(20\text{ N})/(10\text{ m/s}^2)]a$, which gives $a = 5\text{ m/s}^2$.

5. **A** The force pulling the block down the ramp is $mg \sin\theta$, and the maximum force of static friction is $\mu_s F_N = \mu_s mg \cos\theta$. If $mg \sin\theta$ is greater than $\mu_s mg \cos\theta$, then there is a net force down the ramp, and the block will accelerate down. So, the question becomes, "Is $\sin\theta$ greater than $\mu_s \cos\theta$?" Since $\theta = 30°$ and $\mu_s = 0.5$, the answer is "yes."

6. **E** One way to attack this question is to notice that if the two masses happen to be equal, that is, if $M = m$, then the blocks won't accelerate (because their weights balance). The only expression given that becomes zero when $M = m$ is the one given in choice (E). If we draw a free-body diagram,



Newton's Second Law gives us the following two equations:

$$F_T - mg = ma \qquad (1)$$

$$F_T - Mg = M(-a) \qquad (2)$$

Subtracting these equations yields $Mg - mg = ma + Ma = (M + m)a$, so

$$a = \frac{Mg - mg}{M + m} = \frac{M - m}{M + m} g$$

7. **E** If $\mathbf{F}_{net} = \mathbf{0}$, then $\mathbf{a} = \mathbf{0}$. No acceleration means constant speed (possibly, but not necessarily, zero) with no change in direction. Therefore, statements (B), (C), and (D) are false, and statement (A) is not necessarily true.

8. **D** The horizontal motion across the frictionless tables is unaffected by (vertical) gravitational acceleration. It would take as much force to accelerate the block across the table on Earth as it would on the Moon. (If friction *were* taken into account, then the smaller weight of the block on the Moon would imply a smaller normal force by the table and hence a smaller frictional force. Less force would be needed on the Moon in this case.)

9. **D** The maximum force which static friction can exert on the crate is $\mu_s F_N = \mu_s F_w = \mu_s mg =$ (0.4)(100 kg)(10 N/kg) = 392 N. Since the force applied to the crate is only 344 N, static friction is able to apply that same magnitude of force on the crate, keeping it stationary. [Choice (B) is incorrect because the static friction force is *not* the reaction force to **F**; both **F** and $\mathbf{F}_{f\,(static)}$ act on the same object (the crate) and therefore cannot form an action/reaction pair.]

10. **A** With Crate #2 on top of Crate #1, the force pushing downward on the floor is greater, so the normal force exerted by the floor on Crate #1 is greater, which increases the friction force. Statements (B), (C), (D), and (E) are all false.

CHAPTER 6 REVIEW QUESTIONS

Section I: Multiple Choice

1. **E** Neither the velocity nor the acceleration is constant because the direction of each of these vectors is always changing as the object moves along its circular path. And the net force on the object is not zero, because a centripetal force must be acting to provide the necessary centripetal acceleration to maintain the object's circular motion.

2. **B** When the bucket is at the lowest point in its vertical circle, it feels a tension force $\mathbf{F}_T$ upward and the gravitational force $\mathbf{F}_w$ downward. The net force toward the center of the circle, which is the centripetal force, is $F_T - F_w$. Thus,

$$F_T - F_w = m\frac{v^2}{r} \Rightarrow v = \sqrt{\frac{r(F_T - mg)}{m}} = \sqrt{\frac{(0.60 \text{ m})[50 \text{ N} - (3 \text{ kg})(10 \text{ N/kg})]}{3 \text{ kg}}} = 2 \text{ m/s}$$

3. **C** When the bucket reaches the topmost point in its vertical circle, the forces acting on the bucket are its weight, $\mathbf{F}_w$, and the downward tension force, $\mathbf{F}_T$. The net force, $\mathbf{F}_w + \mathbf{F}_T$, provides the centripetal force. In order for the rope to avoid becoming slack, $\mathbf{F}_T$ must not vanish. Therefore, the cut-off speed for ensuring that the bucket makes it around the circle is the speed at which $\mathbf{F}_T$ just becomes zero; any greater speed would imply that the bucket would make it around. Thus,

$$F_w + F_T = m\frac{v^2}{r} \Rightarrow F_w + 0 = m\frac{v^2_{\text{cut-off}}}{r} \Rightarrow v_{\text{cut-off}} = \sqrt{\frac{rF_w}{m}} = \sqrt{gr}$$

$$= \sqrt{(10 \text{ m/s}^2)(0.60 \text{ m})}$$

$$= 2.4 \text{ m/s}$$

4. **D** Centripetal acceleration is given by the equation $a_c = v^2/r$. Since the object covers a distance of $2\pi r$ in 1 revolution, its speed is $2\pi r\ s^{-1}$. Therefore,

$$a_c = \frac{v^2}{r} = \frac{(2\pi r\ s^{-1})^2}{r} = 4\pi^2 r\ s^{-2}$$

8. **A** Gravitational force obeys an inverse-square law: $F_{\text{grav}} \propto 1/r^2$. Therefore, if r increases by a factor of 2, then F_{grav} decreases by a factor of $2^2 = 4$.

9. **E** Mass is an intrinsic property of an object and does not change with location. This eliminates choices (A) and (C). If an object's height above the surface of the earth is equal to $2R_E$, then its distance from the center of the earth is $3R_E$. Thus, the object's distance from the earth's center increases by a factor of 3, so its weight decreases by a factor of $3^2 = 9$.

10. **C** The gravitational force that the Moon exerts on the planet is equal in magnitude to the gravitational force that the planet exerts on the Moon (Newton's Third Law).

11. **D** The gravitational acceleration at the surface of a planet of mass M and radius R is given by the equation $g = GM/R^2$. Therefore, for the dwarf planet Pluto:

$$g_{\text{Pluto}} = G\frac{M_{\text{Pluto}}}{R_{\text{Pluto}}^2} = G\frac{\frac{1}{500}M_{\text{Earth}}}{\left(\frac{1}{15}R_{\text{Earth}}\right)^2} = \frac{15^2}{500}\cdot G\frac{M_{\text{Earth}}}{R_{\text{Earth}}^2} = \frac{225}{500}(10\,g^{\text{m/s}^2}) = \frac{225}{50}\,\text{m/s}^2$$

13. **E** The gravitational pull by Jupiter provides the centripetal force on its moon:

$$G\frac{Mm}{R^2} = \frac{mv^2}{R}$$

$$G\frac{M}{R} = v^2$$

$$= \left(\frac{2\pi R}{T}\right)^2$$

$$= \frac{4\pi^2 R^2}{T^2}$$

$$M = \frac{4\pi^2 R^3}{GT^2}$$

15. **B** Because the planet is spinning clockwise and the velocity is tangent to the circle, the velocity must point down. The acceleration and force point toward the center of the circle.

16. **B** If there were no forces or balanced forces in and out the satellite would have a net force of zero. If the net force were zero, the satellite would continue in a straight line and not orbit the planet.

CHAPTER 4 REVIEW QUESTIONS

SECTION I: MULTIPLE CHOICE

1. **A** Since the force **F** is perpendicular to the displacement, the work it does is zero.

2. **B** By the work–energy theorem,

$$W = \Delta K = \frac{1}{2}m(v^2 - v_0^2) = \frac{1}{2}(4\text{ kg})[(6\text{ m/s})^2 - (3\text{ m/s})^2] = 54\text{ J}$$

3. **B** Since the box (mass m) falls through a vertical distance of h, its gravitational potential energy decreases by mgh. The length of the ramp is irrelevant here.

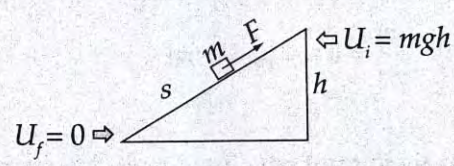
4. **C** Since the centripetal force always points along a radius toward the center of the circle, and the velocity of the object is always tangent to the circle (and thus perpendicular to the radius), the work done by the centripetal force is zero. Alternatively, since the object's speed remains constant, the work–energy theorem tells us that no work is being performed.

5. **A** The gravitational force points downward while the book's displacement is upward. Therefore, the work done by gravity is $-mgh = -(2\text{ kg})(10\text{ N/kg})(1.5\text{ m}) = -30\text{ J}$.

6. **D** The work done by gravity as the block slides down the inclined plane is equal to the potential energy at the top (mgh).

$$mgh = W = \Delta K = \frac{1}{2}m(v^2 - v_0^2) = \frac{1}{2}mv^2 \quad \Rightarrow \quad v = \sqrt{2gh} = \sqrt{2(10)(6.4)(\sin 30^\circ)} = 8\text{ m/s}$$

7. **D** Since a nonconservative force (namely, friction) is acting during the motion, we use the modified Conservation of Mechanical Energy equation.



$$K_i + U_i + W_{friction} = K_i + U_f$$
$$0 + mgh - Fs = K_f + 0$$
$$mgh - Fs = K_f$$

8. **E** Apply Conservation of Mechanical Energy (including the negative work done by $\mathbf{F}_r$, the force of air resistance):

$$K_i + U_i + W_r = K_f + U_f$$
$$0 + mgh - F_r h = \frac{1}{2}mv^2 + 0$$
$$v = \sqrt{\frac{2h(mg - F_r)}{m}}$$
$$= \sqrt{\frac{2(40\text{ m})[(4\text{ kg})(10\text{ N/kg}) - 20\text{ N}]}{4\text{ kg}}}$$
$$= 20\text{ m/s}$$

9. **E** Because the rock has lost half of its gravitational potential energy, its kinetic energy at the half-way point is half of its kinetic energy at impact. Since K is proportional to v^2, if $K_{\text{at halfway point}}$ is equal to $\frac{1}{2}K_{\text{at impact}}$, then the rock's speed at the halfway point is $\sqrt{1/2} = 1/\sqrt{2}$ its speed at impact.

10. **D** Using the equation $P = Fv$, we find that $P = (200\text{ N})(2\text{ m/s}) = 400\text{ W}$.

CHAPTER 5 REVIEW QUESTIONS

Section I: Multiple Choice

1. **C** The magnitude of the object's linear momentum is $p = mv$. If $p = 6$ kg · m/s and $m = 2$ kg, then $v = 3$ m/s. Therefore, the object's kinetic energy is $K = \frac{1}{2}mv^2 = \frac{1}{2}(2\text{ kg})(3\text{ m/s})^2 = 9$ J.

2. **C** The impulse delivered to the ball, $J = F\Delta t$, equals its change in momentum. Since the ball started from rest, we have

$$F\Delta t = mv \quad \Rightarrow \quad \Delta t = \frac{mv}{F} = \frac{(0.5\text{ kg})(4\text{ m/s})}{20\text{ N}} = 0.1\text{ s}$$

3. **E** The impulse delivered to the ball, $J = \bar{F}\Delta t$, equals its change in momentum. Thus,

$$\bar{F}\Delta t = \Delta p = p_f - p_i = m(v_f - v_i) \quad \Rightarrow \quad \bar{F} = \frac{m(v_f - v_i)}{\Delta t} = \frac{(2\text{ kg})(8\text{ m/s} - 4\text{ m/s})}{0.5\text{ s}} = 16\text{ N}$$

4. **D** The impulse delivered to the ball is equal to its change in momentum. The momentum of the ball was $m\mathbf{v}$ before hitting the wall and $m(-\mathbf{v})$ after. Therefore, the change in momentum is $m(-\mathbf{v}) - m\mathbf{v} = -2m\mathbf{v}$, so the magnitude of the momentum change (and the impulse) is $2mv$.

5. **B** By definition of *perfectly inelastic*, the objects move off together with one common velocity, $\mathbf{v}'$, after the collision. By Conservation of Linear Momentum,

$$\begin{aligned} m_1\mathbf{v}_1 + m_2\mathbf{v}_2 &= (m_1 + m_2)\mathbf{v}' \\ \mathbf{v}' &= \frac{m_1v_1 + m_2v_2}{m_1 + m_2} \\ &= \frac{(3\text{ kg})(2\text{ m/s}) + (5\text{ kg})(-2\text{ m/s})}{3\text{ kg} + 5\text{ kg}} \\ &= -0.5\text{ m/s} \end{aligned}$$

6. **D** First, apply Conservation of Linear Momentum to calculate the speed of the combined object after the (perfectly inelastic) collision:

$$\begin{aligned} m_1v_1 + m_2v_2 &= (m_1 + m_2)v' \\ v' &= \frac{m_1v_1 + m_2v_2}{m_1 + m_2} \\ &= \frac{m_1v_1 + (2m_1)(0)}{m_1 + 2m_1} \\ &= \frac{1}{3}v_1 \end{aligned}$$

Therefore, the ratio of the kinetic energy after the collision to the kinetic energy before the collision is

$$\frac{K'}{K} = \frac{\frac{1}{2}m'v'^2}{\frac{1}{2}m_1v_1^2} = \frac{\frac{1}{2}(m_1 + 2m_1)(\frac{1}{3}v_1)^2}{\frac{1}{2}m_1v_1^2} = \frac{1}{3}$$

7. **C** Total linear momentum is conserved in a collision during which the net external force is zero. If kinetic energy is lost, then by definition, the collision is not elastic.

8. **E** Because the two carts are initially at rest, the initial momentum is zero. Therefore, the final total momentum must be zero.

9. **D** The linear momentum of the bullet must have the same magnitude as the linear momentum of the block in order for their combined momentum after impact to be zero. The block has momentum MV to the left, so the bullet must have momentum MV to the right. Since the bullet's mass is m, its speed must be $v = MV/m$.

10. **C** In a perfectly inelastic collision, kinetic energy is never conserved; some of the initial kinetic energy is always lost to heat and some is converted to potential energy in the deformed shapes of the objects as they lock together.