Exercises

8.1 Rigid Bodies, Translations, and Rotations

1. In pure rotational motion of a rigid body, (a) all the particles of the body have the same angular velocity, (b) all the particles of the body have the same tangential velocity, (c) the acceleration is always zero, (d) there are always two simultaneous axes of rotation.

2. The condition for rolling without slipping is (a) $a = r\omega^2$, (b) $v = r\omega$, (c) $F = ma$, (d) $a_c = v^2/r$.

3. Suppose someone in your physics class says that it is possible for a rigid body to have translational motion and rotational motion at the same time. Would you agree? Why?

4. For a rolling cylinder, what would happen if v were less than $r\omega$? Is it possible for v to be greater than $r\omega$? Explain.

5. For the tires on your skidding car, (a) $v = r\omega$, (b) $v > r\omega$, (c) $v < r\omega$.

6. ■ A rope goes over a circular pulley with a radius 6.5 cm. If the pulley makes four revolutions without the rope slipping, what length of rope passes over the pulley?

7. ■ A wheel rolls five revolutions on a horizontal surface without slipping. If the center of the wheel moves 3.2 m, what is the radius of the wheel?

8. ■ A wheel rolls uniformly on level ground without slipping. A piece of mud on the wheel flies off when it is at the 9 o'clock position (rear of wheel). Describe the subsequent motion of the mud.

9. ■ A circular disk with a radius of 0.25 m rolls without slipping with an angular speed of 2.0 rad/s on a level surface. (a) What is the linear speed of the center of mass of the disk? (b) What is the instantaneous tangential speed of the top of the disk?

10. ■■ A ball with a radius of 15 cm rolls on a level surface; the translational speed of the center of mass is 0.25 m/s. What is the angular speed about the center of mass if the ball rolls without slipping?

11. ■■ A disk with a radius of 0.15 m rotates through 270° as it travels 0.71 m. Does the disk roll without slipping?

12. ■■ Show that $a = r\alpha$ is also a condition for rolling without slipping.

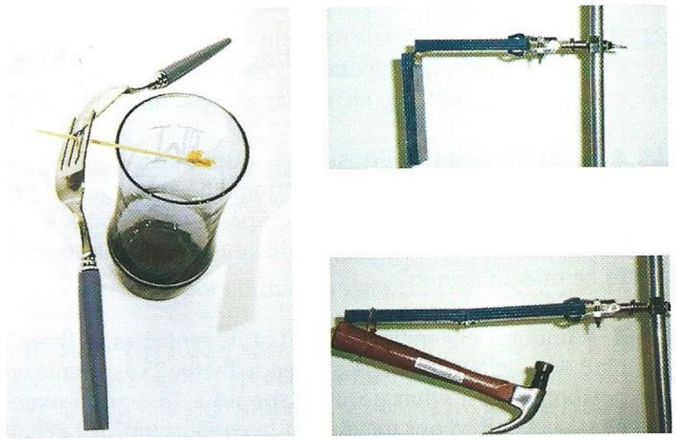
13. ■■■ A cylinder with a diameter of 20 cm rolls with an angular speed of 0.50 rad/s on a level surface. If the cylinder experiences a uniform tangential acceleration of 0.018 m/s^2 without slipping until its angular speed is 1.25 rad/s, through how many complete revolutions does the cylinder rotate during the acceleration time?

8.2 Torque, Equilibrium, and Stability

14. A net torque is possible when (a) all forces act through the axis of rotation, (b) $\Sigma \mathbf{F}_i = 0$, (c) a body is in rotational equilibrium, (d) a body remains in unstable equilibrium.

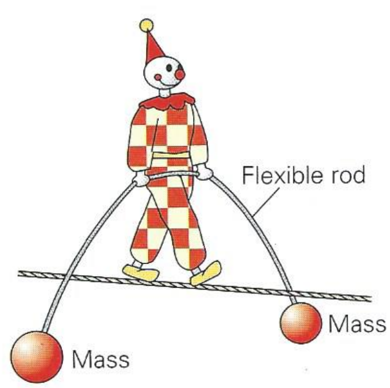
15. If an object in unstable equilibrium is slightly displaced, (a) its potential energy will decrease, (b) the center of gravity is directly above the axis of rotation, (c) no gravitational work is done, (d) stable equilibrium follows.

16. Explain the balancing acts in •Fig. 8.29. Where are the centers of gravity?



•**FIGURE 8.29 Balancing acts** See Exercise 16. *Left:* A toothpick on the rim of the glass supports a fork and spoon. *Right:* (*top*) A hinged board is mounted on a pole. (*bottom*) The handle of a hammer is placed in a loop that runs around the board; the hinged part of the board remains horizontal.

17. •Figure 8.30 shows a toy clown walking on a tightrope. Explain how this brainless toy can perform such a difficult task. Is the clown in stable equilibrium? What happens if



•**FIGURE 8.30 Tightrope walking** See Exercise 17.

the weights are removed? [Hint: Think about the center of gravity.]

18. ■ The drain plug on a car's engine is required to be tightened to a torque of 25 m·N. If you are using a 0.15-meter-long wrench to change the oil of that engine, what is the minimum force you need to apply to loosen the plug?

19. ■ In Exercise 18, due to space limitations (you are crawling under the car), you cannot apply the force perpendicularly to the length of the wrench. If your force makes a 30° angle to that length, what is the force required?

20. ■ In Fig. 8.4a, if the arm makes a 37° angle to the horizontal and a torque of 18 m·N is to be produced, what is the force required by the biceps muscle?

21. ■ How many different positions of stable equilibrium and unstable equilibrium are there for a cube? Consider each surface, edge, and corner to be a different position.

22. ■ The pedals of a bicycle rotate in a circle with a diameter of 40 cm. What is the maximum torque a 55-kilogram rider can apply by putting all of her weight on one pedal?

23. ■ A 35-kilogram child sits on a uniform seesaw of negligible mass; she is 2.0 m from the pivot point (or fulcrum). How far from the pivot point on the other side will her 30-kilogram playmate have to sit for the seesaw to be in equilibrium?

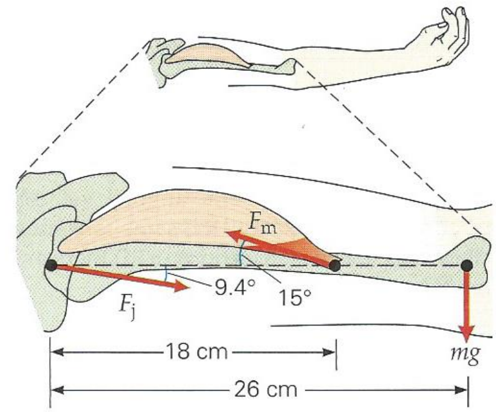
24. ■ A uniform meterstick pivoted at its center, as in Example 8.4, has a 100-gram mass suspended at the 25.0-centimeter position. (a) At what position should a 75.0-gram mass be suspended to put the system in equilibrium? (b) What mass would have to be suspended at the 90.0-centimeter position for the system to be in equilibrium?

25. ■■ Show that the balanced meterstick in Example 8.4 is in static rotational equilibrium about a horizontal axis through the zero end of the stick.

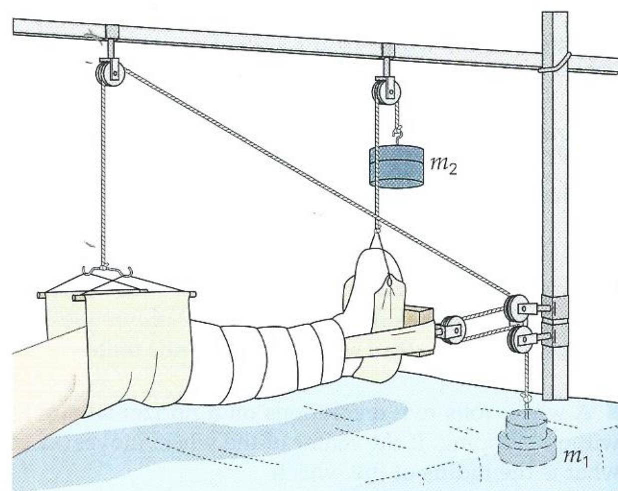
26. ■■ Telephone and electrical lines are allowed to sag between poles so that the tension will not be too great when something hits or sits on the line. Suppose that a line were stretched almost perfectly horizontally between two poles that are 30 m apart. If a 0.25-kilogram bird perches on the wire midway between the poles and the wire sags 1.0 cm, what would the tension in the wire be?

27. ■■ In •Fig. 8.31, what is the force F_m supplied by the deltoid muscle so as to hold up the outstretched arm if the mass of the arm is 3.0 kg? (F_j is the joint force on the bone of the upper arm—the humerus.)

28. ■■ A variation of *Russell traction* (•Fig. 8.32) supports the lower leg when in a cast. Suppose that the patient's leg and cast have a combined mass of 15.0 kg and m_1 is 4.50 kg. (a) What is the reaction force of the leg muscles to the traction? (b) What must m_2 be to keep the leg horizontal?

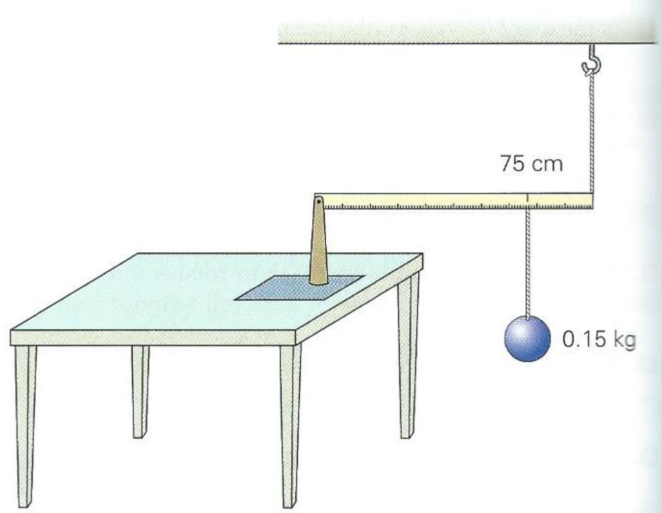


•**FIGURE 8.31 Arm in static equilibrium** See Exercise 27.



•**FIGURE 8.32 Static traction** See Exercise 28.

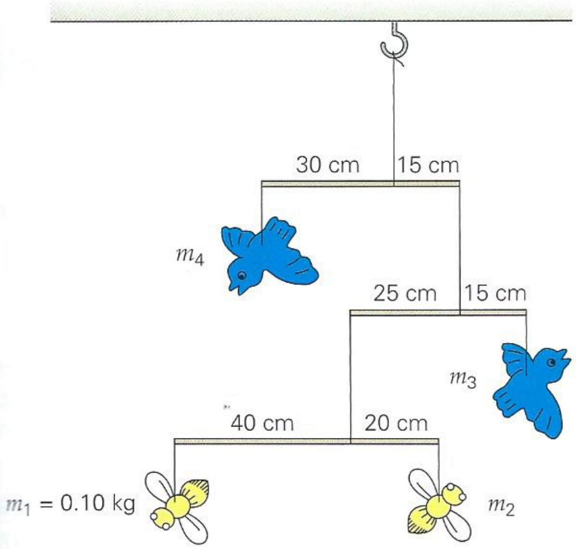
29. ■■ A uniform meterstick weighing 5.0 N is pivoted so it can rotate about a horizontal axis through one end (•Fig. 8.33). If a 0.15-kilogram mass is suspended 75 cm from the pivoted end, what is the tension in the string?



•**FIGURE 8.33 What's the tension?** See Exercise 29.

30. ■■ In Example 8.5, if the mass of the painter is 65 kg, what frictional force must act on the bottom of the ladder to keep it from slipping?

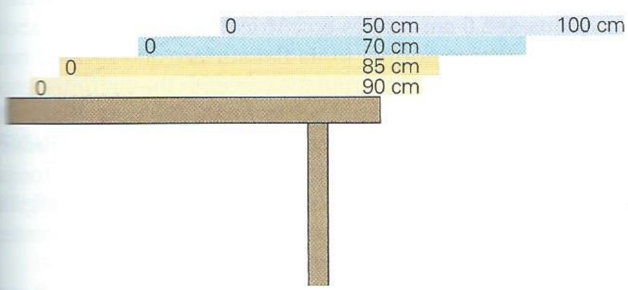
31. ■■ An artist wishes to construct a birds-and-bees mobile, as shown in •Fig. 8.34. If the mass of the bee on the lower left is 0.10 kg and each vertical support string has a length of 30 cm, what are the masses of the other birds and bees? (Neglect the masses of the bars and strings.)



•FIGURE 8.34 **Birds and bees** See Exercise 31.

32. ■■ (a) How many uniform, identical textbooks of width 25.0 cm can be stacked on top of each other on a level surface without the stack falling over if each successive book is displaced 3.00 cm in width relative to the book below it? (b) If the books are 5.00 cm thick, what will be the height of the center of mass of the stack above the level surface?

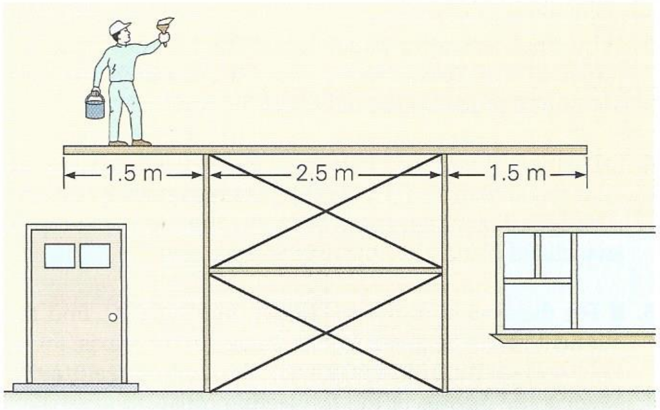
33. ■■ If four metersticks were stacked on a table with 10 cm, 15 cm, 30 cm, and 50 cm, respectively, hanging over the edge, as shown in •Fig. 8.35, would the metersticks remain on the table?



•FIGURE 8.35 **Will they fall off?** See Exercise 33.

34. ■■ A 10.0-kilogram solid uniform cube with 0.500-meter sides rests on a level surface. What is the minimum amount of work necessary to put the cube into an unstable equilibrium position?

35. ■■■ While standing on a long board resting on a scaffold, a 70-kilogram painter paints the side of a house (•Fig. 8.36). If the mass of the board is 15 kg, how close to the end can the painter stand without tipping the board over?



•FIGURE 8.36 **Not too far!** See Exercises 35 and 36.

36. ■■■ Suppose that the board in Fig. 8.36 were suspended from vertical ropes attached to each end instead of resting on scaffolding. If the painter stood 1.5 m from one end of the board, what would the tensions in the ropes be? (See Exercise 35 for additional data.)

37. ■■■ The forces acting on Einstein and the bicycle (Fig. 1 of the Insight on p. 266) are the total weight of Einstein and the bicycle (mg) at the center of gravity of the system, the normal force (N) by the road, and the force of static friction (f_s) on the tires exerted by the road. (a) Explain why the angle of lean θ the bicycle makes with the vertical must be given by $\tan \theta = f_s/N$ if Einstein is to maintain balance. (b) The angle θ in the picture is about 11°. What is the minimum coefficient of static friction μ_s between the road and the tires? (c) If the radius of the circular path is 6.5 m, what is the maximum speed of Einstein's bicycle? [Hint: The net torque about the center of gravity must be zero for rotational equilibrium.]

8.3 Rotational Dynamics

38. The moment of inertia of a rigid body (a) depends on the axis of rotation, (b) cannot be zero, (c) depends on mass distribution, (d) all of the preceding.

39. Which of the following best describes the physical quantity called torque: (a) rotational analogue of force, (b) energy due to rotation, (c) rate of change of linear momentum, (d) force that is tangent to a circle?

40. (a) Does the moment of inertia of a rigid body depend in any way on the center of mass? Explain. (b) Can a moment of inertia have a negative value? If so, explain what this would mean.

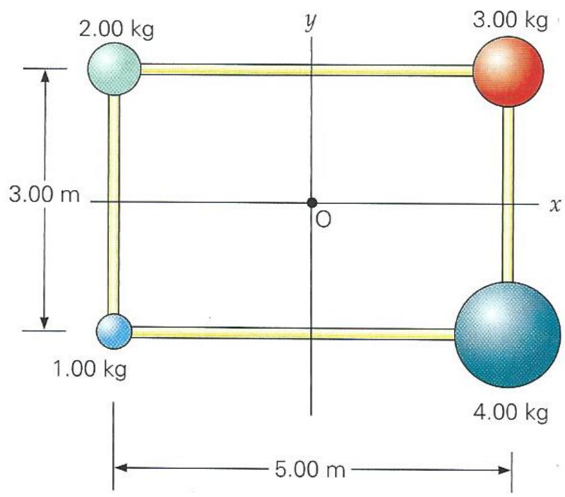
41. Why does the moment of inertia of a rigid body have different values for different axes of rotation? What does this mean physically?

42. When a hard-boiled egg laying on a table is given a quick torque (spin), it will rise up and spin on one end like a top. A raw egg will not. Why the difference?

43. Why does jerking a paper towel from a roll cause the paper to tear better than pulling it smoothly? Will the amount of paper on the roll affect the results?

44. (a) Why is it easier to balance a meterstick vertically on your finger than on a pencil? (b) A softball, a volleyball, and a basketball are released at the same time from the top of an inclined plane. Give the results of the race.

45. ■ For the system of masses shown in •Fig. 8.37, find the moment of inertia about (a) the x axis, (b) the y axis, (c) an axis through the origin perpendicular to the page (z axis). Neglect the masses of the connecting rods.



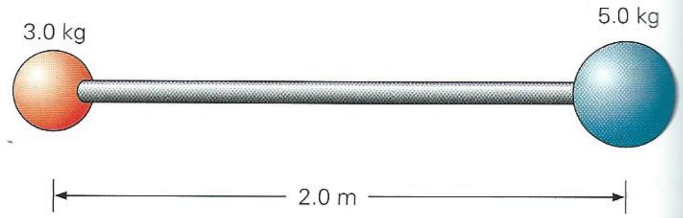
•FIGURE 8.37 Moments of inertia about different axes See Exercise 45.

46. ■ A fixed 0.15-kilogram solid-disk pulley with a radius of 0.075 m is acted on by a net torque of 6.4 m·N. What is the angular acceleration of the pulley?

47. ■ What net torque is needed to give a uniform 20-kilogram solid ball with a radius of 0.20 m and angular acceleration of 2.0 rad/s^2?

48. ■ A light meterstick is loaded with bodies of masses 2.0 kg and 4.0 kg at the 30 cm and 75 cm positions, respectively. What is (a) the moment of inertia about an axis through the 0-centimeter end of the meterstick? (b) the moment of inertia about an axis through the center of mass of the system? (c) Use the parallel axis theorem to find the moment of inertia about the axis through the 0-centimeter end of the stick, and compare the result with that of part (a).

49. ■■ Two masses are joined by a light rod as shown in •Fig. 8.38. Find the moment of inertia of the system about an axis perpendicular to the rod through (a) the center of the rod and (b) the center of mass. (c) Is the moment of inertia about the center of mass the minimum?



•FIGURE 8.38 Moments of inertia about axes through different centers See Exercise 49.

50. ■■ A 2000-kilogram Ferris wheel accelerates from rest to an angular speed of 2.0 rad/s in 12 s. Approximating the Ferris wheel as a circular disk with a radius of 30 m, what is the net torque on the wheel?

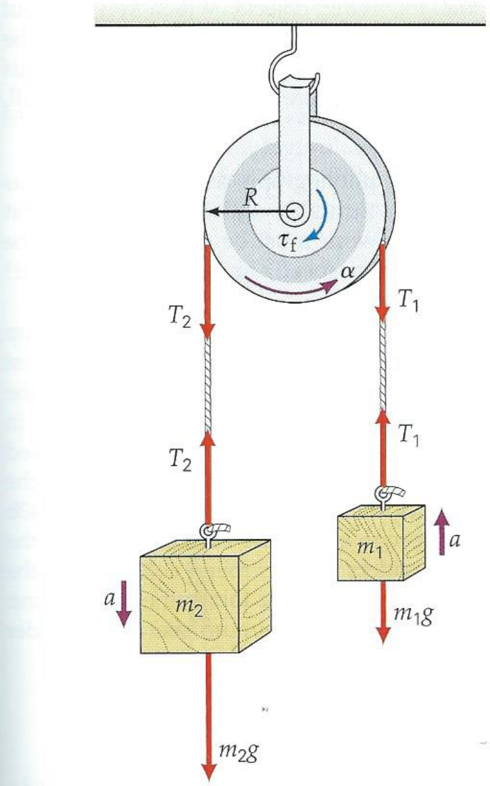
51. ■■ A 15-kilogram uniform sphere with a radius of 15 cm rotates about an axis tangent to its surface at 3.0 rad/s. A constant torque of 10 m·N then increases the rotational speed to 7.5 rad/s. Through what angle does the sphere rotate while accelerating?

52. ■■ A 10-kilogram solid disk of radius 0.50 m is rotated about an axis through its center. If the disk accelerates from rest to an angular speed of 3.0 rad/s while rotating 2.0 revolutions, what net torque is required?

53. ■■ If the Earth rotated about a north–south axis tangent to the Earth at the Equator, how much more moment of inertia would it have compared to that about an axis through its center?

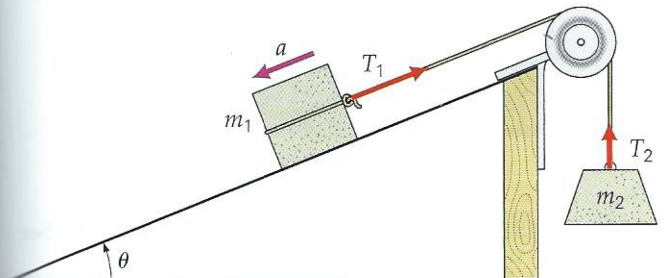
54. ■■ A 0.25-kilogram disk-shaped machine part with a radius of 6.0 cm rotates eccentrically (off-centered) about an axis that is normal to its flat surface and located two-thirds of the distance from the center to the circumference. (a) What torque is required to rotate the part about this off-center axis with an angular acceleration of 2.0 rad/s^2? (b) How much greater is this torque than the torque required to rotate the part with the same angular acceleration about a parallel axis through the center?

55. ■■ Two masses are suspended from a pulley as shown in •Fig. 8.39 (the Atwood machine revisited, Chapter 4). The pulley has a mass of 0.20 kg, a radius of 0.15 m, and a constant torque of 0.35 m·N due to the friction between the rotating pulley and its axle. What is the magnitude of the acceleration of the suspended masses if $m_1 = 0.40$ kg and $m_2 = 0.80$ kg? (Neglect the mass of the string.)



•FIGURE 8.39 The Atwood machine revisited See Exercise 55.

56. ■■ For the system in •Fig. 8.40, $m_1 = 8.0$ kg, $m_2 = 3.0$ kg, $\theta = 30°$, and the radius and mass of the pulley are 0.10 m and 0.10 kg, respectively. (a) What is the acceleration of the masses? (Neglect friction and the string's mass.) (b) The pulley has a constant frictional torque of 0.050 m·N when the system is in motion, what is the acceleration? [Hint: Isolate the forces. The tensions in the strings are different. Why?]



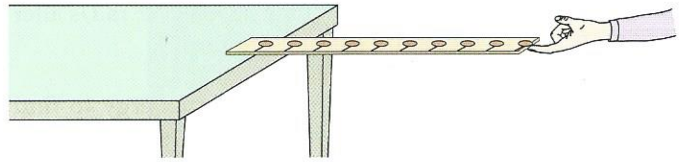
•FIGURE 8.40 Inclined plane and pulley See Exercise 56.

57. ■■ What is the magnitude of the tangential force that must be applied to the rim of a 2.0-kilogram wheel that is disk-shaped and has a radius of 0.50 m in order to give it an angular acceleration of 4.8 rad/s^2? (Neglect friction.)

58. ■■ A man starts his lawn mower by applying to the starter rope a constant tangential force of 150 N to the 0.30-kilogram disk-shaped flywheel. The diameter of the flywheel is 18 cm. What is the angular speed of the wheel after it has turned through one revolution? (Neglect friction and motor compression.)

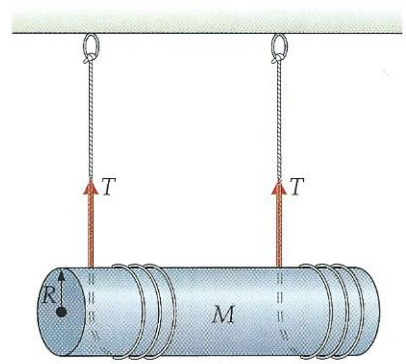
59. ■■ A meterstick, pivoted about a horizontal axis through the 0-centimeter end, is held in a horizontal position and let go. (a) What is the tangential acceleration of the 100-centimeter position? Are you surprised by this result? (b) Which position has a tangential acceleration equal to the acceleration due to gravity?

60. ■■ Pennies are placed every 10 cm on a meterstick. One end is put on a table and the other end is held horizontally with a finger as shown in •Fig. 8.41. If the finger is pulled away, what happens to the pennies? [Hint: See Exercise 59.]



•FIGURE 8.41 Money left behind? See Exercise 60.

61. ■■■ A uniform 2.0-kilogram cylinder of radius 0.15 m is suspended by two strings wrapped around it (•Fig. 8.42). As the cylinder descends, the strings unwind from it. What is the acceleration of the center of mass of the cylinder? (Neglect the mass of the string.)



•FIGURE 8.42 Unwinding with gravity See Exercise 61.

62. ■■■ A uniform hoop rolls without slipping down a 15° inclined plane. What is the acceleration of the hoop's center of mass?

63. ■■■ In Fig. 8.20, what would be the maximum angle of incline (in terms of the coefficient of static friction) for the ball to roll without slipping down the incline?

8.4 Rotational Work and Kinetic Energy

64. From $W = \tau\theta$, the unit(s) of rotational work is (a) watt, (b) N·m, (c) kg·rad/s^2, (d) N·rad.

65. A bowling ball rolls without slipping on a flat surface. The ball has (a) rotational kinetic energy; (b) translational kinetic energy; (c) both translational and rotational kinetic energies.

66. ■ A constant retarding torque of 12 m·N stops a rolling wheel of diameter 0.80 m in a distance of 15 m. How much work is done by the torque?

67. ■ A person opens a door by applying a 15-newton force perpendicular to it at a distance 0.90 m from the hinges. The door is pushed wide open (to 120°) in 2.0 s. (a) How much work was done? (b) What was the average power delivered?

68. ■ A constant torque of 10 m · N is applied to a 10-kilogram uniform disk of radius 0.20 m. What is the angular speed of the disk about an axis through its center after it rotates 2.0 revolutions from rest?

69. ■ A 2.5-kilogram pulley of radius 0.15 m is pivoted about an axis through its center. What constant torque is required so the pulley will reach an angular speed of 25 rad/s after rotating 3.0 revolutions, starting from rest?

70. ■ Use the conservation of mechanical energy to find the linear speed of the descending mass ($m = 1.0$ kg) of Fig. 8.19 after it has descended a vertical distance of 2.0 m from rest. (For the pulley, $M = 0.30$ kg and $R = 0.15$ m. Neglect friction and the mass of the string.)

71. ■■ A sphere with a radius of 15 cm rolls on a level surface with a constant angular speed of 10 rad/s. To what height on a 30° inclined plane will the sphere roll before coming to rest? (Neglect frictional losses.)

72. ■■ A thin 1.0-meter-long rod pivoted at one end falls (rotates) from a horizontal position, starting from rest and with no friction. What is the angular speed of the rod when it is vertical? [Hint: Consider the center of mass and use the conservation of mechanical energy.]

73. ■■ A uniform sphere and a uniform cylinder with the same mass and radius roll at the same velocity side by side on a level surface without slipping. If the sphere and the cylinder approach an inclined plane and roll up it without slipping, will they be at the same height on the plane when they come to a stop? If not, what will be the percentage height difference?

74. ■■ A hoop starts from rest at a height 1.2 m above the base of an inclined plane and rolls down under the influence of gravity. What is the linear speed of the hoop's center of mass just as the hoop leaves the incline and rolls onto a horizontal surface? (Neglect friction.)

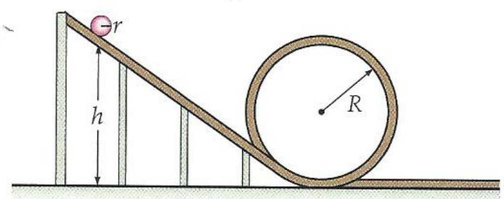
75. ■■ An industrial flywheel with a moment of inertia of $4.25 \times 10^2\ \text{kg}\cdot\text{m}^2$ rotates with a speed of 7500 rpm. (a) How much work is required to bring it to rest? (b) If this work is done uniformly in 1.5 min, how much power is expended?

76. ■■ A cylindrical hoop, a cylinder, and a sphere of equal radius and mass are released at the same time from the top of an inclined plane. Using the conservation of mechanical energy, show that the sphere always gets to the bottom of the incline first with a faster speed and that the hoop always arrives last with the slowest speed.

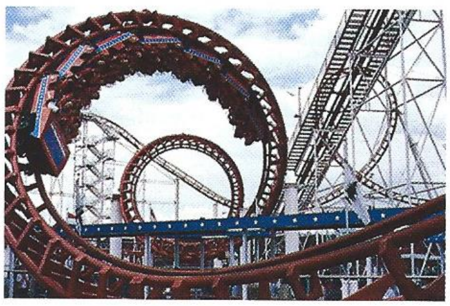
77. ■■ For the following objects, which roll without slipping, determine the rotational kinetic energy about the center of mass as a percentage of the total instantaneous kinetic energy: (a) solid sphere, (b) a thin spherical shell, (c) a thin cylindrical shell.

78. ■■ A 0.050-kilogram phonograph record with a radius 0.15 m drops onto a turntable and is soon rotating at $33\frac{1}{3}$ rpm. How much work must be supplied to get the record to rotate at this speed, and what supplies it?

79. ■■■ A steel ball rolls down an incline into a loop-the-loop of radius R (•Fig. 8.43a). (a) What minimum speed must the ball have at the top of the loop in order to stay on the track? (b) At what vertical height (h) on the incline, in terms of the radius of the loop, must the ball be released in order for it to have the required minimum speed at the top of the loop? (Neglect frictional losses.) (c) Figure 8.43b shows the loop-the-loop of a roller coaster. What are the sensations of the riders if the roller coaster has the minimum speed or greater at the top of the loop? [Hint: In case the speed is below the minimum, seat and shoulder straps hold the riders in.]



(a)



(b)

•FIGURE 8.43 Loop-the-loop and rotational speed See Exercise 79.

8.5 Angular Momentum

80. The units of angular momentum are (a) N·m, (b) kg·m/s², (c) kg·m²/s, (d) J·m.

81. A child stands on the edge of a rotating (hand-driven) merry-go-round. He then starts to walk toward the center of the merry-go-round. A dangerous situation results. Why?

82. The release of vast amounts of carbon dioxide may increase the Earth's average temperature through the greenhouse effect and cause the polar ice caps to melt. If this occurred

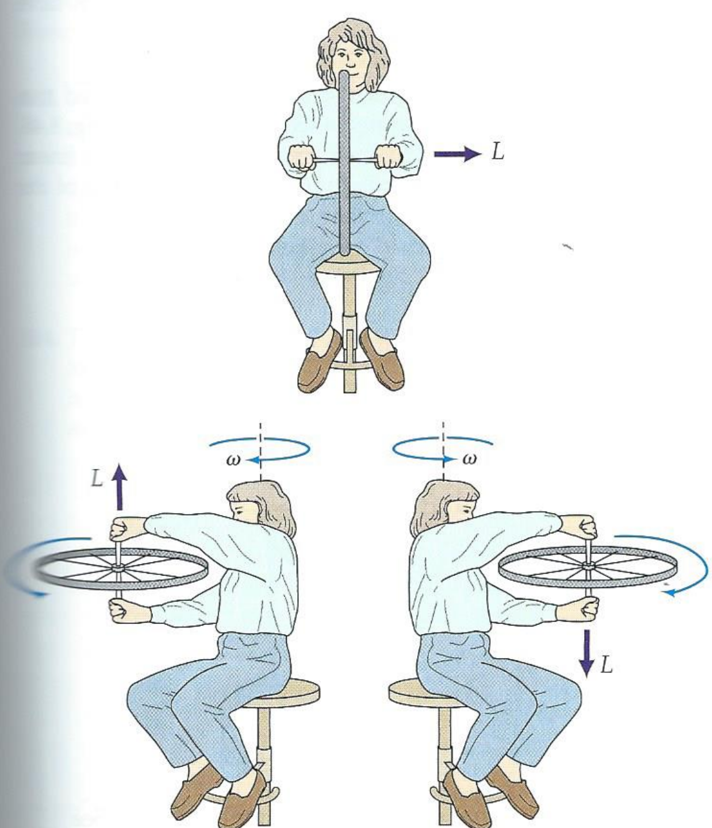
and the ocean level rose substantially, what effect would it have on the Earth's rotation and on the length of the day?

83. An ice skater goes into a fast spin by tucking her arms in (•Fig. 8.44a), and a high-platform diver often draws her legs up against her chest (Fig. 8.44b). Why are the arms and legs put into these positions in each case?

(a) (b)

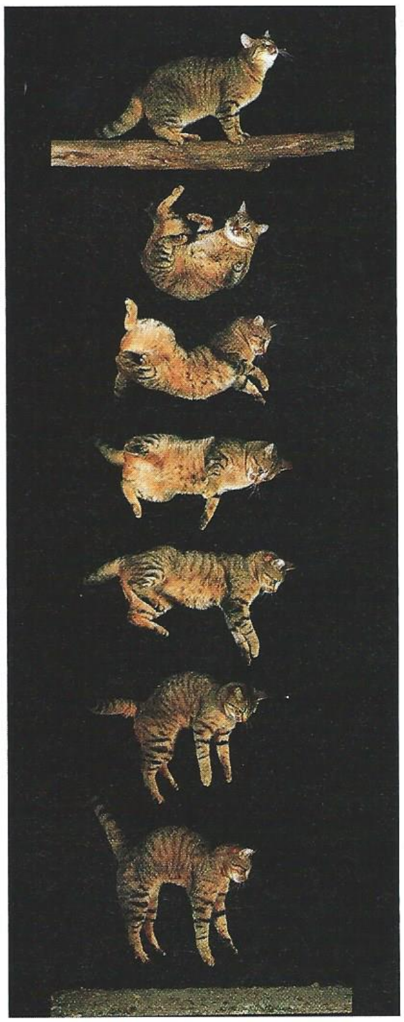
•FIGURE 8.44 **Faster rotation** See Exercise 83.

84. In the classroom demonstration illustrated in •Fig. 8.45, a person on a rotating stool holds a rotating bicycle wheel by handles attached to the wheel. When the wheel is held horizontally, she rotates one way (clockwise as viewed from above). When the wheel is turned over, she rotates in the opposite direction. Explain why this occurs. [Hint: Consider angular momentum vectors.]



•FIGURE 8.45 **A double rotation** See Exercise 84.

85. Cats usually land on their feet when they fall, even if held upside down when dropped (•Fig. 8.46). While a cat is falling, there is no external torque and its center of mass falls as a particle. How can cats turn themselves over while falling?



•FIGURE 8.46 **One down, eight to go** See Exercise 85.

86. ■ What is the angular momentum of a 2.0-gram particle moving counterclockwise (as viewed from above) with an angular speed of 5π rad/s in a horizontal circle of radius 15 cm? (Give magnitude and direction.)

87. ■ A 10-kilogram rotating disk of radius 0.25 m has an angular momentum of 0.45 kg·m^2/s. What is its angular speed?

88. ■■ Compute the ratio of the Earth's orbital angular momentum and its rotational angular momentum. Are these momenta in the same direction?

89. ■■ The period of the Moon's rotation is the same as the period of its revolution: 27.3 days (sidereal). What is the angular momentum for each, rotation and revolution? (Because the periods are equal, we see only one side of the Moon from Earth.)

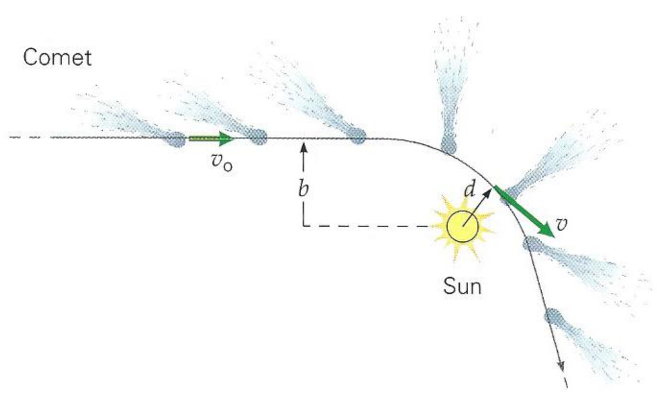
90. ■■ Circular disks are used in automobile clutches and transmissions. When a rotating disk couples with a stationary one through friction, energy from the rotating disk is transferred to the stationary one. If a disk rotating at 800 rpm couples with a stationary disk with three times the moment of inertia, what is the angular speed of the combination?

91. ■■ A rotating spherical star in part of its life cycle expands to six times its normal volume. Assuming the mass remains constant and uniformly distributed inside the star, how is the period of rotation affected?

92. ■■ A skater has a moment of inertia of 100 $kg \cdot m^2$ when his arms are outstretched and a moment of inertia of 75 $kg \cdot m^2$ when his arms are tucked in close to his chest. If he starts to spin at an angular speed of 2.0 rps (revolutions per second) with his arms outstretched, what will his angular speed be when they are tucked in?

93. ■■ An ice skater spinning with outstretched arms has an angular speed of 4.0 rad/s. She then tucks in her arms, decreasing her moment of inertia by 7.5%. (a) What is the resulting angular speed? (b) By what factor does the skater's kinetic energy change? (Neglect any frictional effects.) (c) Where does the extra kinetic energy come from?

94. ■■■ A comet approaches the Sun as illustrated in •Fig. 8.47 and is deflected by the Sun's gravitational attraction. This event is considered a collision, and b is called the impact parameter. Find the distance of closest approach (d) in terms of the impact parameter and the velocities (v_o at large distances and v at closest approach). Consider the radius of the Sun to be negligible compared to d. (As the figure shows, the tail of a comet always "points" away from the Sun.)



•**FIGURE 8.47 A comet "collision"** See Exercise 94.

95. ■■■ A 0.50-kilogram kitten stands on the edge of a lazy Susan (a turntable) of mass 1.5 kg and radius 0.30 m. Assume that the lazy Susan has frictionless bearings and is initially at rest. (a) What will happen if the kitten starts walking around the edge of the lazy Susan? (b) If the kitten walks at a speed of 0.25 m/s relative to the ground, what will be the angular speed of the lazy Susan? (c) When the kitten has walked completely around the edge and is back at its starting point, will that point be above the same point on the ground as it was at the start? If not, where is the kitten relative to the starting ground point? (Speculate on what might happen if everyone on Earth suddenly started to run eastward. What effect might this have on the length of a day?)

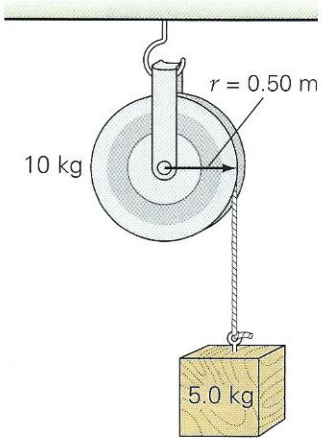
Additional Exercises

96. A 10 000-kilogram bridge of length 10 m is supported at both ends. If a 2000-kilogram car is parked on the bridge 3.0 m from the left support, what are the supporting forces at the left and right ends?

97. A spring is twisted 60° about its linear axis (axis of symmetry) by a torque of 100 m · N. How much torsional, or rotational, energy is stored in the spring? [Hint: Let the restoring torque of the spring be $\tau = k\theta$, the rotational analogue of $F = kx$ (Hooke's law—see Chapter 5) with the minus sign omitted.]

98. Prove that a thin hoop or ring starting from rest will roll more slowly down an inclined plane than an annular cylinder. (Remember that masses and radii do not have to be taken into account.)

99. A 10-kilogram pulley of radius 0.50 m is connected to a 5.0-kilogram mass through a string as shown in •Fig. 8.48. If the mass is let go from rest, (a) what is its linear acceleration? (b) What is the angular acceleration of the pulley?

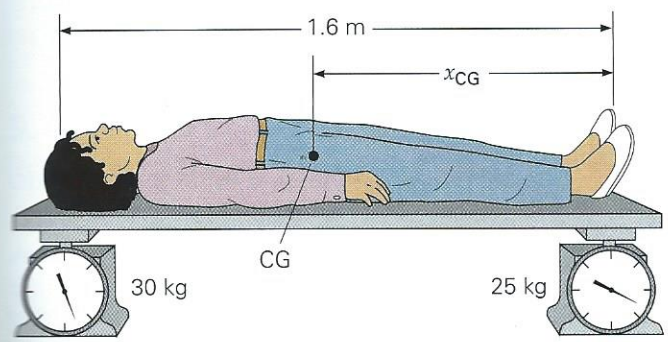


•**FIGURE 8.48 Linear and angular accelerations** See Exercise 99.

100. A bicycle wheel has a diameter of 0.80 m and a mass of 2.0 kg. (a) If the bicycle travels with a linear speed of 1.5 m/s, what is the angular speed of the wheel? (b) What is the angular momentum of the wheel? (Consider the wheel to be a thin ring.)

101. A piece of machinery with a moment of inertia of 2.6 kg·m^2 rotates with a constant angular speed of 4.0 rad/s when experiencing a frictional torque of 0.56 m·N. What is the net torque acting on the piece?

102. The location of a person's center of gravity relative to his or her height can be found by using the arrangement shown in •Fig. 8.49. The scales are initially adjusted to zero with the board alone. Locate the center of gravity of the person relative to the horizontal dimension. Would you expect the location of the center of gravity in other dimensions to be exactly at the midway points? Explain.



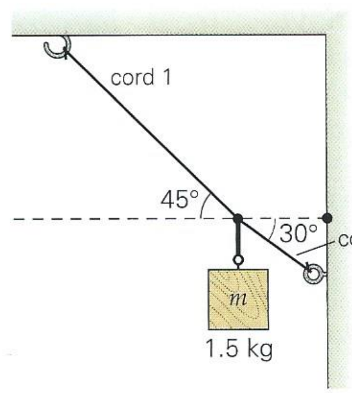
•**FIGURE 8.49 Locating the center of gravity** See Exercise 102.

103. Using bricks identical to those in Example 8.6, you are asked to create a stack of nine bricks (maximum) without its toppling, with each added brick displaced an equal distance horizontally in the same direction. (a) What is the maximum displacement that will allow this? (b) What is the height of the center of mass of the stack if the uniform bricks are 8.0 cm thick?

104. The *radius of gyration* (k) is defined as the distance from an axis of rotation at which all the mass of an object would have to be concentrated to give the same moment of inertia as the actual mass distribution would have—that is, $I = Mk^2$. Take the object to be a rotating particle of mass M. From the axes shown in Fig. 8.16, determine the radius of gyration for (a) a uniform sphere, (b) a uniform cylinder, and (c) a particle.

105. A 25-kilogram child jumps onto the rim of a 100-kilogram rotating disk of radius 2.0 m. If the angular speed of the disk before the child's jump was 2.0 rad/s, what is the angular speed of the disk–child system?

106. A mass is suspended by two cords as shown in •Fig. 8.50. What are the tensions in the cords?



•**FIGURE 8.50 Strung-out equilibrium** See Exercises 106 and 107.

107. If the cord attached to the vertical wall in Fig. 8.50 were horizontal (instead of at a 30° angle), what would the tensions in the cords be?

108. The outer back wheels of an oversize tractor-trailer rig are 3.66 m apart. When the trailer is loaded, its center of gravity is equidistant from its sides and 3.58 m above the road surface. At what road angle will the parked trailer be in unstable equilibrium?

109. A 0.50-kilogram thin rectangular plate has dimensions of 30 cm by 40 cm. For which axis of rotation does the plate have the greater rotational inertia, an axis tangent to a smaller side at its midpoint or an axis tangent to a larger side at its midpoint? How many times more? (Both axes are perpendicular to the plate surface.)