Physics for Scientists and Engineers, 4e **(Giancoli)**

Chapter 5 Using Newton's Laws: Friction, Circular Motion, Drag Forces

5.1 Conceptual Questions

1) Is it possible for an object moving with a constant speed to accelerate? Explain.
Answer: Yes, although the speed is constant, the direction of the velocity can be changing.
Diff: 1 Page Ref: Sec. 5-2

2) An airplane is flying with constant speed along a horizontal circle. Is the direction of its acceleration constant?
Answer: No. The acceleration is directed towards the center of the circle, so the acceleration vector rotates as the body rotates.
Diff: 1 Page Ref: Sec. 5-2

3) Why does a cyclist tilt her bicycle on a curve?
Answer: In order to make the force of the seat normal to the seat. The seat has to provide a vertical force equal to her weight and a horizontal centripetal force that keeps her going around the curve. The resultant is inclined at an angle, and if the bicycle is tilted at that angle she will not feel a tendency to slide off the seat.
Diff: 1 Page Ref: Sec. 5-4

4) The force of friction between two surfaces is independent of the area of contact between the surfaces.
Answer: TRUE
Diff: 1 Page Ref: Sec. 5-1

5) The coefficient of static friction is always larger than the coefficient of kinetic friction.
Answer: TRUE
Diff: 1 Page Ref: Sec. 5-1

6) The force of static friction between two surfaces is parallel to the surface of contact, and in the direction that opposes relative motion.
Answer: TRUE
Diff: 1 Page Ref: Sec. 5-1

7) It is often easier to keep a heavy object sliding than it is to start it sliding in the first place.
Answer: TRUE
Diff: 1 Page Ref: Sec. 5-1

8) In problems involving a slope or inclined plane, the normal force is always perpendicular to the slope or the plane.
Answer: TRUE
Diff: 1 Page Ref: Sec. 5-1

9) In problems involving a slope or inclined plane, the force due to gravity is always perpendicular to the slope or the plane.
Answer: FALSE
Diff: 1 Page Ref: Sec. 5-1

10) A body moving with constant speed cannot be accelerating.
Answer: FALSE
Diff: 1 Page Ref: Sec. 5-2

11) For uniform circular motion, the velocity and acceleration vectors are perpendicular to each other at every point in the path.
Answer: TRUE
Diff: 1 Page Ref: Sec. 5-2

12) A net horizontal force is required for a body to move in a horizontal circle.
Answer: TRUE
Diff: 1 Page Ref: Sec. 5-3

13) The banking angle for a properly banked curve does not depend on the mass of the car going over it.
Answer: TRUE
Diff: 1 Page Ref: Sec. 5-4

14) The banking of curves increases the chance of skidding.
Answer: FALSE
Diff: 1 Page Ref: Sec. 5-4

15) When a curve is properly banked a passenger in a car traveling on it at the designed speed does not feel a lateral force.
Answer: TRUE
Diff: 1 Page Ref: Sec. 5-4

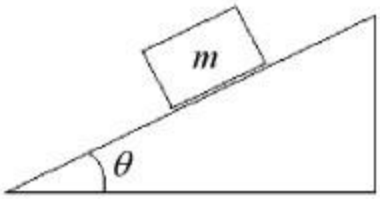
16) Nonuniform circular motion occurs when the net force on an object is exerted toward the center of the circular path the object is following.
Answer: FALSE
Diff: 1 Page Ref: Sec. 5-5

17) The drag force is independent of the velocity of the object.
Answer: FALSE
Diff: 1 Page Ref: Sec. 5-6

18) Its more difficult to start moving a heavy carton from rest than it is to keep pushing it with constant velocity, because
A) The normal force is greater when the carton is at rest.
B) $\mu_s < \mu_k$.
C) Initially, the normal force is not perpendicular to the applied force.
D) $\mu_k < \mu_s$.
E) $\mu_s = \mu_k$.
Answer: D
Diff: 1 Page Ref: Sec. 5-1

19) A packing crate slides down an inclined ramp at constant velocity. Thus we can deduce that
A) a frictional force is acting on it.
B) a net downward force is acting on it.
C) a net upward force is acting on it.
D) it is not acted on by appreciable normal force.
E) it is not acted on by appreciable gravitational force.
Answer: A
Diff: 1 Page Ref: Sec. 5-1

FIGURE 5-1



20) In Fig. 5-1, the block of mass m is at rest on an inclined plane that makes an angle θ with the horizontal. The force of static friction f must be such that

A) $f > mg$. B) $f > mg\cos\theta$. C) $f > mg\sin\theta$. D) $f = mg\cos\theta$. E) $f = mg\sin\theta$.

Answer: E

Diff: 2 Page Ref: Sec. 5-1

21) For an object that travels at a fixed speed along a circular path, the acceleration of the object is

A) larger in magnitude the smaller the radius of the circle.
B) in the same direction as the velocity of the object.
C) smaller in magnitude the smaller the radius of the circle.
D) in the opposite direction of the velocity of the object.
E) zero.

Answer: A

Diff: 1 Page Ref: Sec. 5-2

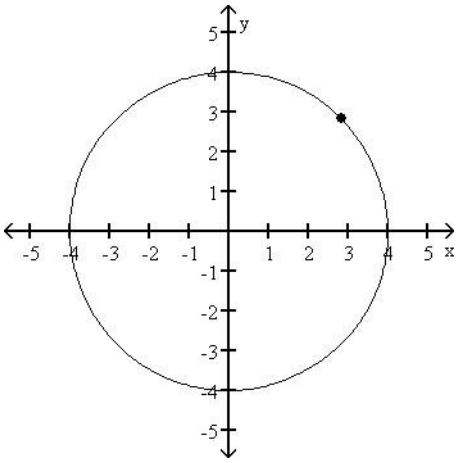
22) What type of acceleration does an object moving with constant speed in a circular path experience?

A) free fall.
B) terminal acceleration.
C) constant acceleration.
D) linear acceleration.
E) centripetal acceleration.

Answer: E

Diff: 1 Page Ref: Sec. 5-2

FIGURE 5-2



23) Fig. 5-2 indicates the current position of an object traveling at constant speed clockwise around the circle. Which arrow best represent the direction of the current acceleration of the object?

A)  B)  C)  D)  E) 

Answer: D
Diff: 1 Page Ref: Sec. 5-2

24) When an object experiences uniform circular motion, the direction of the acceleration is
A) in the same direction as the velocity vector.
B) in the opposite direction of the velocity vector.
C) is directed toward the center of the circular path.
D) is directed away from the center of the circular path.
E) depends on the speed of the object.
Answer: C
Diff: 1 Page Ref: Sec. 5-2

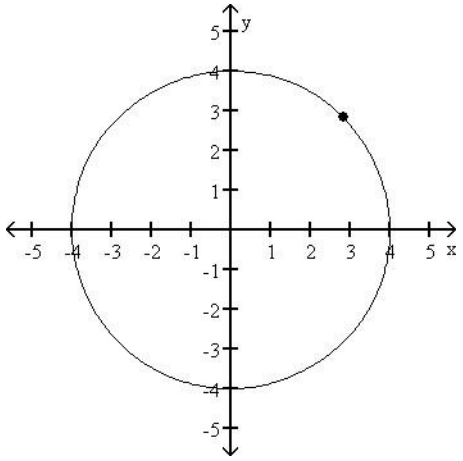
25) Consider a particle moving with constant speed such that its acceleration of constant magnitude is always perpendicular to its velocity.
A) It is moving in a straight line.
B) It is moving in a circle.
C) It is moving in a parabola.
D) It is moving in a hyperbola.
E) None of the above is definitely true all of the time.
Answer: B
Diff: 2 Page Ref: Sec. 5-2

26) What force is needed to make an object move in a circle?
A) kinetic friction
B) static friction
C) centripetal force
D) weight
E) tension
Answer: C
Diff: 1 Page Ref: Sec. 5-3

27) When an object experiences uniform circular motion, the direction of the net force is
A) in the same direction as the motion of the object.
B) in the opposite direction of the motion of the object.
C) is directed toward the center of the circular path.
D) is directed away from the center of the circular path.
E) is dependent on the speed of the object.
Answer: C
Diff: 1 Page Ref: Sec. 5-3

28) When an object moves at constant speed on a circular path, which of the following is true?
A) A net force pointing along the direction of motion acts on the object.
B) A net force pointing along the opposite direction of motion acts on the object.
C) A net force pointing away from the center of the circle acts on the object.
D) A net force pointing towards the center of the circle acts on the object.
E) The net force acting on the object is zero.
Answer: D
Diff: 1 Page Ref: Sec. 5-3

FIGURE 5-2



29) Fig. 5-2 indicates the current position of an object traveling at constant speed clockwise around the circle. Which arrow best represent the direction the object would travel if the centripetal force was suddenly reduced to zero?

A) 
B) 
C) 
D) 
E) 

Answer: A
Diff: 1 Page Ref: Sec. 5-3

30) As a car drives with its tires rolling freely without any slippage, the type of friction acting between the tires and the road is
A) static friction.
B) kinetic friction.
C) a combination of static and kinetic friction.
D) neither static nor kinetic friction, but some other type of friction.
E) It is impossible to tell what type of friction acts in this situation.
Answer: A
Diff: 1 Page Ref: Sec. 5-4

31) A car goes around a curve at a constant speed. What is the direction of the net force on the car?
A) toward the curve's center
B) away from the curve's center
C) toward the front of the car
D) toward the back of the car
E) the net force is zero
Answer: A
Diff: 2 Page Ref: Sec. 5-4

32) A car of mass m goes around a banked curve of radius r with speed v. If the road is frictionless due to ice, the car can still negotiate the curve if the horizontal component of the normal force on the car from the road is equal in magnitude to
A) mg/2. B) mg. C) mg $\sin\theta$. D) mv^2/r. E) $\tan[v^2/(rg)]$.
Answer: D
Diff: 2 Page Ref: Sec. 5-4

33) The banking angle in a turn on the Olympic bobsled track is not constant, but increases upward from the horizontal. Coming around a turn, the bobsled team will intentionally "climb the wall," then go lower coming out of the turn. Why do they do this?
A) to give the team better control, because they are able to see ahead of the turn
B) to prevent the bobsled from turning over
C) to take the turn at a faster speed
D) to take the turn at a slower speed
E) to reduce the g-force on them
Answer: C
Diff: 2 Page Ref: Sec. 5-4

34) Is it possible for an object moving around a circular path to have both centripetal and tangential acceleration?
A) No, because then the path would not be a circle.
B) No, an object can only have one or the other at any given time.
C) Yes, this is possible if the speed is constant.
D) Yes, this is possible if the speed is changing.
Answer: D
Diff: 2 Page Ref: Sec. 5-5

35) When a parachutist jumps from an airplane, he eventually reaches a constant speed, called the terminal velocity. This means that
A) the acceleration is equal to *g*.
B) the force of air resistance is equal to zero.
C) the effect of gravity has died down.
D) the effect of gravity increases as he becomes closer to the ground.
E) the force of air resistance is equal to the weight of the parachutist.
Answer: E
Diff: 1 Page Ref: Sec. 5-6

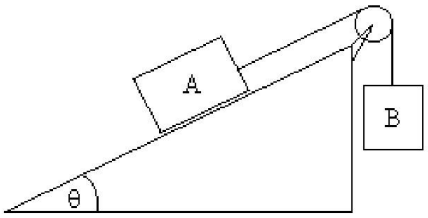
36) For very small objects at very low speeds, the drag force is directly proportional to the magnitude of the velocity. The proportionality constant depends on
A) the viscosity of the fluid.
B) the size of the object.
C) the shape of the object.
D) all of the above choices.
E) none of the above choices.
Answer: D
Diff: 2 Page Ref: Sec. 5-6

5.2 Quantitative Problems

1) A 55.0-kg box rests on a horizontal surface. The coefficient of static friction between the box and the surface is 0.300. What horizontal force must be applied to the box for it to start sliding along the surface?
Answer: 162 N
Diff: 1 Page Ref: Sec. 5-1

2) A 55-kg box rests on a horizontal surface. The coefficient of static friction between the box and the surface is 0.30. A 140-N force is applied to the box. What is the frictional force on the box?
Answer: 140 N
Diff: 1 Page Ref: Sec. 5-1

FIGURE 5-3

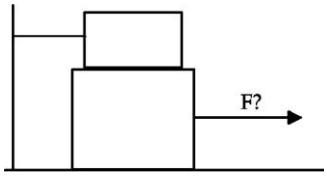


3) Two masses are connected by a string which goes over an ideal pulley as shown in Fig. 5-3. Block A has a mass of 3.00 kg and can slide along a rough plane inclined 30.0° to the horizontal. The coefficient of static friction between block A and the plane is 0.400. What mass should block B have in order to start block A sliding up the ramp?
Answer: 2.54 kg
Diff: 3 Page Ref: Sec. 5-1

4) A 60.0-kg mass person wishes to push a 100-kg mass box across a level floor. The coefficient of static friction between the person's shoes and the floor is 0.700. What is the maximum coefficient of static friction between the box and the floor such that the person can push horizontally on the box and cause it to start moving?
A) 0.375 B) 0.600 C) 0.420 D) 0.625 E) 0.700
Answer: C
Diff: 1 Page Ref: Sec. 5-1

5) A child pulls a 3.00-kg sled across level ground at constant velocity with a light rope that makes an angle 34.0° above horizontal. The tension in the rope is 5.00 N. Assuming the acceleration of gravity is 9.81 m/s^2, what is the coefficient of friction between the sled and the ground?
A) 0.156 B) 0.188 C) 0.0441 D) 0.0851 E) 0.103
Answer: A
Diff: 2 Page Ref: Sec. 5-1

FIGURE 5-4



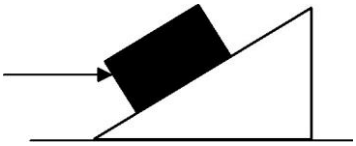
6) A 4.00-kg block rests between the floor and a 3.00-kg block as shown in Fig. 5-4. The 3.00-kg block is tied to a wall by a horizontal rope. If the coefficient of static friction is 0.800 between each pair of surfaces in contact, what force must be applied horizontally to the 4.00-kg block to make it move?

A) 16.2 N B) 54.9 N C) 21.1 N D) 23.5 N E) 78.5 N

Answer: E

Diff: 2 Page Ref: Sec. 5-1

FIGURE 5-5



7) A 4.00-kg block rests on a 30.0 degree incline as shown in Fig. 5-5. If the coefficient of static friction between the block and the incline is 0.700, with what magnitude force must a horizontal force act on the block to start it moving up the incline?

A) 34.0 N B) 51.1 N C) 54.7 N D) 84.1 N E) 76.4 N

Answer: D

Diff: 2 Page Ref: Sec. 5-1

8) A 4.00-kg block is sliding up the plane on a 30.0 degree incline as shown in Fig. 5-5. If the coefficient of kinetic friction between the block and the incline is 0.700, what will be the acceleration of the block if a 50.0-N horizontal force pushes on the block?

A) 4.40 m/s^2 down the incline
B) 12.5 m/s^2 up the incline
C) 0.107 m/s^2 down the incline
D) 10.8 m/s^2 up the incline
E) 3.88 m/s^2 up the incline

Answer: A

Diff: 2 Page Ref: Sec. 5-1

9) A box is sliding down an incline tilted at an angle 14.0° above horizontal. The box is sliding down the incline at a speed of 1.70 m/s. The coefficient of kinetic friction between the box and the incline is 0.380. How far does the box slide down the incline before coming to rest?

A) 1.16 m
B) 2.33 m
C) 1.78 m
D) 0.720 m
E) The box does not stop. It accelerates down the plane.

Answer: A

Diff: 2 Page Ref: Sec. 5-1

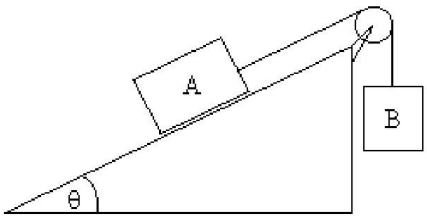
10) A 50.0-kg block is being pulled up a 13.0° slope by a force of 250 N which is parallel to the slope. The coefficient of kinetic friction between the block and the slope is 0.200. What is the acceleration of the block?

A) 0.528 m/s^2 B) 0.158 m/s^2 C) 0.833 m/s^2 D) 0.983 m/s^2 E) 0.260 m/s^2

Answer: C

Diff: 3 Page Ref: Sec. 5-1

FIGURE 5-6



11) Two masses are connected by a string which goes over an ideal pulley as shown in Fig. 5-6. Block A has a mass of 3.00 kg and can slide along a rough plane inclined 30.0° to the horizontal. The coefficient of kinetic friction between block A and the plane is 0.400. Block B has a mass of 2.77 kg. What is the acceleration of the blocks?

A) 0.392 m/s^2 B) 1.96 m/s^2 C) 3.12 m/s^2 D) 5.35 m/s^2 E) 0 m/s^2

Answer: A

Diff: 3 Page Ref: Sec. 5-1

12) A 2-kg ball is moving with a constant speed of 5 m/s in a horizontal circle whose radius is 50 cm. What is the acceleration of the ball?

A) 0 m/s^2 B) 10 m/s^2 C) 20 m/s^2 D) 50 m/s^2 E) 500 m/s^2

Answer: D

Diff: 1 Page Ref: Sec. 5-2

13) A ball is tied to the end of a cable of negligible mass. The ball is spun in a circle with a radius 2.00 m making 0.700 revolutions per second. What is the centripetal acceleration of the ball?

A) 67.9 m/s B) 38.7 m/s^2 C) 29.3 m/s D) 14.8 m/s E) 74.2 m/s

Answer: B

Diff: 2 Page Ref: Sec. 5-2

14) A 2-kg ball is moving with a constant speed of 5 m/s in a horizontal circle whose radius is 50 cm. What is the magnitude of the net force on the ball?

A) 0 N B) 20 N C) 40 N D) 50 N E) 100 N

Answer: E

Diff: 1 Page Ref: Sec. 5-3

15) A child stands on a playground merry-go-round a distance of 1.50 m from the rotation axis. The coefficient of static friction between the child's shoes and the surface of the merry-go-round is 0.700. Assuming the acceleration of gravity is 9.81 m/s^2, what is the maximum constant angular speed of the merry-go-round for which the child will not start to slide?

A) 6.45 rad/s
B) 1.32 rad/s
C) 2.14 rad/s
D) 4.58 rad/s
E) 8.32 rad/s

Answer: C

Diff: 1 Page Ref: Sec. 5-3

16) A car travels around 200 m radius flat curve at 40 m/s at constant speed. What is the minimum static coefficient of friction which allows it to travel at this speed without sliding?
A) 1.23 B) 0.815 C) 0.736 D) 0.952 E) 0.662
Answer: B
Diff: 2 Page Ref: Sec. 5-4

17) A car enters a 300-m radius flat curve on a rainy day when the coefficient of static friction between its tires and the road is 0.600. What is the maximum speed which the car can travel around the curve without sliding?
A) 29.6 m/s B) 33.1 m/s C) 24.8 m/s D) 42.0 m/s E) 37.9 m/s
Answer: D
Diff: 2 Page Ref: Sec. 5-4

18) A car drives over a hilltop that has a radius of curvature 120 m at the top of the hill. At what speed would the car be traveling when it tires just barely lose contact with the road when the car is at the top of the hill?
A) 45.5 m/s B) 41.8 m/s C) 34.3 m/s D) 22.2 m/s E) 27.6 m/s
Answer: C
Diff: 2 Page Ref: Sec. 5-4

19) An airplane is flying with constant speed of 300 m/s along a horizontal circle with a radius of 15,000 m. If the lift force of the air on the wings is perpendicular to the wings, at what angle relative to the horizontal should the wings be banked?
A) 15.1° B) 22.2° C) 31.5° D) 37.7° E) 63.0°
Answer: C
Diff: 2 Page Ref: Sec. 5-4

20) A 1000-kg car is picking up speed as it goes around a horizontal curve whose radius is 100 m. The coefficient of static friction between the tires and the road is 0.350. At what speed will the car begin to skid sideways?
A) 9.25 m/s B) 23.6 m/s C) 34.3 m/s D) 35.0 m/s E) 18.5 m/s
Answer: E
Diff: 2 Page Ref: Sec. 5-4

21) A 600-kg car is going around a banked curve with a radius of 110 m at a speed of 27.5 m/s. What is the appropriate banking angle so that the car stays on its path without the assistance of friction?
A) 35.0° B) 13.5° C) 33.8° D) 56.2° E) 60.9°
Answer: A
Diff: 2 Page Ref: Sec. 5-4

22) A 600-kg car is going around a curve with a radius of 120 m that is banked at an angle of 20° with a speed of 24.5 m/s. What is the minimum coefficient of static friction required for the car not to skid?
A) 0.12 B) 0.24 C) 0.36 D) 0.48 E) 0.60
Answer: A
Diff: 3 Page Ref: Sec. 5-4

23) A 600-kg car is going around a curve with a radius of 120 m that is banked at an angle of 25.0° with a speed of 30.0 m/s. The coefficient of static friction between the car and the road is 0.300. What is the force exerted by friction on the car?
A) 1590 N B) 3430 N C) 7240 N D) 7820 N E) 795 N
Answer: A
Diff: 3 Page Ref: Sec. 5-4

24) A 600-kg car is going over a curve with a radius of 120 m that is banked at an angle of 25° with a speed of 30.0 m/s. The coefficient of static friction between the car and the road is 0.30. What is the normal force exerted by the road on the car?

A) 1590 N B) 3430 N C) 3620 N D) 7240 N E) 5330 N

Answer: D

Diff: 3 Page Ref: Sec. 5-4

25) A race car enters a flat 200-m radius curve at a speed of 20.0 m/s while increasing its speed at a constant 2.00 m/s^2. If the coefficient of static friction is 0.700, what will the speed of the car be when the car begins to slide?

A) 36.2 m/s B) 24.3 m/s C) 37.1 m/s D) 28.7 m/s E) 31.5 m/s

Answer: A

Diff: 2 Page Ref: Sec. 5-5

26) The magnitude of the drag force on a 20.0-kg object is proportional to its speed. The object has a terminal velocity 80 m/s. What is the magnitude of the drag force on the object when it is falling with a speed 30 m/s?

A) 196 N B) 7.50 N C) 15.0 N D) 73.6 N E) 42.7 N

Answer: D

Diff: 1 Page Ref: Sec. 5-6

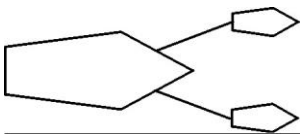
27) A 30.0-kg object has a drag force with a magnitude proportional to the square of its speed. The object falls with an acceleration 4.00 m/s^2 downward when it is falling downward at 70.0 m/s. What is its terminal velocity?

A) 110 m/s B) 157 m/s C) 91.0 m/s D) 172 m/s E) 108 m/s

Answer: C

Diff: 1 Page Ref: Sec. 5-6

FIGURE 5-7



28) A ship is being pulled through a harbor by two tug boats at constant velocity as shown in Fig. 5-7. The lines attached to the two tug boats have the same tension, 200,000 N. The lines each make an angle 28.0° to the direction the ship is being towed. What is the magnitude of the drag force on the ship?

A) 177×10^5 N B) 1.88×10^5 N C) 93.9×10^4 N D) zero E) 3.53×10^5 N

Answer: E

Diff: 1 Page Ref: Sec. 5-6

29) An object is acted on by a drag force with a magnitude that is proportional to the speed. The object accelerates downward at 3.00 m/s^2 when it is falling with a speed 20.0 m/s. What is the terminal speed of the object as it is falling?

A) 38.1 m/s B) 55.9 m/s C) 28.8 m/s D) 65.4 m/s E) 43.2 m/s

Answer: C

Diff: 1 Page Ref: Sec. 5-6

30) What is the terminal velocity of a 6.00-kg mass object in falling with a drag force with a magnitude that depends on speed, v, as $F_{drag} = (30.0\ N{\cdot}s/m)v$?

A) 1.96 m/s B) 41.9 m/s C) 24.2 m/s D) 12.6 m/s E) 62.2 m/s

Answer: A

Diff: 1 Page Ref: Sec. 5-6

31) What is the terminal velocity of an 80.00-kg mass object in falling with a drag force with a magnitude that depends on speed, v, as $F_{\text{drag}} = (12.0\ \text{N·s/m})v + (4.00\ \text{N·s/m})v^2$?

A) 6.45 m/s B) 72.2 m/s C) 34.2 m/s D) 12.6 m/s E) 47.3 m/s

Answer: D

Diff: 2 Page Ref: Sec. 5-6

32) A 1.20-kg ball is hanging on the end of a rope. The rope makes an angle 25.0° from the vertical when a 15.0 m/s horizontal wind blows. If the wind's force on the rope is negligible, what is the drag force on the ball?

A) 32.3 N B) 24.1 N C) 3.68 N D) 5.49 N E) 11.8 N

Answer: D

Diff: 2 Page Ref: Sec. 5-6