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

Chapter 10 Rotational Motion

10.1 Conceptual Questions

1) A child is riding on a merry-go-round, which is accelerating. What is the relationship between the angular speed ω and the angular acceleration α of the merry-go-round when the tangential and centripetal accelerations of the child are equal?
Answer: $\alpha = \omega^2$
Diff: 1 Page Ref: Sec. 10-1

2) Can two different forces, acting through the same point, produce the same torque on an object?
Answer: Yes, as long as the component of the force perpendicular to the line joining the axis to the force is the same for both forces.
Diff: 1 Page Ref: Sec. 10-4

3) Jane says that the magnitude of the torque exerted by a force of magnitude F is equal to the perpendicular distance from the axis of rotation $r_\perp$ multiplied by F, while Jason insists that it is equal to the distance from the axis of rotation r multiplied by the magnitude of the perpendicular component of the force, $F_\perp$. Who is right?
Answer: They are both right. Both answers are equivalent to $\tau = F\, r \sin\theta$, where θ is the angle between the force and the radial line.
Diff: 1 Page Ref: Sec. 10-4

4) A hollow cylinder and a solid cylinder are constructed so they have the same mass and radius. Which cylinder has the larger moment of inertia?
Answer: the hollow cylinder
Diff: 1 Page Ref: Sec. 10-7

5) A car is traveling along a highway at 65 mph. Which point in the tires is moving forward at 65 mph?
Answer: the center of each tire
Diff: 1 Page Ref: Sec. 10-9

6) A car is traveling along a highway at 65 mph. What is the linear speed of the top of the tires? What is the linear speed at the bottom of the tires?
Answer: 130 mph; 0 mph
Diff: 1 Page Ref: Sec. 10-9

7) When a rigid body rotates about a fixed axis all the points in the body have the same angular displacement.
Answer: TRUE
Diff: 1 Page Ref: Sec. 10-1

8) When a rigid body rotates about a fixed axis all the points in the body have the same linear displacement.
Answer: FALSE
Diff: 1 Page Ref: Sec. 10-1

9) When a rigid body rotates about a fixed axis all the points in the body have the same angular speed.
Answer: TRUE
Diff: 1 Page Ref: Sec. 10-1

10) When a rigid body rotates about a fixed axis all the points in the body have the same tangential speed.
Answer: FALSE
Diff: 1 Page Ref: Sec. 10-1

11) When a rigid body rotates about a fixed axis all the points in the body have the same angular acceleration.
Answer: TRUE
Diff: 1 Page Ref: Sec. 10-1

12) When a rigid body rotates about a fixed axis all the points in the body have the same tangential acceleration.
Answer: FALSE
Diff: 1 Page Ref: Sec. 10-1

13) When a rigid body rotates about a fixed axis all the points in the body have the same centripetal acceleration.
Answer: FALSE
Diff: 1 Page Ref: Sec. 10-1

14) Mass can be considered concentrated at the center of mass for rotational motion.
Answer: FALSE
Diff: 1 Page Ref: Sec. 10-5

15) The parallel-axis theorem can be applied only to flat objects.
Answer: FALSE
Diff: 1 Page Ref: Sec. 10-7

16) The perpendicular-axis theorem can be applied to any object.
Answer: FALSE
Diff: 1 Page Ref: Sec. 10-7

17) Rolling without slipping depends on static friction between the rolling object and the ground.
Answer: TRUE
Diff: 1 Page Ref: Sec. 10-9

18) Consider a rigid body that is rotating. Which of the following is an accurate statement?
A) Its center of rotation is its center of gravity.
B) All points on the body are moving with the same angular velocity.
C) All points on the body are moving with the same linear velocity.
D) Its center of rotation is at rest, i.e., not moving.
E) Its center of rotation is accelerating.
Answer: B
Diff: 1 Page Ref: Sec. 10-1

19) Two children are riding on a merry-go-round. Child A is at a greater distance from the axis of rotation than child B. Which child has the larger angular displacement?
A) Child A
B) Child B
C) They have the same zero angular displacement.
D) They have the same non-zero angular displacement.
E) There is not enough information given to answer the question.
Answer: D
Diff: 1 Page Ref: Sec. 10-1

20) Two children are riding on a merry-go-round. Child A is at a greater distance from the axis of rotation than child B. Which child has the larger linear displacement?
A) Child A
B) Child B
C) They have the same zero linear displacement.
D) They have the same non-zero linear displacement.
E) There is not enough information given to answer the question.
Answer: A
Diff: 1 Page Ref: Sec. 10-1

21) Two children are riding on a merry-go-round. Child A is at a greater distance from the axis of rotation than child B. Which child has the larger angular speed?
A) Child A
B) Child B
C) They have the same zero angular speed.
D) They have the same non-zero angular speed.
E) There is not enough information given to answer the question.
Answer: D
Diff: 1 Page Ref: Sec. 10-1

22) Two children are riding on a merry-go-round. Child A is at a greater distance from the axis of rotation than child B. Which child has the larger tangential speed?
A) Child A
B) Child B
C) They have the same zero tangential speed.
D) They have the same non-zero tangential speed.
E) There is not enough information given to answer the question.
Answer: A
Diff: 1 Page Ref: Sec. 10-1

23) Two children are riding on a merry-go-round. Child A is at a greater distance from the axis of rotation than child B. Which child has the larger centripetal acceleration?
A) Child A
B) Child B
C) They have the same zero centripetal acceleration.
D) They have the same non-zero centripetal acceleration.
E) There is not enough information given to answer the question.
Answer: A
Diff: 1 Page Ref: Sec. 10-1

24) Two children are riding on a merry-go-round. Child A is at a greater distance from the axis of rotation than child B. Which child has the larger tangential acceleration?
A) Child A
B) Child B
C) They have the same zero centripetal acceleration.
D) They have the same non-zero centripetal acceleration.
E) There is not enough information given to answer the question.
Answer: A
Diff: 1 Page Ref: Sec. 10-1

25) A rigid body is rotating about a fixed axis through the origin. A point on the object located on the x-axis at time t is moving in the positive z direction. What is unit vector in the direction of the angular velocity of the body?

A) $\hat{i}$

B) j

C) $-j$

D) $-\hat{i}$

E) There is not enough information given to determine the answer.

Answer: C

Diff: 1 Page Ref: Sec. 10-2

26) A rigid body is rotating about a fixed axis through the origin. The angular velocity is ωk, where ω is positive. What is the unit vector in the direction of the velocity of a point on the body located on the positive y axis?

A) $-\hat{i}$

B) $-j$

C) $\hat{i}$

D) j

E) There is not enough information given to determine the answer.

Answer: A

Diff: 1 Page Ref: Sec. 10-2

27) As you are leaving a building, the door opens outward. If the hinges on the door are on your right, what is the direction of the angular velocity of the door as you open it?

A) up B) down C) to your left D) to your right E) forwards

Answer: B

Diff: 1 Page Ref: Sec. 10-2

28) When you ride a bicycle, in what direction is the angular velocity of the wheels?

A) to your left B) to your right C) forwards D) backwards E) up

Answer: A

Diff: 1 Page Ref: Sec. 10-2

29) If a constant net torque is applied to an object, that object will

A) rotate with constant linear velocity.

B) rotate with constant angular velocity.

C) rotate with constant angular acceleration.

D) having an increasing moment of inertia.

E) having a decreasing moment of inertia.

Answer: C

Diff: 1 Page Ref: Sec. 10-4

30) Two equal forces are applied to a door. The first force is applied at the midpoint of the door; the second force is applied at the doorknob. Both forces are applied perpendicular to the door. Which force exerts the greater torque?

A) the first at the midpoint
B) the second at the doorknob
C) both exert equal non-zero torques
D) both exert zero torques
E) additional information is needed

Answer: B
Diff: 1 Page Ref: Sec. 10-4

31) Two equal forces are applied to a door at the doorknob. The first force is applied perpendicular to the door; the second force is applied at 30° to the plane of the door. Which force exerts the greater torque?

A) the first applied perpendicular to the door
B) the second applied at an angle
C) both exert equal non-zero torques
D) both exert zero torques
E) additional information is needed

Answer: A
Diff: 1 Page Ref: Sec. 10-4

FIGURE 10-1

32) The rotating systems shown in Fig. 10-1 differ only in that the two identical movable masses are positioned a distance r from the axis of rotation (left), or a distance $r/2$ from the axis of rotation (right). If you release the hanging blocks simultaneously from rest,

A) the block at left lands first.
B) the block at right lands first.
C) both blocks land at the same time.
D) it is impossible to tell which block reaches the bottom first.

Answer: B
Diff: 1 Page Ref: Sec. 10-5

33) The rotating systems shown in Fig. 10-1 differ only in that the two identical movable masses are positioned a distance r from the axis of rotation (left), or a distance $r/2$ from the axis of rotation (right). If you release the hanging blocks simultaneously from rest, and call t_L the time taken by the block on the left and t_R the time taken by the block on the right to reach the bottom, respectively, then

A) $t_L = \frac{1}{2} t_R$. B) $t_L = t_R$. C) $t_L = \sqrt{2}\ t_R$. D) $t_L = 2\ t_R$. E) $t_L = 4\ t_R$.

Answer: D
Diff: 1 Page Ref: Sec. 10-5

34) What is the quantity used to measure an object's resistance to changes in rotational motion?
A) mass
B) moment of inertia
C) torque
D) angular velocity
E) angular acceleration
Answer: B
Diff: 1 Page Ref: Sec. 10-7

35) A boy and a girl are riding on a merry-go-round that is turning. The boy is twice as far as the girl from the merry-go-round's center. If the boy and girl are of equal mass, which statement is true about the boy's moment of inertia with respect to the axis of rotation?
A) His moment of inertia is 4 times the girl's.
B) His moment of inertia is twice the girl's.
C) The moment of inertia is the same for both.
D) The boy has a greater moment of inertia, but it is impossible to say exactly how much more.
E) The boy has a smaller moment of inertia, but it is impossible to say exactly how much smaller.
Answer: A
Diff: 1 Page Ref: Sec. 10-7

36) A dumbbell-shaped object is composed by two equal masses, m, connected by a rod of negligible mass and length r. If I_1 is the moment of inertia of this object with respect to an axis passing through the center of the rod and perpendicular to it and I_2 is the moment of inertia with respect to an axis passing through one of the masses we can say that
A) $I_1 = I_2$.
B) $I_1 > I_2$.
C) $I_1 < I_2$.
D) There is no way to compare I_1 and I_2.
Answer: C
Diff: 1 Page Ref: Sec. 10-7

37) Rolling without slipping depends on
A) kinetic friction between the rolling object and the ground.
B) static friction between the rolling object and the ground.
C) normal force between the rolling object and the ground.
D) tension between the rolling object and the ground.
E) the force of gravity between the rolling object and the earth.
Answer: B
Diff: 1 Page Ref: Sec. 10-9

38) A wheel of radius R is rolling on a horizontal surface. Its center is moving forward with speed v. A point on the wheel a distance r/3 below the center is moving forward at a speed $2v/3$. The wheel is
A) rolling without slipping.
B) not rotating at all.
C) made of rubber.
D) slipping because its angular speed is too low to be rolling without slipping.
E) slipping because its angular speed is too high to be rolling without slipping.
Answer: A
Diff: 1 Page Ref: Sec. 10-9

39) Consider a hoop of radius *R* and mass *M* rolling without slipping. Which form of kinetic energy is larger, translational or rotational?

A) Translational kinetic energy is larger.
B) Rotational kinetic energy is larger.
C) Both are equal.
D) You need to know the speed of the hoop to tell.
E) You need to know the acceleration of the hoop to tell.

Answer: C
Diff: 2 Page Ref: Sec. 10-9

40) Consider a solid sphere of radius *R* and mass *M* rolling without slipping. Which form of kinetic energy is larger, translational or rotational?

A) Translational kinetic energy is larger.
B) Rotational kinetic energy is larger.
C) Both are equal.
D) You need to know the speed of the sphere to tell.
E) You need to know the acceleration of the sphere to tell.

Answer: A
Diff: 2 Page Ref: Sec. 10-9

41) A disk and a hoop of the same mass and radius are released at the same time at the top of an inclined plane and roll without slipping. Which object reaches the bottom of the incline first?

A) The hoop
B) The disk
C) Both reach the bottom at the same time.
D) It depends on the angle of inclination.
E) It depends on the length of the inclined surface.

Answer: B
Diff: 2 Page Ref: Sec. 10-9

42) A solid sphere, solid cylinder, and a hollow pipe all have equal masses and radii. If the three are released simultaneously at the top of an inclined plane, and roll without slipping which will reach the bottom first?

A) sphere
B) pipe
C) cylinder
D) they all reach bottom in the same time
E) It depends on the angle of inclination.

Answer: A
Diff: 2 Page Ref: Sec. 10-9

43) A disk, a hoop, and a solid sphere are released at the same time at the top of an inclined plane. They all roll without slipping. In what order do they reach the bottom?

A) disk, hoop, sphere
B) hoop, sphere, disk
C) sphere, disk, hoop
D) sphere, hoop, disk
E) hoop, disk, sphere

Answer: C
Diff: 2 Page Ref: Sec. 10-9

44) Suppose a solid sphere of mass M and radius R rolls without slipping down an inclined plane starting from rest. The linear velocity of the sphere at the bottom of the incline depends on

A) the mass of the sphere.
B) the radius of the sphere.
C) both the mass and the radius of the sphere.
D) neither the mass nor the radius of the sphere.

Answer: D

Diff: 2 Page Ref: Sec. 10-9

45) Suppose a solid sphere of mass M and radius R rolls without slipping down an inclined plane starting from rest. The angular velocity of the sphere at the bottom of the incline depends on

A) the mass of the sphere.
B) the radius of the sphere.
C) both the mass and the radius of the sphere.
D) neither the mass nor the radius of the sphere.

Answer: B

Diff: 2 Page Ref: Sec. 10-9

FIGURE 10-2

46) A ball is released from rest on a no-slip surface, as shown. After reaching its lowest point, the ball begins to rise again, this time on a frictionless surface as shown in Fig. 10-2. When the ball reaches its maximum height on the frictionless surface, it is

A) at a greater height as when it was released.
B) at a lesser height as when it was released.
C) at the same height as when it was released.
D) impossible to tell without knowing the mass of the ball.
E) impossible to tell without knowing the radius of the ball.

Answer: B

Diff: 2 Page Ref: Sec. 10-10

10.2 Quantitative Problems

1) A child is riding a merry-go-round which completes one revolution every 8.36 s. The child is standing 4.65 m from the center of the merry-go-round.
(a) What is the tangential speed of the child?
(b) What is the magnitude of the centripetal acceleration of the child?

Answer: (a) 3.49 m/s
(b) 2.63 m/s^2

Diff: 1 Page Ref: Sec. 10-1

2) The angular velocity of a wheel is given by $\omega(t)$ = (2.00 rad/s^2)t + (1.00 rad/s^4)t^3.
(a) What is the angular displacement of the wheel from time t = 0.00 s to time $t = T$?
(b) What is the angular acceleration of the wheel as a function of time?

Answer: (a) (1.00 rad/s^2)T^2 + (0.250 rad/s^4)T^4
(b) (2.00 rad/s^2) + (3.00 rad/s^4)t^2

Diff: 1 Page Ref: Sec. 10-1

3) A child is riding a merry-go-round, which has an instantaneous angular speed of 1.25 rad/s and an angular acceleration of 0.745 rad/s^2. The child is standing 4.65 m from the center of the merry-go-round. (a) What is the magnitude of the acceleration of the child?
(b) What angle does the acceleration of the child make with the tangential direction?
Answer: (a) 8.05 m/s^2
(b) 64.5°
Diff: 2 Page Ref: Sec. 10-1

4) A grinding wheel is spinning at a rate of 20.0 revolutions per second. When the power to the grinder is turned off, the grinding wheel slows with constant angular acceleration and takes 80.0 s to come to a rest.
(a) What was the angular acceleration of the grinding wheel as it came to rest?
(b) How many rotations did the wheel make during the time it was coming to rest?
Answer: (a) 1.57 rad/s^2
(b) 800 revolutions
Diff: 1 Page Ref: Sec. 10-3

5) A centrifuge takes 100 s to spin up from rest to its final angular speed with constant angular acceleration. A point located 8.00 cm from the axis of rotation of the centrifuge moves with a speed of 150 m/s when the centrifuge is at full speed.
(a) What is the average angular acceleration of the centrifuge as it spins up?
(b) How many revolutions does the centrifuge make as it goes from rest to its final angular speed?
Answer: (a) 18.8 rad/s^2
(b) 1.49×10^4 revolutions
Diff: 1 Page Ref: Sec. 10-3

6) A 10.0-kg mass is located at the (1.00 m) $\hat{i}$ + (2.00 m) j + (2.00 m) k. A 5.00-kg mass is located at (-1.00 m) $\hat{i}$ + (1.00 m) j + (1.00 m) k.
(a) Determine the moment of inertia of this system about an axis through the origin parallel to the *x*-axis.
(b) Determine the moment of inertia of this system about an axis through the origin parallel to the *y*-axis.
(c) Determine the moment of inertia of this system about an axis through the origin parallel to the *z*-axis.
Answer: (a) 90.0 kg·m^2
(b) 60.0 kg·m^2
(c) 60.0 kg·m^2
Diff: 1 Page Ref: Sec. 10-7

7) A massless rod of length 1.00 m has a 2.00-kg mass attached to one end and a 3.00-kg mass attached to the other. The system rotates about a fixed axis perpendicular to the rod that passes through the rod 30.0 cm from the end with the 3.00-kg mass attached. The kinetic energy of the system is 100 J.
(a) What is the moment of inertia of this system about this axis?
(b) What is the angular speed of this system?
Answer: (a) 1.25 kg·m^2
(b) 2.01 rev/s
Diff: 2 Page Ref: Sec. 10-8

8) A bowling ball of mass 7.5 kg and radius 9.0 cm rolls without slipping 10 m down a lane at 4.3 m/s.
(a) Calculate the angular displacement of the bowling ball.
(b) Calculate the angular velocity of the bowling ball.
(c) Calculate the centripetal acceleration of the bowling ball.
(d) Calculate the tangential acceleration of the bowling ball.
Answer: (a) 110 rad
(b) 48 rad/s
(c) 210 m/s^2
(d) 0 m/s^2
Diff: 1 Page Ref: Sec. 10-9

9) A solid sphere of mass 1.5 kg and radius 15 cm rolls without slipping down a 35° incline that is 7.0 m long. Assume it started from rest. The moment of inertia of a sphere is given by $I= (2/5)MR^2$.
(a) Calculate the linear speed of the sphere when it reaches the bottom of the incline.
(b) Determine the angular speed of the sphere at the bottom of the incline.
(c) Does the linear speed depend on the radius or mass of the sphere? Does the angular speed depend on the radius or mass of the sphere?
Answer: (a) 7.5 m/s
(b) 50 rad/s
(c) The linear speed depends on neither the radius nor the mass of the sphere. The angular speed depends on the radius of the sphere.
Diff: 2 Page Ref: Sec. 10-9

10) A 2.00-kg solid sphere of radius 5.00 cm rolls down a 20.0° inclined plane starting from rest.
(a) What is the magnitude of the acceleration of the center of mass of the sphere?
(b) How far down the plane does it roll without slipping in 1.00 s?
Answer: (a) 2.44 m/s^2
(b) 1.22 m
Diff: 2 Page Ref: Sec. 10-9

11) A potter's wheel decelerates from 50 rev/min to 30 rev/min in 5.0 s, with a constant deceleration. What is the magnitude of the deceleration?
A) 4.0 rad/s^2 B) 0.42 rad/s^2 C) 25 rad/s^2 D) 38 rad/s^2 E) 20 rad/s^2
Answer: B
Diff: 1 Page Ref: Sec. 10-1

12) A fan is turned off, and its angular speed decreases from 10.0 rad/s to 6.3 rad/s in 5.0 s. What is the magnitude of the angular acceleration of the fan?
A) 0.86 rad/s^2 B) 0.74 rad/s^2 C) 0.37 rad/s^2 D) 11.6 rad/s^2 E) 1.16 rad/s^2
Answer: B
Diff: 1 Page Ref: Sec. 10-1

13) How long does it take for a rotating object to speed up from 15.0 to 33.3 rad/s if it has an angular acceleration of 3.45 rad/s^2?
A) 4.35 s B) 5.30 s C) 9.57 s D) 10.6 s E) 63.1 s
Answer: B
Diff: 1 Page Ref: Sec. 10-1

14) How long does it take a wheel that is rotating at 33.3 rpm to speed up to 78.0 rpm if it has an angular acceleration of 2.15 rad/s^2?
A) 20.8 s B) 4.75 s C) 10.4 s D) 2.18 s E) 5.20 s
Answer: D
Diff: 2 Page Ref: Sec. 10-1

15) A wheel that is rotating at 33.3 rad/s is given an angular acceleration of 2.15 rad/s^2. Through what angle has the wheel turned when its angular speed reaches 72.0 rad/s?

A) 83.2 rad B) 316 rad C) 697 rad D) 66.8 rad E) 948 rad

Answer: E

Diff: 1 Page Ref: Sec. 10-3

16) A wheel rotates through an angle of 13.8 rad as it slows down from 22.0 rad/s to 13.5 rad/s. What is the magnitude of the average angular acceleration of the wheel?

A) 0.616 rad/s^2 B) 5.45 rad/s^2 C) 111 rad/s^2 D) 22.5 rad/s^2 E) 10.9 rad/s^2

Answer: E

Diff: 1 Page Ref: Sec. 10-3

17) A pulley has an initial angular speed of 12.5 rad/s and a constant angular acceleration of 3.41 rad/s^2. Through what angle does the pulley turn in 5.26 s?

A) 113 rad B) 22.6 rad C) 42.6 rad D) 19.3 rad E) 160 rad

Answer: A

Diff: 1 Page Ref: Sec. 10-3

18) A flywheel rotating at 640 rev/min is brought to rest with a uniform deceleration of 2.0 rad/s^2. How many revolutions does it make before coming to rest?

A) 320 B) 17 C) 160 D) 360 E) 180

Answer: E

Diff: 1 Page Ref: Sec. 10-3

19) A wheel rotates through an angle of 320° as it slows down from 78.0 rpm to 22.8 rpm. What is the magnitude of the average angular acceleration of the wheel?

A) 2.34 r rad/s^2 B) 5.48 rad/s^2 C) 6.50 rad/s^2 D) 8.35 rad/s^2 E) 10.9 rad/s^2

Answer: B

Diff: 2 Page Ref: Sec. 10-3

20) A lathe, initially at rest, accelerates at 0.60 rad/s^2 for 10 s, then runs at a constant angular velocity for 20 s, and finally decelerates uniformly for 10 s to come to a complete stop. What is its average angular velocity?

A) 4.5 rad/s B) 3.5 rad/s C) 5.0 rad/s D) 3.0 rad/s E) 4.0 rad/s

Answer: A

Diff: 2 Page Ref: Sec. 10-3

21) In an effort to loosen the bolt on the wheel of a car, a man with a mass of 70 kg steps on the end of a 50-cm tire iron which is extending horizontally from the bolt. How much torque is he applying to the bolt?

A) 340 N m B) 14 N m C) 140 N m D) 70 N m E) 35 N m

Answer: A

Diff: 1 Page Ref: Sec. 10-4

22) A wrench is acting on a nut. The length of the wrench lies directly to the east of the nut. A force 150 N acts on the wrench at a position 15.0 cm from the center of the nut in a direction 30.0° north of east. What is the torque about the center of the nut?

A) 22.5 N·m B) 11.3 N·m C) 19.5 N·m D) 2250 N·m E) 1949 N·m

Answer: B

Diff: 1 Page Ref: Sec. 10-4

23) A man is holding an 8.00-kg vacuum cleaner at arm's length, a distance of 0.550 m from his shoulder. What is the torque on the shoulder joint if the arm is horizontal?

A) 0.242 Nm B) 4.40 Nm C) 43.2 Nm D) 14.5 Nm E) 0 Nm

Answer: C

Diff: 1 Page Ref: Sec. 10-4

24) A man is holding an 8.00-kg vacuum cleaner at arm's length, a distance of 0.550 m from his shoulder. What is the torque on the shoulder joint if the arm is held at 30.0° below the horizontal?

A) 21.6 Nm B) 2.20 Nm C) 4.40 Nm D) 12.6 Nm E) 37.4 Nm

Answer: E

Diff: 2 Page Ref: Sec. 10-4

25) A two-dimensional object placed in the xy-plane has three forces acting on it: a force of 3.0 N along the x-axis acting at a point (3 m, 4 m); A force of 2.0 N along the y-axis acting at (-2 m, 5 m); and a force of 5 N in the negative x direction acting at (-2 m, -3 m). What is the net torque about the point (-1 m, 1 m)?

A) 7 N m counterclockwise
B) 23 N m clockwise
C) 3 N m counterclockwise
D) 31 N m clockwise
E) 7 N m clockwise

Answer: D

Diff: 2 Page Ref: Sec. 10-4

26) A person pushes on a doorknob with a force of 5.00 N perpendicular to the surface of the door. The doorknob is located 0.800 m from axis of the hinges of the door. The door begins to rotate with an angular acceleration of 2.00 rad/s^2. What is the moment of inertia of the door about the hinges?

A) 2.00 kg·m^2 B) 1.00 kg·m^2 C) 12.5 kg·m^2 D) 8.00 kg·m^2 E) 6.40 kg·m^2

Answer: A

Diff: 1 Page Ref: Sec. 10-6

27) A person pushes on a doorknob with a force of 5.00 N. The direction of the force is at an angle of 20.0° from the perpendicular to the surface of the door. The doorknob is located 0.800 m from axis of the hinges of the door. The door begins to rotate with an angular acceleration of 2.00 rad/s^2. What is the moment of inertia of the door about the hinges?

A) 4.28 kg·m^2 B) 7.52 kg·m^2 C) 1.88 kg·m^2 D) 0.684 kg·m^2 E) 2.74 kg·m^2

Answer: C

Diff: 1 Page Ref: Sec. 10-6

28) A horizontal 2.00-m long, 5.00-kg uniform beam that lies along the east-west direction is acted on by two forces. At the east end of the beam, a 200-N forces pushes downward. At the west end of the beam, a 200-N force pushed upward. What is the angular acceleration of the beam?

A) 240 rad/s^2 north
B) 1.33×10^2 rad/s^2 north
C) zero
D) 240 rad/s^2 south
E) 1.33×10^2 rad/s^2 south

Answer: A

Diff: 1 Page Ref: Sec. 10-6

29) In a lab experiment, a student brings up the rotational speed of a rotational motion apparatus to 30.0 rpm. She then allows the apparatus to slow down on its own, and counts 240 revolutions before the apparatus comes to a stop. The moment of inertia of the flywheel is 0.0850 kg·m^2. What is the retarding torque on the flywheel?

A) 0.0425 Nm
B) 0.159 Nm
C) 0.0787Nm
D) 0.000278 Nm
E) 0.0000136 Nm

Answer: D
Diff: 2 Page Ref: Sec. 10-6

30) A string is wrapped around a pulley with a radius of 2.0 cm. The pulley is initially at rest. A constant force of 50 N is applied to the string, causing the pulley to rotate and the string to unwind. If the string unwinds 1.2 m in 4.9 s, what is the moment of inertia of the pulley?

A) 0.17 kg·m^2 B) 17 kg·m^2 C) 14 kg·m^2 D) 0.20 kg·m^2 E) 0.017 kg·m^2

Answer: D
Diff: 2 Page Ref: Sec. 10-6

31) A car has a mass of 930 kg has wheels with a radius of 35 cm, and the distance between the axles is 3.1 m. The coefficient of static friction between the tires and the road is 0.52. It is equipped with anti-lock brakes so that the tires do not slide when it is braking. If the weight of the car is supported equally by the four tires, what is the total torque on the tires exerted by the forces between the tires and the horizontal road when there is maximum braking, i.e. when the tires are about to slip?

A) 1.2×10^2 N m
B) 1.7×10^3 N m
C) 1.2×10^4 N m
D) 1.6×10^2 N m
E) 1.4×10^4 N m

Answer: B
Diff: 3 Page Ref: Sec. 10-6

32) What is the rotational inertia (moment of inertia) of a 12-kg uniform rod, 0.30 m long, rotating about an axis perpendicular to the rod and passing through the center of the rod?

A) 0.27 kg·m^2 B) 0.18 kg·m^2 C) 0.090 kg·m^2 D) 0.54 kg·m^2 E) 0.36 kg·m^2

Answer: C
Diff: 1 Page Ref: Sec. 10-7

33) A long, thin rod of uniform cross section and length L has a density that depends on position along the bar. The linear density of the rod is given as $A(1 - x/L) + B$, where L is the distance from the left end of the rod. Determine the moment of inertia of the rod about an axis perpendicular to the rod that passes through the left end of the rod.

A) $(A/4 + 2B/3)L^2$
B) $(A/4 - B/3)L^3$
C) $(-A/4 + B/3)L^3$
D) $(-5A/4 + 2B/3)L^3$
E) $(A/12 + B/3)L^3$

Answer: E
Diff: 1 Page Ref: Sec. 10-7

34) A 10.0-kg rod has a varying linear density that is symmetric about the midpoint of the rod. The moment of inertia about an axis perpendicular to the rod that passes through the rod 30.0 cm from its midpoint is 5.00 kg·m^2. What is the moment of inertia about an axis perpendicular to the rod that passes through the rod 20.0 cm from its midpoint?

A) 7.50 kg·m^2
B) 4.50 kg·m^2
C) 5.10 kg·m^2
D) 4.90 kg·m^2
E) Answer depends on whether the new axis is on the same side of the midpoint as the 30.0 cm distant axis or if its on the opposite side of the midpoint.

Answer: B
Diff: 1 Page Ref: Sec. 10-7

35) A hollow sphere has a mass of 15 kg, an inner radius of 12 cm and an outer radius of 18 cm. What is the rotational inertia (moment of inertia) of the sphere about an axis passing through its center?

A) 0.15 kg·m^2 B) 0.24 kg·m^2 C) 0.13 kg·m^2 D) 0.17 kg·m^2 E) 0.19 kg·m^2

Answer: B
Diff: 3 Page Ref: Sec. 10-7

36) A piece of thin wire of mass m and length 3a is bent into an equilateral triangle. Find the rotational inertia (moment of inertia) of the wire when it is rotating about an axis perpendicular to the plane of the triangle and passing through one of its vertices.

A) $\frac{2}{3}$ ma^2 B) $\frac{7}{4}$ ma^2 C) $\frac{1}{3}$ ma^2 D) $\frac{7}{12}$ ma^2 E) $\frac{1}{2}$ ma^2

Answer: E
Diff: 3 Page Ref: Sec. 10-7

37) Determine the moment of inertia of an equilateral triangular plate of mass *M* and sides *L* about an axis perpendicular to the plate that passes through one vertex of the triangle.

A) $3ML^2/8$ B) $\sqrt{3}\,ML^2/2$ C) $\sqrt{3}\,ML^2/4$ D) $3ML^2/4$ E) $5ML^2/12$

Answer: E
Diff: 3 Page Ref: Sec. 10-7

38) A thin hoop with a radius of 10 cm and a mass of 3.0 kg is rotating about its center with an angular speed of 3.5 rad/s. What is its kinetic energy?

A) 0.18 J B) 0.092 J C) 0.96 J D) 1.05 J E) 0.53 J

Answer: A
Diff: 1 Page Ref: Sec. 10-8

39) A solid cylinder with a radius of 10 cm and a mass of 3.0 kg is rotating about its center with an angular speed of 3.5 rad/s. What is its kinetic energy?

A) 0.18 J B) 0.092 J C) 0.96 J D) 1.05 J E) 0.53 J

Answer: B
Diff: 1 Page Ref: Sec. 10-8

40) The moment of inertia of a uniform rod (about its center) is given by $I = ML^2/12$. What is the kinetic energy of a 120-cm rod with a mass of 450 g rotating about its center at 3.60 rad/s?

A) 0.350 J B) 4.20 J C) 0.700 J D) 0.960 J E) 2.10 J

Answer: A
Diff: 1 Page Ref: Sec. 10-8

41) A uniform solid sphere of mass M and radius R rotates with an angular speed ω. What must be the angular speed of a uniform solid cylinder of mass M, radius R, and height $2R$ that has the same rotational kinetic energy of the sphere?

A) $2\omega/5$ B) $\sqrt{2/5}\,\omega$ C) $4\omega/5$ D) $2\omega/\sqrt{5}$ E) $\omega/\sqrt{5}$

Answer: D

Diff: 1 Page Ref: Sec. 10-8

42) A car is traveling at 20.0 m/s on tires with a diameter of 70.0 cm. The car slows to a rest after traveling 300.0 m. If the tires rolled without slipping, what was the magnitude of the average angular acceleration of the tires during the time the car slowed to a rest?

A) 0.667 rad/s^2 B) 1.33 rad/s^2 C) 0.952 rad/s^2 D) 1.67 rad/s^2 E) 1.90 rad/s^2

Answer: E

Diff: 1 Page Ref: Sec. 10-9

43) A thin cylindrical shell is released from rest and rolls without slipping down an inclined plane that makes an angle of 30° with the horizontal. How long does it take it to travel 3.1 m?

A) 1.4 s B) 1.1 s C) 2.1 s D) 1.6 s E) 1.8 s

Answer: D

Diff: 2 Page Ref: Sec. 10-9

44) A homogeneous cylinder is released from rest and rolls without slipping down an inclined plane inclined at 18° to the horizontal. How fast is it moving after it has rolled 2.2 m down the plane?

A) 4.3 m/s B) 5.2 m/s C) 3.0 m/s D) 3.7 m/s E) 2.6 m/s

Answer: C

Diff: 2 Page Ref: Sec. 10-9

45) A mass M uniform solid cylinder of radius R and a mass M thin uniform spherical shell of radius R roll without slipping. If both objects have the same kinetic energy, what is the ratio of the speed of the cylinder to the speed of the spherical shell?

A) $\sqrt{3}/2$ B) 1/3 C) $\sqrt{4/3}$ D) $4/\sqrt{3}$ E) 4/3

Answer: A

Diff: 2 Page Ref: Sec. 10-9

46) A solid disk is released from rest and rolls without slipping down an inclined plane that makes an angle of 25.0° with the horizontal. What is the speed of the disk after it has rolled 3.00 m, measured along the plane?

A) 2.04 m/s B) 3.53 m/s C) 4.07 m/s D) 5.71 m/s E) 6.29 m/s

Answer: C

Diff: 2 Page Ref: Sec. 10-9

47) A solid sphere is rolling without slipping along a horizontal surface with a speed of 4.50 m/s when it starts up a ramp that makes an angle of 25.0° with the horizontal. What is the speed of the sphere after it has rolled 3.00 m up the ramp?

A) 4.01 m/s B) 8.02 m/s C) 1.91 m/s D) 2.16 m/s E) 1.58 m/s

Answer: E

Diff: 3 Page Ref: Sec. 10-9

48) A hoop is rolling without slipping along a horizontal surface with a speed of 4.50 m/s when it starts up a ramp that makes an angle of 25.0° with the horizontal. What is the speed of the hoop after it has rolled 3.00 m up the ramp?

A) 2.80 m/s B) 1.91 m/s C) 2.06 m/s D) 3.79 m/s E) 8.02 m/s

Answer: A

Diff: 3 Page Ref: Sec. 10-9

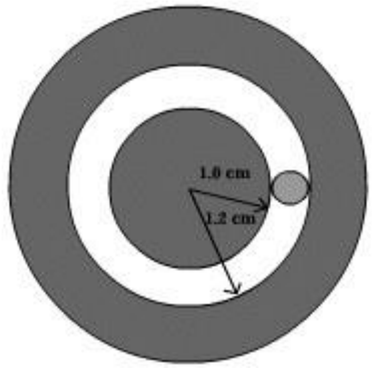
49) A hoop is rolling without slipping along a horizontal surface with a speed of 4.50 m/s when it starts down a ramp that makes an angle of 25.0° with the horizontal. What is the speed of the hoop after it has rolled 3.00 m down the ramp?

A) 4.87 m/s B) 6.34 m/s C) 5.23 m/s D) 5.72 m/s E) 8.02 m/s

Answer: D

Diff: 3 Page Ref: Sec. 10-9

FIGURE 10-3



50) Fig. 10-3 illustrates a simplified roller bearing. The inner cylinder has a radius of 1.0 cm and is stationary. The outer hollow cylinder has a radius of 1.2 cm and is rotating at 8.0 rpm. Between the two cylinders are several small cylinders with a radius of 0.10 cm, which roll without slipping on both the inner and outer cylinders. Only one of these cylinders is shown in the figure. What is the angular speed of the small cylinders?

A) 12 rpm B) 10 rpm C) 48 rpm D) 36 rpm E) 50 rpm

Answer: C

Diff: 3 Page Ref: Sec. 10-9

51) Fig. 10-3 illustrates a simplified roller bearing. The outer hollow cylinder has a radius of 1.2 cm and is stationary. The inner cylinder has a radius of 1.0 cm and is rotating at 11 rpm. Between the two cylinders are several small cylinders with a radius of 0.10 cm, which roll without slipping on both the inner and outer cylinders. Only one of these cylinders is shown in the figure. What is the angular speed of the small cylinders?

A) 12 rpm B) 10 rpm C) 20 rpm D) 62 rpm E) 55 rpm

Answer: E

Diff: 3 Page Ref: Sec. 10-9

52) Fig. 10-3 illustrates a simplified roller bearing. The outer hollow cylinder has a radius of 1.20 cm and is stationary. The inner cylinder has a radius of 1.00 cm and is rotating at 9.00 rpm. Between the two cylinders are several small cylinders with a radius of 0.100 cm, which roll without slipping on both the inner and outer cylinders. Only one of these cylinders is shown in the figure. How long does it take a small cylinder to complete a full revolution around the inner cylinder?

A) 6.00 s B) 14.7 s C) 5.64 s D) 0.542 s E) 1.38 s

Answer: B

Diff: 3 Page Ref: Sec. 10-9

53) A spool whose inner core has a radius of 1.00 cm and whose end caps have a radius of 1.50 cm has a string tightly wound around the inner core. The spool is free to roll without slipping on a horizontal surface. If the string unwinds horizontally from the bottom of the core with a constant speed of 25.0 cm/s, what is the speed of the spool?

A) 5.00 cm/s B) 15.0 cm/s C) 25.0 cm/s D) 37.5 cm/s E) 75.0 cm/s

Answer: E

Diff: 3 Page Ref: Sec. 10-9