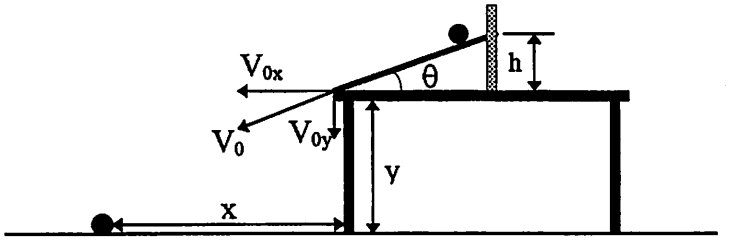
Energy of Rotation Lab Name_____ Period___

Purpose: The purpose of this lab is to apply energy conservation to objects that rotate and to review projectile motion.



Procedure: 1. Set up a ramp to roll a billiard ball down. The end of the ramp should be flush with the edge of the lab table. The angle the ramp makes with the horizontal should be between 15 and 30 degrees.
2. Record the ball's mass (M) and radius (R), the height of the top of the ramp above the table (h), the angle the ramp makes with the horizontal (θ) (use $\tan\theta = y/x$), and the table height (y) in the table below.

Trial #	M (kg)	R (m)	h (m)	θ (deg)	y (m)
1					
2					

3. Derive an equation for the ball's speed at the end of the ramp using the fact that energy is conserved. The potential energy at the top of the ramp will equal the sum of the translational (K_T) and rotational kinetic energy (K_R) at the bottom of the ramp (assume U=0 at bottom of ramp). Use $I = 2/5MR^2$ for the moment of inertia of a solid sphere. Use your equation to calculate the speed of the ball as it leaves the ramp (V_0) and enter it in the table below. Show your work neatly and clearly below.

Draw a free-body diagram of the billiard ball below. Sum the torques about the center OR the contact point and show that the acceleration of the billiard ball is:

$$\frac{5}{7}g\sin(\theta)$$

4. Using your knowledge of projectile motion, predict how far the ball will land from the end of the ramp (x). First, calculate V_{0x} and V_{0y}, the x and y components of the ball's velocity as it leaves the ramp. Use V_{0y} and the equation: $y-y_0 = V_{0y}t + 1/2at^2$ to calculate the time it will take the ball to land. Use V_{0x} and the equation: $x-x_0 = V_{0x}t$ to calculate the horizontal distance the ball will travel. Show your work below and record your calculations and prediction in the table below.

Trial	V_0	V_x	V_y	t	x	Actual x	% Error
#	(m/s)	(m/s)	(m/s)	(s)	(m)	(m)	(%)
1							
2							

5. Place a target on the floor so that the bulls' eye is where you predict the ball will land. Roll the ball and mark the target where the ball hits it. Measure the x distance from this mark to the edge of the ramp and record it in the above table. Calculate percent error where your prediction is the theoretical value. If you miss the target, find your calculation error before proceeding.

6. Repeat steps 1-5 for a second trial with a different ramp height and angle.

Questions: 1. Calculate the K_T of the ball and K_R of the ball at the bottom of the ramp for trial #1. What percent of the total energy is K_R?

2. If we used a hollow cylinder instead of a solid sphere, what percent of the energy would be K_R? Compare with the answer above and explain why the solid sphere will beat a hollow cylinder in a race. Hint: use the equations for K_R and K_T, not numbers.

3. If the ramp were frictionless, what would be V_0 of the ball for trial #1?