Walk-in Lab 10
Rolling
Physics 121

CID(s): ______________________

Description
In class I showed you a race between a disk and a ring rolling down a little wooden ramp. The disk won the race, and we decided it was because the ring had a larger moment of inertia. More of the ring’s mass was concentrated farther away from the rotation axis.

Today you get to recreate this race with the added bonus of measuring the speed at the bottom of the ramp. Have fun, work in groups of up to three people, and email me your ideas for making the lab better. See you in class, and have an great day.

Objective: To verify conservation of energy for rotating objects.

Equipment: carpeted ramp, some rolling things, photogate, meter sticks, air track, glider.

Part A
Let’s do a little sanity check and measure the conservation of energy for something that does not roll. The glider on the air track has almost no friction. If you measure the gravitational potential energy of the glider at the top of the track, it ought to equal its kinetic energy at the bottom of the track.

So put the glider on the track. Hold it at the top of the track. Measure how high it is from the table. Next, keep the glider on the track and hold it in the middle of the photogate. Measure how high the glider is from the table. The difference of these two numbers is the height $h$. Write your answer here:

$h = \text{_______} \text{ (m)}$

Now put the glider back at the top of the track, make sure the air is on, and let the glider slide to the bottom. Use the timer to measure how long it takes for the glider to pass through the photogate. The speed of the glider is equal to the length of the glider divided by your measured time. Write your answers here:

$L_{\text{glider}} = \text{_______} \text{ (m)}, \Delta t = \text{_______} \text{ (s)}, v_{\text{glider}} = L_{\text{glider}}/\Delta t \text{_______} \text{ (m/s)}$

Let’s see if this number makes sense. Use the conservation of energy ($mgh = \frac{1}{2}mv^2$) to calculate the speed of the glider at the bottom of the ramp. Write your formula here:

$v_{\text{calc}} = \text{____________________} \text{ (The formula goes here.)}$

Now plug in your number for the height and calculate the speed. Does it agree with what you measure? Write your answer here:

$v_{\text{calc}} = \text{_______} \text{ (m/s)}, \text{ and } \% \text{ error} = \text{_______}$

Part B
Now we are ready to roll, so to speak. You should have a ball, a disk, and a ring to roll down the carpeted ramp. We want to do the same thing here that we did with the glider. First, measure the height $H$ difference from the starting point to the photogate. Write your answer here:

$H = \text{_______} \text{ (m)}$

Measure the size of the three rolling objects. This will be the length of the object that passes through the photogate. If the photogate is aligned, the “length” of your object will be the diameter of the ball, the diameter of the disk, and twice the thickness of the ring (I think). Write your answers here:
Put these objects (one at a time) at the top of the ramp, reset the timer, and let the objects roll down through the photogate. Write your times for each of the objects here:

\[ \Delta t_{\text{ball}} = \text{__________ (m)}, \quad \Delta t_{\text{disk}} = \text{__________ (m)}, \quad \Delta t_{\text{ring}} = \text{__________ (m)} \]

Now use \( L/\Delta t \) to calculate the speed. Write your answers here:

\[ v_{\text{ball}} = \text{__________ (m)}, \quad v_{\text{disk}} = \text{__________ (m)}, \quad v_{\text{ring}} = \text{__________ (m)} \]

The last thing you need to do for this part is to use the conservation of energy to find out what the velocity should be. Because of rotational kinetic energy, the equation from Part A picks up an extra term. Now it is \( mgH = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 \). Look up values for \( I \) in your book (hopefully someone brought their book, or maybe someone wrote it down for you in the lab somewhere). Recall that \( \omega = v/R \) and rewrite the conservation of energy equation substituting in your expressions for \( I \) and \( \omega \). Do some arithmetical magic and find a new expression for \( v \). Write your formulas and calculated values here:

\[ v_{\text{ball}} = \text{__________________________ (the formula) and } v_{\text{ball}} = \text{__________ (m, the number)} \]

\[ v_{\text{disk}} = \text{__________________________ (the formula) and } v_{\text{disk}} = \text{__________ (m, the number)} \]

\[ v_{\text{ring}} = \text{__________________________ (the formula) and } v_{\text{ring}} = \text{__________ (m, the number)} \]

**Part C**

Summarize your results here:

<table>
<thead>
<tr>
<th></th>
<th>Equation</th>
<th>H</th>
<th>predicted ( v )</th>
<th>measured ( v )</th>
<th>% error</th>
</tr>
</thead>
<tbody>
<tr>
<td>glider</td>
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<tr>
<td>ball</td>
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<td>disk</td>
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<td>ring</td>
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