tia of 110 kg · m^2. At touchdown, the wheels begin to spin under the action of friction. Each wheel supports a weight of 1.40×10^4 N, and the wheels attain their angular speed in 0.480 s while rolling without slipping. What is the coefficient of kinetic friction between the wheels and the runway? Assume that the speed of the plane is constant.

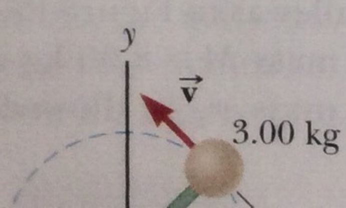
SECTION 8.6 ROTATIONAL KINETIC ENERGY

42. A car is designed to get its energy from a rotating flywheel with a radius of 2.00 m and a mass of 500 kg. Before a trip, the flywheel is attached to an electric motor, which brings the flywheel's rotational speed up to 5 000 rev/min. (a) Find the kinetic energy stored in the flywheel. (b) If the flywheel is to supply energy to the car as a 10.0-hp motor would, find the length of time the car could run before the flywheel would have to be brought back up to speed.

43. A horizontal 800-N merry-go-round of radius 1.50 m is started from rest by a constant horizontal force of 50.0 N applied tangentially to the merry-go-round. Find the kinetic energy of the merry-go-round after 3.00 s. (Assume it is a solid cylinder.)

44. **ecp** Four objects—a hoop, a solid cylinder, a solid sphere, and a thin, spherical shell—each has a mass of 4.80 kg and a radius of 0.230 m. (a) Find the moment of inertia for each object as it rotates about the axes shown in Table 8.1. (b) Suppose each object is rolled down a ramp. Rank the translational speed of each object from highest to lowest. (c) Rank the objects' rotational kinetic energies from highest to lowest as the objects roll down the ramp.

45. A light rod 1.00 m in length rotates about an axis perpendicular to its length and passing through its center as in Figure P8.45. Two particles of masses 4.00 kg and 3.00 kg are connected to the ends of the rod. (a) Neglecting the mass of the rod, what is the system's kinetic energy when its angular speed is 2.50 rad/s? (b) Repeat the problem, assuming the mass of the rod is taken to be 2.00 kg.



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and a radius of 0.230 m. (a) Find the moment of inertia for each object as it rotates about the axes shown in Table 8.1. (b) Suppose each object is rolled down a ramp. Rank the translational speed of each object from highest to lowest. (c) Rank the objects' rotational kinetic energies from highest to lowest as the objects roll down the ramp.

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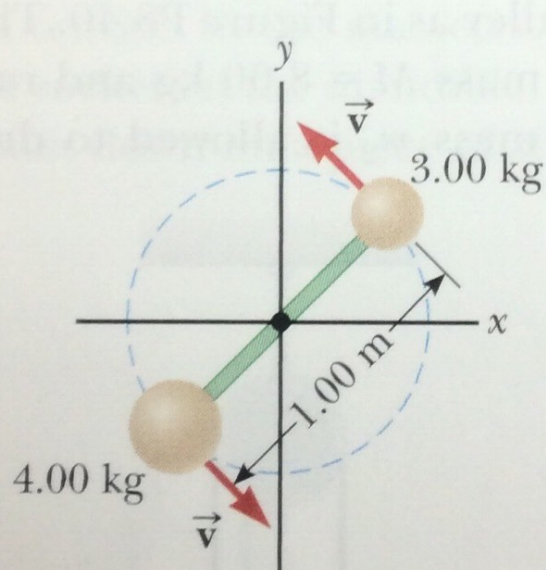

FIGURE P8.45 Problems 45 and 57

46. A 240-N sphere 0.20 m in radius rolls without slipping 6.0 m down a ramp that is inclined at 37° with the horizontal. What is the angular speed of the sphere at the bottom of the slope if it starts from rest?

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47. A solid, uniform disk of radius 0.250 m and mass 55.0 kg rolls down a ramp of length 4.50 m that makes an angle of 15.0° with the horizontal. The disk starts from rest from the top of the ramp. Find (a) the speed of the disk's center of mass when it reaches the bottom of the ramp and (b) the angular speed of the disk at the bottom of the ramp.

48. ecp A solid uniform sphere of mass m and radius R rolls without slipping down an incline of height h. (a) What forms of mechanical energy are associated with the sphere at any point along the incline when its angular speed is ω? Answer in words and symbolically in terms of the quantities m, g, y, I, ω, and v. (b) What force acting on the sphere causes it to roll rather than slip down the incline? (c) Determine the ratio of the sphere's rotational kinetic energy to its total kinetic energy at any instant.

49. The top in Figure P8.49 has a moment of inertia of $4.00 \times 10^{-4}\ \text{kg}\cdot\text{m}^2$ and is initially at rest. It is free to rotate about a stationary axis AA'. A string wrapped around a peg along the axis of the top is pulled in such a manner as to maintain a constant tension of 5.57 N in the string. If the string does not slip while wound around the peg, what is the angular speed of the top after 80.0 cm of string has been pulled off the peg? *Hint:* Consider the work that is done.

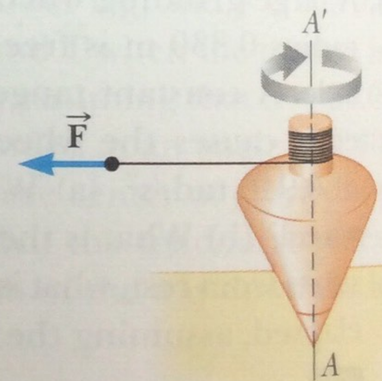

FIGURE P8.49

50. A constant torque of 25.0 N · m is applied to a grindstone whose moment of inertia is $0.130\ \text{kg}\cdot\text{m}^2$. Using energy principles and neglecting friction, find the angular speed after the grindstone has made 15.0 revolutions. *Hint:* The angular equivalent of $W_{net} = F\Delta x = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$ is W_{net} $= \tau\Delta\theta = \frac{1}{2}I\omega_f^2 - \frac{1}{2}I\omega_i^2$ ... lf that

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FIGURE P8.49

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51. A 10.0-kg cylinder rolls without slipping on a rough surface. At an instant when its center of gravity has a speed of 10.0 m/s, determine (a) the translational kinetic energy of its center of gravity, (b) the rotational kinetic energy about its center of gravity, and (c) its total kinetic energy.

52. Use conservation of energy to determine the angular speed of the spool shown in Figure P8.52 after the

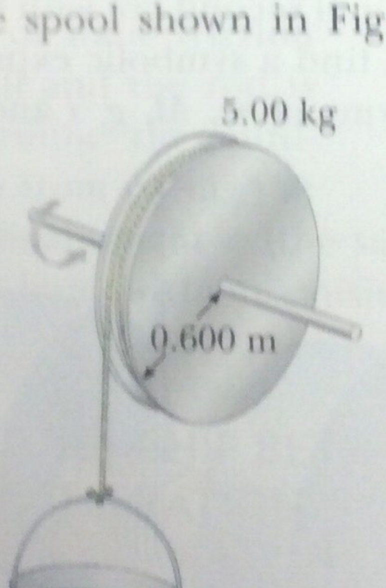

FIGURE P8.52

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3.00-kg bucket has fallen 4.00 m, starting from rest. The light string attached to the bucket is wrapped around the spool and does not slip as it unwinds.

53. ecp A giant swing at an amusement park consists of a 365-kg uniform arm 10.0 m long, with two seats of negligible mass connected at the lower end of the arm (Fig. P8.53). (a) How far from the upper end is the center of mass of the arm? (b) The gravitational potential energy of the arm is the same as if all its mass were concentrated at the center of mass. If the arm is raised through a 45.0° angle, find the gravitational potential energy, where the zero level is taken to be 10.0 m below the axis. (c) The arm drops from rest from the position described in part (b). Find the gravitational potential energy of the system when it reaches the vertical orientation. (d) Find the speed of the seats at the bottom of the swing.

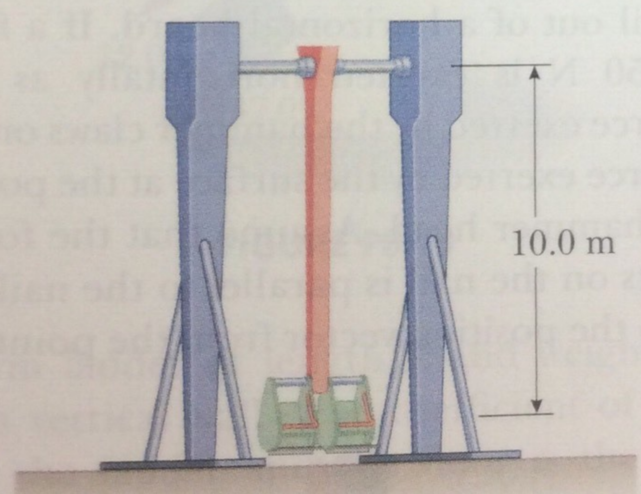

FIGURE P8.53

SECTION 8.7 ANGULAR MOMENTUM

54. Each of the following objects has a radius of 0.180 m and a mass of 2.40 kg, and each rotates about an axis through its center (as in Table 8.1) with an angular speed of

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