Chapter 8
Conceptual Questions and Concepts and Calculations

CONCEPTUAL QUESTIONS

1. In the drawing, the flat triangular sheet $ABC$ is lying in the plane of the paper. This sheet is going to rotate about an axis that also lies in the plane of the paper and passes through point $A$. Draw two such axes that are oriented so that points $B$ and $C$ will move on circular paths having the same radii.

2. A pair of scissors is being used to cut a string. Does each blade of the scissors have the same angular velocity (both magnitude and direction) at a given instant? Give your reasoning.

3. An electric clock is hanging on the wall in the living room. The battery is removed, and the second hand comes to a halt over a brief period of time. During this period, what is the direction of the angular acceleration of the second hand? Why?

4. The earth rotates once per day about its axis. Where on the earth’s surface should you stand in order to have the smallest possible tangential speed? Justify your answer.

5. **ssm** A thin rod rotates at a constant angular speed. Consider the tangential speed of each point on the rod for the case when the axis of rotation is perpendicular to the rod (a) at its center and (b) at one end. Explain for each case whether there are any points on the rod that have the same tangential speeds.

6. A car is up on a hydraulic lift at a garage. The wheels are free to rotate, and the drive wheels are rotating with a constant angular velocity. Does a point on the rim of a wheel have (a) a tangential acceleration and (b) a centripetal acceleration? In each case, give your reasoning.

7. Two points are located on a rigid wheel that is rotating with an increasing angular velocity about a fixed axis. The axis is perpendicular to the wheel at its center. Point 1 is located on the rim, and point 2 is halfway between the rim and the axis. At any given instant, which point (if either) has the greater (a) angular velocity, (b) angular acceleration, (c) tangential speed, (d) tangential acceleration, and (e) centripetal acceleration? Provide a reason for each of your answers.

8. A building is located on the earth’s equator. Which has the greatest tangential speed due to the earth’s rotation, the top floor, the bottom floor, or neither? Justify your answer.

9. **ssm** Section 5.6 discusses how the uniform circular motion of a space station can be used to create artificial gravity for the astronauts. This can be done by adjusting the angular speed of the space station, so the centripetal acceleration at the astronaut’s feet equals $g$, the magnitude of the acceleration due to gravity (see Figure 5.19). If such an adjustment is made, will the acceleration due to the artificial gravity be greater than, equal to, or less than $g$ at the astronaut’s head? Account for your answer.

10. It is possible, but not very practical, to build a clock in which the tips of the second hand, the minute hand, and the hour hand move with the same tangential speed. Explain why not.

11. Explain why a point on the rim of a tire has an acceleration when the tire is on a car that is moving at a constant linear velocity.

12. A bicycle is turned upside down, the front wheel is spinning (see the drawing), and there is an angular acceleration. At the instant shown, there are six points on the wheel that have arrows associated with them. Which of the following quantities could the arrows represent: (a) tangential velocity, (b) tangential acceleration, (c) centripetal acceleration? In each case, answer why the arrows do or do not represent the quantity.

13. **ssm** Suppose that the speedometer of a truck is set to read the linear speed of the truck, but uses a device that actually measures the angular speed of the tires. If larger-diameter tires are mounted on the truck, will the reading on the speedometer be correct? If not, will the reading be greater than or less than the true linear speed of the truck? Why?

14. The blades of a fan rotate more and more slowly after the fan is shut off. Eventually they stop rotating altogether. In such a situation, we sometimes assume that the angular acceleration of the blades is
constant and apply the equations of rotational kinematics as an approximation. Explain why the angular acceleration can never really be constant in this kind of situation.

15. Rolling motion is one example that involves rotation about an axis that is not fixed. Give three other examples. In each case, identify the axis of rotation and explain why it is not fixed.
CONCEPTS & CALCULATIONS

Note: Each of these problems consists of Concept Questions followed by a related quantitative Problem. The Concept Questions involve little or no mathematics. They focus on the concepts with which the problems deal. Recognizing the concepts is the essential initial step in any problem-solving technique.

69. **Concept Questions** (a) In general, is the direction of an object’s average angular velocity \( \bar{\omega} \) the same as its initial angle \( \theta_0 \), its final angle \( \theta_f \), or the difference \( \theta_f - \theta_0 \) between its final and initial angles? (b) The table that follows lists four pairs of initial and final angles of a wheel on a moving car. Decide which pairs give a positive average angular velocity and which give a negative average angular velocity. Provide reasons for your answers.

<table>
<thead>
<tr>
<th>Initial angle ( \theta_0 )</th>
<th>Final angle ( \theta_f )</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) 0.45 rad</td>
<td>0.75 rad</td>
</tr>
<tr>
<td>(b) 0.94 rad</td>
<td>0.54 rad</td>
</tr>
<tr>
<td>(c) 5.4 rad</td>
<td>4.2 rad</td>
</tr>
<tr>
<td>(d) 3.0 rad</td>
<td>3.8 rad</td>
</tr>
</tbody>
</table>

**Problem** The elapsed time for each of the four pairs of angles is 2.0 s. Review the concept of average angular velocity in Section 8.2 and then determine the average angular velocity (magnitude and direction) for each of the four pairs of angles in the table. Check to see that the directions (positive or negative) of the angular velocities agree with the directions found in the Concept Question.

70. **Concept Questions** (a) In general, does the average angular acceleration of a rotating object have the same direction as its initial angular velocity \( \omega_0 \), its final angular velocity \( \omega_f \), or the difference \( \omega_f - \omega_0 \) between its final and initial angular velocities? (b) The table that follows lists four pairs of initial and final angular velocities for a rotating fan blade. Determine the direction (positive or negative) of the average angular acceleration for each pair. Provide reasons for your answers.

<table>
<thead>
<tr>
<th>Initial angular velocity ( \omega_0 )</th>
<th>Final angular velocity ( \omega_f )</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) +2.0 rad/s</td>
<td>+5.0 rad/s</td>
</tr>
<tr>
<td>(b) +5.0 rad/s</td>
<td>+2.0 rad/s</td>
</tr>
<tr>
<td>(c) −7.0 rad/s</td>
<td>−3.0 rad/s</td>
</tr>
<tr>
<td>(d) +4.0 rad/s</td>
<td>−4.0 rad/s</td>
</tr>
</tbody>
</table>

**Problem** The elapsed time for each of the four pairs of angular velocities is 4.0 s. Find the average angular acceleration (magnitude and direction) for each of the four pairs. Be sure that your directions agree with those found in the Concept Question.

71. **Concept Question** In the table are listed the initial angular velocity \( \omega_0 \) and the angular acceleration \( \alpha \) of four rotating objects at a given instant in time.

<table>
<thead>
<tr>
<th>Initial angular velocity ( \omega_0 )</th>
<th>Angular acceleration ( \alpha )</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) +12 rad/s</td>
<td>+3.0 rad/s²</td>
</tr>
<tr>
<td>(b) +12 rad/s</td>
<td>−3.0 rad/s²</td>
</tr>
<tr>
<td>(c) −12 rad/s</td>
<td>+3.0 rad/s²</td>
</tr>
<tr>
<td>(d) −12 rad/s</td>
<td>−3.0 rad/s²</td>
</tr>
</tbody>
</table>

In each case, state whether the angular speed of the object is increasing or decreasing in time. Account for your answers.

**Problem** For each of the four pairs in the table, determine the final angular speed of the object if the elapsed time is 2.0 s. Compare your final angular speeds with the initial angular speeds and make sure that your answers are consistent with your answers to the Concept Question.

72. **Concept Questions** Does the tip of a rotating fan blade have a tangential acceleration when the blade is rotating (a) at a constant angular velocity and (b) at a constant angular acceleration? Provide reasons for your answers.

**Problem** A fan blade is rotating with a constant angular acceleration of +12.0 rad/s². At what point on the blade, measured from the axis of rotation, does the magnitude of the tangential acceleration equal that of the acceleration due to gravity?

73. **Concept Questions** During a time \( t \), a wheel has a constant angular acceleration, so its angular velocity increases from an initial value of \( \omega_0 \) to a final value of \( \omega_f \). During this time, is the angular displacement less than, greater than, or equal to (a) \( \omega_0 t \) or (b) \( \omega_0 t^2 / 2 \)? In each case, justify your answer. (c) If you conclude that the angular displacement does not equal \( \omega_0 t \) or \( \omega_0 t^2 / 2 \), then how does it depend on \( \omega_0 \), \( \omega_f \), and \( t \)?

**Problem** A car is traveling along a road, and the engine is turning over with an angular velocity of +220 rad/s. The driver steps on the accelerator, and in a time of 10.0 s the angular velocity increases to
+280 rad/s. (a) What would have been the angular displacement of the engine if its angular velocity had remained constant at the initial value of +220 rad/s during the 10.0 s? (b) What would have been the angular displacement if the angular velocity had been equal to its final value of +280 rad/s during the 10.0 s? (c) Determine the actual value of the angular displacement during this period. Check your answers to see that they are consistent with those to the Concept Questions.

**74. Concept Questions** Two identical dragsters, starting from rest, accelerate side-by-side along a straight track. The wheels on one of the cars roll without slipping, while the wheels on the other slip during part of the time. (a) For which car, the winner or the loser, do the wheels roll without slipping? Why? For the dragster whose wheels roll without slipping, is there (b) a relationship between its linear speed and the angular speed of its wheels, and (c) a relationship between the magnitude of its linear acceleration and the magnitude of the angular acceleration of its wheels? If a relationship exists in either case, what is it?

**Problem** A dragster starts from rest and accelerates down the track. Each tire has a radius of 0.320 m and rolls without slipping. At a distance of 384 m, the angular speed of the wheels is 288 rad/s. Determine (a) the linear speed of the dragster and (b) the magnitude of the angular acceleration of its wheels.

**75. Concept Questions** A propeller is rotating about an axis perpendicular to its center, as the drawing shows. The axis is parallel to the ground. An arrow is fired at the propeller, travels parallel to the axis, and passes through one of the open spaces between the propeller blades. The vertical drop of the arrow may be ignored. There is a maximum value for the angular speed \( \omega \) of the propeller beyond which the arrow cannot pass through an open space without being struck by one of the blades. (a) If the arrow is to pass through an open space, does it matter if the arrow is aimed closer to or farther away from the axis (see points A and B in the drawing, for example)? Explain. (b) Does the maximum value of \( \omega \) increase, decrease, or remain the same with increasing arrow speed \( v \)? Why? (c) Does the maximum value of \( \omega \) increase, decrease, or remain the same with increasing arrow length \( L \)? Justify your answer.

**Problem** The angular open spaces between the three propeller blades are each \( \pi/3 \) rad (60.0°). Find the maximum value of the angular speed \( \omega \) when the arrow has the lengths \( L \) and speeds \( v \) shown in the following table. Check to see that your answers agree with your answers to the Concept Questions.

<table>
<thead>
<tr>
<th>( L )</th>
<th>( v )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.71 m</td>
<td>75.0 m/s</td>
</tr>
<tr>
<td>0.71 m</td>
<td>91.0 m/s</td>
</tr>
<tr>
<td>0.81 m</td>
<td>91.0 m/s</td>
</tr>
</tbody>
</table>

**76. Concept Questions** At a county fair there is a betting game that involves a spinning wheel. As the drawing shows, the wheel is set into rotational motion with the beginning of the angular section labeled “1” at the marker at the top of the wheel. The wheel then decelerates and eventually comes to a halt on one of the numbered angular sections. (a) Given the initial angular velocity and the magnitude of the angular deceleration, which one of the equations of rotational kinematics would you use to calculate the angular displacement of the wheel? (b) When using the equations of rotational kinematics, can the initial angular velocity and the angular deceleration be expressed in rev/s and rev/s², respectively, or is it necessary to use radian measure? Explain. (c) Does a greater initial angular velocity necessarily mean that the wheel comes to a halt on an angular section labeled with a greater number (8 versus 6, for example)? Provide a reason for your answer.

**Problem** The wheel in the drawing is divided into twelve angular sections, each of which is 30.0°. Determine the numbered section on which the wheel comes to a halt when the deceleration of the wheel has a magnitude of 0.200 rev/s² and the initial angular velocity is (a) +1.20 rev/s and (b) +1.47 rev/s. Check to see that your answers are consistent with your answers to the Concept Questions.
Chapter 9
Conceptual Questions and Concepts and Calculations

CONCEPTUAL QUESTIONS

1. Sometimes, even with a wrench, one cannot loosen a nut that is frozen tightly to a bolt. It is often possible to loosen the nut by slipping a long pipe over the wrench handle. The purpose of the pipe is to extend the length of the handle, so that the applied force can be located farther away from the nut. Explain why this trick works.

2. Explain (a) how it is possible for a large force to produce only a small, or even zero, torque, and (b) how it is possible for a small force to produce a large torque.

3. A magnetic tape is being played on a cassette deck. The tension in the tape applies a torque to the supply reel. Assuming the tension remains constant during playback, discuss how this torque varies as the reel becomes empty.

4. A flat rectangular sheet of plywood can rotate about an axis perpendicular to the sheet through one corner. How should a force (acting in the plane of the sheet) be applied to the plywood so as to create the largest possible torque? Give your reasoning.

5. The drawing shows two tubes of toothpaste. The tubes themselves are the same, and the cap on each tube is threaded and must be removed by unscrewing it. However, one cap is advertised as being an “easy-off” cap, the other being a normal cap. Using the concept of torque, explain why the “easy-off” cap is easier to unscrew than the normal cap.

6. Suppose you are standing on a train, both feet together, facing a window. The front of the train is to your left. The train starts moving forward. To keep from falling, you slide your right foot out toward the rear of the train. Explain in terms of torque how this action keeps you from falling over.

7. Starting in the spring, fruit begins to grow on the outer end of a branch on a pear tree. Explain how the center of gravity of the pear-growing branch shifts during the course of the summer.

8. ssm The free-body diagram in the drawing shows the forces that act on a thin rod. The three forces are drawn to scale and lie in the plane of the paper. Are these forces sufficient to keep the rod in equilibrium, or are additional forces necessary? Explain.

9. An A-shaped stepladder is standing on frictionless ground. The ladder consists of two sections joined at the top and kept from spreading apart by a horizontal crossbar. Draw a free-body diagram showing the forces that keep one section of the ladder in equilibrium.

10. The drawing shows a wine rack for a single bottle of wine that seems to defy common sense as it balances on a table top. Treat the rack and wine bottle as a rigid body and draw the external forces that keep it in equilibrium. In particular, where must the center of gravity of the rigid body be located? Give your reasoning. (Hint: The physics here is the same as in Figure 9.10c.)

11. A flat triangular sheet of uniform material is shown in the drawing. There are three possible axes of rotation, each perpendicular to the sheet and passing through one corner, A, B, or C. For which axis...
is the greatest net external torque required to bring the triangle up to an angular speed of 10.0 rad/s in 10.0 s, starting from rest? Explain, assuming that the net torque is kept constant while it is being applied.

12. An object has an angular velocity. It also has an angular acceleration due to torques that are present. Therefore, the angular velocity is changing. What happens to the angular velocity if (a) additional torques are applied so as to make the net torque suddenly equal to zero and (b) all the torques are suddenly removed?

13. The space probe in the drawing is initially moving with a constant translational velocity and zero angular velocity. (a) When the two engines are fired, each generating a thrust of magnitude \( T \), will the translational velocity increase, decrease, or remain the same? Why? (b) Explain what will happen to the angular velocity.

14. Sit-ups are more difficult to do with your hands placed behind your head instead of on your stomach. Why?

15. For purposes of computing the translational kinetic energy of a rigid body, its mass can be considered as concentrated at the center of mass. If one wishes to compute the body’s moment of inertia, can the mass be considered as concentrated at the center of mass? If not, why not?

16. A thin sheet of plastic is uniform and has the shape of an equilateral triangle. Consider two axes for rotation. Both are perpendicular to the plane of the triangle, axis A passing through the center of the triangle and axis B passing through one corner. If the angular speed \( \omega \) about each axis is the same, for which axis does the triangle have the greater rotational kinetic energy? Explain.

17. Bob and Bill have the same weight and wear identical shoes. Keeping both feet flat on the floor and the body straight, Bob can lean over farther than Bill can before falling. Whose center of gravity is closer to the ground? Account for your answer.

18. A hoop, a solid cylinder, a spherical shell, and a solid sphere are placed at rest at the top of an incline. All the objects have the same radius. They are then released at the same time. What is the order in which they reach the bottom? Justify your answer.

19. A woman is sitting on the spinning seat of a piano stool with her arms folded. What happens to her (a) angular velocity and (b) angular momentum when she extends her arms outward? Justify your answers.

20. Review Conceptual Example 14 as an aid in answering this question. Suppose the ice cap at the South Pole melted and the water was distributed uniformly over the earth’s oceans. Would the earth’s angular velocity increase, decrease, or remain the same? Explain.

21. The concept behind this question is discussed in Conceptual Example 14. Many rivers, like the Mississippi River, flow from north to south toward the equator. These rivers often carry a large amount of sediment that they deposit when entering the ocean. What effect does this redistribution of the earth’s soil have on the angular velocity of the earth? Why?

22. Conceptual Example 14 provides background for this question. A cloud of interstellar gas is rotating. Because the gravitational force pulls the gas particles together, the cloud shrinks, and, under the right conditions, a star may ultimately be formed. Would the angular velocity of the star be less than, equal to, or greater than, the angular velocity of the rotating gas? Justify your answer.

23. A person is hanging motionless from a vertical rope over a swimming pool. She lets go of the rope and drops straight down. After letting go, is it possible for her to curl into a ball and start spinning? Justify your answer.

24. The photograph shows a workman struggling to keep a stack of boxes balanced on a dolly. The man’s right foot is on the axle of the dolly. Assuming that the boxes are identical, which one creates the greatest torque with respect to the axle? Why?
CONCEPTS & CALCULATIONS

Note: Each of these problems consists of Concept Questions followed by a related quantitative Problem. The Concept Questions involve little or no mathematics. They focus on the concepts with which the problems deal. Recognizing the concepts is the essential initial step in any problem-solving technique.

73. Concept Questions The drawing shows a rectangular piece of wood. The forces applied to corners B and D have the same magnitude and are directed parallel to the long and short sides of the rectangle. An axis of rotation is shown perpendicular to the plane of the rectangle at its center. (a) Relative to this axis, which force produces the torque with the greater magnitude? (b) A force is to be applied to corner A, directed along the short side of the rectangle. The net torque produced by the three forces is zero. How is the force at corner A directed—from A toward B or away from B? Give your reasoning.

Problem The magnitudes of the forces at corners B and D are each 12 N. The long side of the rectangle is twice as long as the short side. Find the magnitude and direction of the force applied to corner A.

74. Concept Questions The wheels, axle, and handles of a wheelbarrow weigh 60.0 N. The load chamber and its contents weigh 525 N. The drawing shows these two forces in two different wheelbarrow designs. To support the wheelbarrow in equilibrium, the man's hands apply a force F to the handles that is directed vertically upward. Consider a rotational axis at the point where the tire contacts the ground, directed perpendicular to the plane of the paper. (a) For which design is there a greater total torque from the 60.0- and 525-N forces? (b) For which design does the torque from the man's force need to be greater? (c) For which design does the man's force need to be greater? Account for your answers.

Problem Find the magnitude of the man's force for both designs. Be sure that your answers are consistent with your answers to the Concept Questions.
75. **Concept Questions** Part a of the drawing shows a uniform horizontal beam attached to a vertical wall by a frictionless hinge and supported from below at an angle \( \theta \) by a brace that is attached to a pin. The forces that keep the beam in equilibrium are its weight \( \mathbf{W} \) and the forces applied to the beam by the hinge and the brace. (a) Part b of the drawing shows the weight \( \mathbf{W} \) and the force \( \mathbf{F} \) from the brace, while assuming that the hinge applies a force \( \mathbf{V} \) that is vertical. Can these three forces keep the beam in equilibrium? (b) Part c of the drawing is like part b, except that it assumes the hinge applies a force \( \mathbf{H} \) that is horizontal rather than vertical. Can the three forces in part c keep the beam in equilibrium? (c) Part d of the drawing assumes that the hinge applies a force that has both a vertical component \( \mathbf{V} \) and a horizontal component \( \mathbf{H} \). Can the forces in part d keep the beam in equilibrium? Justify your answers.

**Problem** The brace makes an angle \( \theta = 39^\circ \) with respect to the beam, which has a weight of 340 N. Find the magnitudes of the forces \( \mathbf{V} \), \( \mathbf{H} \), and \( \mathbf{F} \).

76. **Concept Questions** Multiple-Concept Example 10 provides one model for solving this type of problem. Two wheels have the same mass and radius. One has the shape of a hoop and the other the shape of a solid disk. Each wheel starts from rest and has a constant angular acceleration with respect to a rotational axis that is perpendicular to the plane of the wheel at its center. Each makes the same number of revolutions in the same time. (a) Which wheel, if either, has the greater angular acceleration? (b) Which, if either, has the greater moment of inertia? (c) To which wheel, if either, is a greater net external torque applied? Explain your answers.

**Problem** The mass and radius of each wheel are 4.0 kg and 0.35 m, respectively. Each wheel starts from rest and turns through an angle of 13 rad in 8.0 s. Find the net external torque that acts on each wheel. Check to see that your answers are consistent with your answers to the Concept Questions.

77. **Concept Questions** Two thin rods of length \( L \) are rotating with the same angular speed \( \omega \) (in rad/s) about axes that pass perpendicularly through one end. Rod A is massless but has a particle of mass 0.66 kg attached to its free end. Rod B has a mass 0.66 kg, which is distributed uniformly along its length. (a) Which has the greater moment of inertia—rod A with its attached particle or rod B? (b) Which has the greater rotational kinetic energy? Account for your answers.

**Problem** The length of each rod is 0.75 m, and the angular speed is 4.2 rad/s. Find the kinetic energies of rod A with its attached particle and of rod B. Make sure your answers are consistent with your answers to the Concept Questions.

78. **Concept Questions** As seen from above, a playground carousel is rotating counterclockwise about its center on frictionless bearings. A person standing still on the ground grabs onto one of the bars on the carousel very close to its outer edge and climbs aboard. Thus, this person begins with an angular speed of zero and ends up with a nonzero angular speed, which means that he underwent a counterclockwise angular acceleration. (a) What applies the force to the person to create the torque causing this acceleration? What is the direction of this force? (b) According to Newton's action–reaction law, what can you say about the direction of the force applied to the carousel by the person and about the nature (clockwise or counterclockwise) of the torque that it creates? (c) Does the torque identified in part (b) increase or decrease the angular speed of the carousel?

**Problem** The carousel has a radius of 1.50 m, an initial angular speed of 3.14 rad/s, and a moment of inertia of 125 kg·m². The mass of the person is 40.0 kg. Find the final angular speed of the carousel after the person climbs aboard. Verify that your answer is consistent with your answers to the Concept Questions.

79. **Concept Questions** The drawing shows two identical systems of objects; each consists of three small balls (masses \( m_1 \), \( m_2 \), and \( m_3 \)) connected by massless rods. In both systems the axis is perpendicular to the page, but it is located at a different place, as shown. (a) Do the systems necessarily have the same moments of inertia? If not, why not? (b) The same force of magnitude \( F \) is applied to the same ball in each system (see the drawing). Is the magnitude of the torque created by the applied force greater for system A or for system B? Or is the magnitude the same in the two cases? Explain. (c) The two systems start from rest. Will system A or system B have the greater angular speed at the same later time? Or will they have the same angular speeds? Justify your answer.

**Problem** The masses of the balls are \( m_1 = 9.00 \) kg, \( m_2 = 6.00 \) kg, and \( m_3 = 7.00 \) kg. The magnitude of the force is \( F = 424 \) N. (a) For each of the two systems, determine the moment of inertia about the given axis of rotation. (b) Calculate the torque (magnitude and direction) acting on each system. (c) Both systems start from rest, and the direction of the force moves with the system and always points along the 4.00-m rod. What is the angular velocity of each system after 5.00 s?

80. **Concept Questions** Two identical wheels are moving on horizontal surfaces. The center of mass of each has the same linear speed. However, one wheel is rolling, while the other is sliding (without rolling) on a frictionless surface. Each wheel then encounters an incline plane. One continues to roll up the incline, while the other continues to slide up. Eventually they come to a momentary halt, because the gravitational force slows them down. (a) As the wheels move on the horizontal surfaces, which, if either, has the greater total kinetic energy? Why? (b) When they come to a momentary halt on the incline, which, if either, has the greater potential energy? Justify your answer. (c) Which wheel, if either, rises to the greater height? Explain.

**Problem** Each wheel is a disk of mass 2.0 kg. On the horizontal surfaces the center of mass of each moves with a linear speed of 6.0 m/s. (a) What is the total kinetic energy of each wheel? (b) Determine the maximum height reached by each wheel as it moves up the incline.