Section 8.1 Rotational Motion and Angular Displacement

Section 8.2 Angular Velocity and Angular Acceleration

1. Complete the following statement: The angular measure 1.0 radian is equal to
   (a) 0.0175°.  (c) 1.57°.  (e) 6.28°.
   (b) 57.3°.  (d) 3.14°.

2. A bicycle travels 141 m along a circular track of radius 15 m. What is the angular displacement in radians of the bicycle from its starting position?
   (a) 1.0 rad  (c) 3.0 rad  (e) 9.4 rad
   (b) 1.5 rad  (d) 4.7 rad

3. What is the angular speed in rad/s of the second hand of a watch?
   (a) $1.7 \times 10^{-3}$ rad/s  (c) 0.02 rad/s  (e) 60 rad/s
   (b) 0.10 rad/s  (d) 6.28 rad/s

4. The Earth takes slightly less than one day to complete one rotation about the axis passing through its poles. The actual time is $8.616 \times 10^4$ s. Given this information, what is the angular speed of the Earth about its axis?
   (a) $7.292 \times 10^{-5}$ rad/s  (c) $9.951 \times 10^{-5}$ rad/s  (e) $1.990 \times 10^{-7}$ rad/s
   (b) $2.321 \times 10^{-6}$ rad/s  (d) $6.334 \times 10^{-4}$ rad/s

5. A wheel with a 0.10-m radius is rotating at 35 rev/s. It then slows uniformly to 15 rev/s over a 3.0-s interval. What is the angular acceleration of a point on the wheel?
   (a) $-2.0$ rev/s$^2$  (c) $-6.7$ rev/s$^2$  (e) $-17$ rev/s$^2$
   (b) 0.67 rev/s$^2$  (d) 42 rev/s$^2$

Section 8.3 The Equations of Rotational Kinematics

6. Which equation is valid only when the angular measure is expressed in radians?
   (a) $\alpha = \frac{\Delta \omega}{\Delta t}$  (c) $\omega^2 = \omega_0^2 + 2\alpha \theta$  (e) $\theta = \frac{1}{2} \alpha t^2 + \omega_0 t$
   (b) $\omega = \frac{\Delta \theta}{\Delta t}$  (d) $\omega = \frac{v_r}{r}$

7. During the spin-dry cycle of a washing machine, the motor slows from 95 rad/s to 30 rad/s while turning the drum through an angle of 402 radians. What is the magnitude of the angular acceleration of the motor?
   (a) 64 rad/s$^2$  (c) 10 rad/s$^2$  (e) 1.0 rad/s$^2$
   (b) 32 rad/s$^2$  (d) 20 rad/s$^2$

8. A fan rotating with an initial angular velocity of 1000 rev/min is switched off. In 2 seconds, the angular velocity decreases to 200 rev/min. Assuming the angular acceleration is constant, how many revolutions does the blade undergo during this time?
   (a) 10  (c) 100  (e) 1200
   (b) 20  (d) 125
9. An airplane engine starts from rest; and 2 seconds later, it is rotating with an angular speed of 300 rev/min. If the angular acceleration is constant, how many revolutions does the propeller undergo during this time?
   (a) 5  (c) 50  (e) 600
   (b) 10  (d) 300

10. During the time a compact disc (CD) accelerates from rest to a constant rotational speed of 477 rev/min, it rotates through an angular displacement of 0.250 rev. What is the angular acceleration of the CD?
   (a) 358 rad/s²  (c) 901 rad/s²  (e) 794 rad/s²
   (b) 126 rad/s²  (d) 866 rad/s²

Questions 11 through 13 pertain to the statement below:

A grindstone of radius 4.0 m is initially spinning with an angular speed of 8.0 rad/s. The angular speed is then increased to 10 rad/s over the next 4.0 seconds. Assume that the angular acceleration is constant.

11. What is the average angular speed of the grindstone?
   (a) 0.5 rad/s  (c) 4.5 rad/s  (e) 18 rad/s
   (b) 2.0 rad/s  (d) 9.0 rad/s

12. What is the magnitude of the angular acceleration of the grindstone?
   (a) 0.50 rad/s²  (c) 4.5 rad/s²  (e) 18 rad/s²
   (b) 2.0 rad/s²  (d) 9.0 rad/s²

13. Through how many revolutions does the grindstone turn during the 4.0-second interval?
   (a) 0.64  (c) 4.0  (e) 36
   (b) 3.8  (d) 5.7

14. A grindstone, initially at rest, is given a constant angular acceleration so that it makes 20.0 rev in the first 8.00 s. What is its angular acceleration?
   (a) 0.313 rad/s²  (c) 2.50 rad/s²  (e) 3.93 rad/s²
   (b) 0.625 rad/s²  (d) 1.97 rad/s²

15. A wheel, originally rotating at 126 rad/s undergoes a constant angular deceleration of 5.00 rad/s². What is its angular speed after it has turned through an angle of 628 radians?
   (a) 15 rad/s  (c) 98 rad/s  (e) 150 rad/s
   (b) 19 rad/s  (d) 121 rad/s

16. A wheel turns through an angle of 188 radians in 8.0 s; and its angular speed at the end of the period is 40 rad/s. If the angular acceleration is constant, what was the angular speed of the wheel at the beginning of the 8.0 s interval?
   (a) 4.8 rad/s  (c) 9.1 rad/s  (e) 32.5 rad/s
   (b) 7.0 rad/s  (d) 23.5 rad/s

17. A spinning disc rotating at 130 rev/min slows and stops 31 s later. How many revolutions did the disc make during this time?
   (a) 34  (c) 8.4  (e) 4.2
   (b) 67  (d) 17
18. A 1.0-m roulette wheel reaches a maximum angular speed of 18 rad/s before it begins decelerating. After reaching this maximum angular speed, it turns through 35 revolutions (220 rad) before it stops. How long did it take the wheel to stop after reaching its maximum angular speed?

(a) 12 s  (b) 3.7 s  (c) 24 s  (d) 8.8 s  (e) 24 s

Section 8.4 Angular Variables and Tangential Variables

19. What is the tangential speed of a lug nut on a wheel of a car if the lug nut is located 0.114 m from the axis of rotation; and the wheel is rotating at 6.53 rev/sec?

(a) 0.745 m/s  (b) 1.49 m/s  (c) 2.98 m/s  (d) 4.68 m/s  (e) 9.36 m/s

20. A 0.254-m diameter circular saw blade rotates at a constant angular speed of 117 rad/s. What is the tangential speed of the tip of a saw tooth at the edge of the blade?

(a) 29.7 m/s  (b) 14.9 m/s  (c) 9.46 m/s  (d) 7.45 m/s  (e) 2.17 m/s

21. What is the tangential speed of Nairobi, Kenya, a city near the equator? The earth makes one revolution every 23.93 h and has an equatorial radius of 6380 km.

(a) 74.0 m/s  (b) 116 m/s  (c) 148 m/s  (d) 232 m/s  (e) 465 m/s

Questions 22 and 23 pertain to the following situation:

On an amusement park ride, passengers are seated in a horizontal circle of radius 7.5 m. The seats begin from rest and are uniformly accelerated for 21 seconds to a maximum rotational speed of 1.4 rad/s.

22. What is the tangential acceleration of the passengers during the first 21 s of the ride?

(a) 0.067 m/s²  (b) 0.50 m/s²  (c) 1.4 m/s²  (d) 7.5 m/s²  (e) 11 m/s²

23. What is the instantaneous tangential speed of the passengers 15 s after the acceleration begins?

(a) 0.067 m/s  (b) 0.50 m/s  (c) 1.4 m/s  (d) 7.5 m/s  (e) 11 m/s

Section 8.5 Centripetal Acceleration and Tangential Acceleration

24. A rigid body rotates about a fixed axis with a constant angular acceleration. Which one of the following statements is true concerning the tangential acceleration of any point on the body?

(a) The tangential acceleration is zero m/s².
(b) The tangential acceleration depends on the angular velocity.
(c) The tangential acceleration is equal to the centripetal acceleration.
(d) The tangential acceleration is constant in both magnitude and direction.
(e) The tangential acceleration depends on the change in the angular velocity.

25. A circular disk of radius 0.010 m rotates with a constant angular speed of 5.0 rev/s. What is the acceleration of a point on the edge of the disk?

(a) 0.31 m/s²  (b) 1.6 m/s²  (c) 9.9 m/s²  (d) 2500 m/s²  (e) zero m/s²
26. A circular disk of radius 2.0 m rotates, starting from rest, with a constant angular acceleration of 20.0 rad/s². What is the tangential acceleration of a point on the edge of the disk at the instant that its angular speed is 1.0 rev/s?

(a) 40 m/s²  
(b) 79 m/s²  
(c) 110 m/s²  
(d) 120 m/s²  
(e) zero m/s²

27. Two points are located on a rigid wheel that is rotating with decreasing angular velocity about a fixed axis. Point A is located on the rim of the wheel and point B is halfway between the rim and the axis. Which one of the following statements concerning this situation is true?

(a) Both points have the same centripetal acceleration.  
(b) Both points have the same tangential acceleration.  
(c) The angular velocity at point A is greater than that of point B.  
(d) Both points have the same instantaneous angular velocity.  
(e) Each second, point A turns through a greater angle than point B.

Questions 28 through 30 pertain to the statement below:

A wheel of radius 0.5 m rotates with a constant angular speed about an axis perpendicular to its center. A point on the wheel that is 0.2 m from the center has a tangential speed of 2 m/s.

28. Determine the angular speed of the wheel.

(a) 0.4 rad/s  
(b) 2.0 rad/s  
(c) 4.0 rad/s  
(d) 10 rad/s  
(e) 20 rad/s

29. Determine the tangential speed of a point 0.4 m from the center of the wheel.

(a) 0.4 m/s  
(b) 2 m/s  
(c) 4 m/s  
(d) 10 m/s  
(e) 20 m/s

30. Determine the tangential acceleration of the point that is 0.2 m from the center.

(a) 0.4 m/s²  
(b) 2.0 m/s²  
(c) 4.0 m/s²  
(d) 10 m/s²  
(e) zero m/s²

31. The original Ferris wheel had a radius of 38 m and completed a full revolution (2π radians) every two minutes when operating at its maximum speed. If the wheel were uniformly slowed from its maximum speed to a stop in 35 seconds, what would be the magnitude of the tangential acceleration at the outer rim of the wheel during its deceleration?

(a) 0.0015 m/s²  
(b) 0.057 m/s²  
(c) 0.54 m/s²  
(d) 1.6 m/s²  
(e) 6.8 m/s²

32. A ball attached to a string starts at rest and undergoes a constant angular acceleration as it travels in a horizontal circle of radius 0.30 m. After 0.65 sec, the angular speed of the ball is 9.7 rad/s. What is the tangential acceleration of the ball?

(a) 4.5 m/s²  
(b) 0.32 m/s²  
(c) 15 m/s²  
(d) 7.6 m/s²  
(e) 28 m/s²

Section 8.6 Rolling Motion

33. A bicycle with wheels of radius 0.4 m travels on a level road at a speed of 8 m/s. What is the angular speed of the wheels?

(a) 10 rad/s  
(b) 20 rad/s  
(c) (π/10) rad/s  
(d) (10π) rad/s  
(e) (20/π) rad/s
34. Two motorcycles are riding around a circular track at the same angular velocity. One motorcycle is at a radius of 15 m; and the second is at a radius of 18 m. What is the ratio of their linear speeds, \( v_2/v_1 \)?
   (a) 1.0  
   (b) 0.83  
   (c) 1.4  
   (d) 0.71  
   (e) 1.2

35. A bicycle has tires of radius 0.35 meters. If the bicycle is traveling at a constant speed of 12 m/s, at approximately what angular speed are the tires rotating?
   (a) 85 rev/min  
   (b) 197 rev/min  
   (c) 214 rev/min  
   (d) 327 rev/min  
   (e) 423 rev/min

36. Joe is painting the floor of his basement using a paint roller. The roller has a mass of 2.4 kg and a radius of 3.8 cm. In rolling the roller across the floor, Joe applies a force \( F = 16 \text{ N} \) directed at an angle of 35° as shown. Ignoring the mass of the roller handle, what is the magnitude of the angular acceleration of the roller?
   (a) \( 7.2 \times 10^1 \text{ rad/s}^2 \)  
   (b) \( 1.0 \times 10^2 \text{ rad/s}^2 \)  
   (c) \( 1.7 \times 10^2 \text{ rad/s}^2 \)  
   (d) \( 2.3 \times 10^2 \text{ rad/s}^2 \)  
   (e) \( 2.8 \times 10^2 \text{ rad/s}^2 \)

37. A car travels in a circular path with constant speed. Which one of the following quantities is constant and non-zero for this car?
   (a) linear velocity  
   (b) angular velocity  
   (c) centripetal acceleration  
   (d) angular acceleration  
   (e) total acceleration

38. Which statement concerning a wheel undergoing rolling motion is true?
   (a) The angular acceleration of the wheel must be zero m/s².
   (b) The tangential velocity is the same for all points on the wheel.
   (c) The linear velocity for all points on the rim of the wheel is non-zero.
   (d) The tangential velocity is the same for all points on the rim of the wheel.
   (e) There is no slipping at the point where the wheel touches the surface on which it is rolling.

39. A circular hoop rolls without slipping on a flat horizontal surface. Which one of the following is necessarily true?
   (a) All points on the rim of the hoop have the same speed.
   (b) All points on the rim of the hoop have the same velocity.
   (c) Every point on the rim of the wheel has a different velocity.
   (d) All points on the rim of the hoop have acceleration vectors that are tangent to the hoop.
   (e) All points on the rim of the hoop have acceleration vectors that point toward the center of the hoop.

40. A bicycle wheel of radius 0.70 m is turning at an angular speed of 6.3 rad/s as it rolls on a horizontal surface without slipping. What is the linear speed of the wheel?
   (a) 1.4 m/s  
   (b) 28 m/s  
   (c) 0.11 m/s  
   (d) 4.4 m/s  
   (e) 9.1 m/s
Section 8.7 The Vector Nature of Angular Variables

41. A top is spinning counterclockwise as shown in the figure. It is also moving to the right with a linear speed \( v \). What is the direction of the angular velocity?
(a) upward (d) right
(b) downward (e) into the paper
(c) left

42. A car is moving along a horizontal road at a constant velocity that is directed 45° south of east. What is the direction of the angular velocity of the wheels of the car?
(a) 45° south of west (c) 45° south of east (e) due east
(b) 45° north of west (d) 45° north of east

Additional Problems

Questions 43 through 45 pertain to the statement below:
A grindstone of radius 1.0 m is spinning with a constant angular speed of 2.0 rad/s.

43. What is the tangential speed of a point on the rim of the grindstone?
(a) zero m/s (c) 1.0 m/s (e) 4.0 m/s
(b) 0.5 m/s (d) 2.0 m/s

44. What is the magnitude of the centripetal acceleration of a point on the rim of the grindstone?
(a) zero m/s² (c) 1.0 m/s² (e) 4.0 m/s²
(b) 0.5 m/s² (d) 2.0 m/s²

45. What is the magnitude of the tangential acceleration of a point on the rim of the wheel?
(a) zero m/s² (c) 1.0 m/s² (e) 4.0 m/s²
(b) 0.5 m/s² (d) 2.0 m/s²

Questions 46 through 49 pertain to the statement below:
A long thin rod of length 2L rotates with a constant angular acceleration of 10 rad/s² about an axis that is perpendicular to the rod and passes through its center.

46. What is the ratio of the tangential acceleration of a point on the end of the rod to that of a point a distance \( L/2 \) from the end of the rod?
(a) 1:1 (c) 2:1 (e) 1:4
(b) 1:2 (d) 4:1

47. What is the ratio of the centripetal acceleration of a point on the end of the rod to that of a point a distance \( L/2 \) from the end of the rod?
(a) 1:1 (c) 2:1 (e) 1:4
(b) 1:2 (d) 4:1

48. What is the ratio of the angular speed (at any instant) of a point on the end of the rod to that of a point a distance \( L/2 \) from the end of the rod?
(a) 1:1 (c) 2:1 (e) 1:4
(b) 1:2 (d) 4:1
49. What is the ratio of the tangential speed (at any instant) of a point on the end of the rod to that of a point a distance $L/2$ from the end of the rod?
(a) 1:1 (c) 2:1 (e) 1:4
(b) 1:2 (d) 4:1

Questions 50 and 51 pertain to the following situation:
A bicycle wheel of radius 0.70 m is rolling without slipping on a horizontal surface with an angular speed of 2.0 rev/s when the cyclist begins to uniformly apply the brakes. The bicycle stops in 5.0 s.

50. Through how many revolutions did the wheel turn during the 5.0 seconds of braking?
(a) 10 rev (c) 9.6 rev (e) 0.4 rev
(b) 2.0 rev (d) 5.0 rev

51. How far did the bicycle travel during the 5.0 seconds of braking?
(a) 1.8 m (c) 22 m (e) 44 m
(b) 8.8 m (d) 42 m

Questions 52 through 55 pertain to the statement below:
A 2.0-kg solid disk rolls without slipping on a horizontal surface so that its center proceeds to the right with speed 5.0 m/s.

The point A is the uppermost point on the disk and the point B is along the horizontal line that connects the center of the disk to the rim.

52. What is the direction of the disk’s angular velocity?
(a) to the left (d) out of the paper
(b) to the right (e) It varies from point to point on the disk.
(c) into the paper

53. What is the instantaneous speed of point A with respect to the ground?
(a) zero m/s (c) 5.0 m/s (e) 10.0 m/s
(b) 2.5 m/s (d) 7.1 m/s

54. What is the instantaneous speed of point B with respect to the ground?
(a) zero m/s (c) 7.1 m/s (e) 10.0 m/s
(b) 5.0 m/s (d) 7.5 m/s

55. What is the instantaneous speed of the point of the disk that makes contact with the surface?
(a) zero m/s (c) 7.1 m/s (e) 10.0 m/s
(b) 5.0 m/s (d) 7.5 m/s