Pre-Lab 8

Due: 11/19

Read: Sections 3.8, 7.1

1. In your own words, define the following terms:
   a. Angular displacement
   b. Angular velocity
   c. Angular acceleration
   d. Angular speed

2. You put a CD into your computer drive. As its rotational speed increases from zero up to its maximum, does a point on its rim have:
   (a) tangential acceleration? Explain.
   (b) radial acceleration? Explain.

3. Tom and Mary are riding on a merry-go-round. Tom is on a horse about half way between the center and the outer rim, and Mary is on a horse at the outer rim.
   (a) Which child has the larger angular speed? Explain.
   (b) Which child has the larger linear speed? Explain.
   (c) Which child has the larger radial acceleration? Explain.

4. A flywheel is spinning with its axle pointing along the east-west direction. You are standing west of the flywheel facing toward it. You notice that a point at the top of the flywheel is moving toward your left.
   (a) What is the direction of the flywheel’s angular velocity?
   (b) If the flywheel’s angular speed is increasing, what is the direction of its angular acceleration?
   (c) If the flywheel’s angular speed is decreasing, what is the direction of its angular acceleration?
   (d) If the flywheel’s angular speed is decreasing, what is the direction of the tangential acceleration of a point at the top of the flywheel?
Lab 8: Non-Uniform Circular Motion

Group Questions
Discuss these questions with your lab partners and write down your response only after you can agree on the answers.

1. For each of the following, state whether the given combination of angular acceleration and radial acceleration of a point on the rim of a wheel is possible or impossible. If possible, tell how the wheel would be moving for the situation to occur. If impossible, state why.
   (a) $\alpha = 0$, $a_R = 0$
   
   (b) $\alpha = 0$, $a_R \neq 0$
   
   (c) $\alpha \neq 0$, $a_R = 0$
   
   (d) $\alpha \neq 0$, $a_R \neq 0$

2. For each case, supply the missing items (the description of the motion or the graphs).
   (a) Description:

   (b) Description: The rotating wheel slows down and begins to rotate in the opposite direction.

   (c) Description:
Activity A

In these experiments you will measure the angular velocity and angular acceleration of a flywheel. There is a silver strip on the edge of the wheel that you can use to mark the location of one point as the wheel spins. You can count the number of revolutions of the spinning wheel by watching as the silver tape passes a fixed reference point (such as the metal bracket that holds the wheel to the table). For future reference, measure the radius of the wheel and the radius of the hub.

Give the wheel a spin and start the timer when the tape passes your fixed point. Note the total elapsed time after the first revolution, the third revolution, the 10th revolution, and the 20th revolution. Using these times, determine the average angular velocity of the wheel in revolutions/second and radians/second for 1, 3, 10, and 20 revolutions.

Do these values agree with one another? What might account for any differences?

Which value would give the most precise result for the average angular velocity? Why?

Activity B

In this activity we will determine the angular acceleration of the wheel caused by friction in the wheel bearings. We will assume that the frictional acceleration is constant. Give the wheel a gentle spin, time 3 revolutions just after it starts rotating, and determine the average angular velocity. We'll call this value the initial angular velocity. Let the wheel spin for a few minutes, while you count the number of revolutions and measure the time interval. Then make another determination of the angular velocity for 3 revolutions. This will be the final angular velocity.

Using only the initial and final angular velocities and the waiting time interval, find the angular acceleration. Using only the initial and final angular velocities and the number of revolutions, find the angular acceleration.

During the interval of the waiting time, sketch the angular velocity and angular position as functions of the time.

________ Instructor’s check point

Ph 201, Lab 8, Page 3 of 6
Activity C

1. **Force exerted on hub.** Loop one end of the string over the peg on the hub of the wheel and wind the string around the hub. Attach a weight hanger with a total of 250 g to the string. Rotate the wheel until the weight holder just touches the ground, and note the angular position of the silver tape on the wheel’s rim. Now raise the weight by rotating the wheel exactly 5 revolutions. Measure the height of the weight above the floor.

You are going to release the wheel and allow the weight to fall to the floor. The weight produces a tension in the string that gives the wheel an angular acceleration while the weight is falling. After the weight hits the floor, the acceleration stops and the wheel should rotate with approximately constant angular velocity (if we can ignore the effect of friction in the wheel bearings). Be careful that the rotating wheel does not cause the string to wrap around the hub and raise the weight – the string should slip off the peg on the hub as the wheel rotates.

Release the wheel and measure the time necessary for the weight to hit the floor. Quickly reset the stopwatch and find the angular velocity of the wheel by timing 3 revolutions.

Using the final angular velocity and the time, calculate the angular acceleration. Using the angle through which the wheel turns and the time for the weight to fall, calculate the angular acceleration.

Using your best value of the angular acceleration of the wheel, find the tangential acceleration of a point on the hub of the wheel.

How is the vertical acceleration of the falling weight related to the tangential acceleration of a point on the hub? Explain.

Find the net force acting on the falling weight.

Find the tension in the string.
Is the force that causes the wheel to accelerate exactly equal to, nearly equal to, much greater than, or much smaller than the weight of the hanging mass? If necessary, sketch a free-body diagram of the hanging mass. Make a numerical comparison of these forces and explain the result.

2. *Force applied to rim of wheel.* Using a small piece of masking tape, attach one end of the string to the rim of the wheel. Wrap the string around the rim and attach the weight hanger with a total of 200 g to the string. Lower the weight to the floor and by rotating the wheel raise it by the same vertical distance you did in the previous experiment. You can determine the angle through which you rotate the wheel by careful observation of the silver tape, but you can calculate a more accurate value from the distance you raise the wheel and the radius of the wheel.

Make the necessary measurements and do the calculations to determine the angular acceleration of the wheel as the weight falls.

Find the tension in the string.

Compare your results for the angular acceleration and string tension from this measurement and the previous one. Explain any differences.
Activity A

Radius of wheel_________________  Radius of hub____________________

<table>
<thead>
<tr>
<th>Number of revolutions</th>
<th>1</th>
<th>3</th>
<th>10</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elapsed time (s)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg. angular velocity (rev/s)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg. angular velocity (rad/s)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Activity B

Initial time interval_________  Initial angular velocity_________rev/s  _______rad/s

Final time interval_________  Final angular velocity_________rev/s  _______rad/s

Waiting time_________  Angular acceleration_________rev/s²  _______rad/s²

Number of revolutions________  Angular acceleration_________rev/s²  _______rad/s²

Activity C

Part 1. Force exerted on hub

Distance of fall_________________  Time of fall____________________

Turning angle = 5 revolutions = ___________ radians

Time for 3 revolutions_________  Angular velocity_________rad/s

Angular acceleration: (from $\omega$, $t$)__________rad/s²  (from $\theta$, $t$)__________rad/s²

Part 2. Force exerted on rim

Distance of fall_________________  Time of fall____________________

Turning angle = _______ revolutions = ___________ radians

Time for 3 revolutions_________  Angular velocity_________rad/s

Angular acceleration: (from $\omega$, $t$)__________rad/s²  (from $\theta$, $t$)__________rad/s²