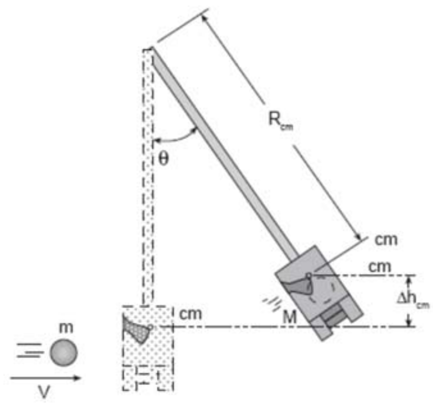
Ballistic Pendulum

Apparatus: Ballistic pendulums, ballistic pendulum accessories, projectile launchers, projectile accessories, projectile metal spheres, meter stick, photogate heads, photogate interface cables, PASCO Science Workshop 750 Interface & Power Supplies.

Purpose: To test the principles of conservation of momentum and mechanical energy.

Experiment 1 – Getting v_{th}



1. Take the pendulum off the support and measure the mass M of the pendulum and the mass m of the **metal** ball.
2. Determine the distance R_{cm} **from the pivot to the center of mass of the pendulum with ball in it** by finding the balance point.
3. Estimate the %error associated with finding R_{cm}.
4. Fire the ball into the pendulum 5 times and record the angle.
5. Use geometry to show that the center of mass rises to $\Delta h_{cm}=R_{cm}(1-\cos\theta)$.
6. Using conservation of energy, determine an expression for the combined ball and pendulum speed just **after** impact.
7. Using conservation of momentum, determine an expression for the speed of the ball just **before** impact.
8. Combine 5, 6, & 7 to get an expression for the theoretical speed of the ball. You final result should look something like: $v_{th} = \frac{m+M}{m}\sqrt{2???}$.
9. Determine v_{th} for each angle.
10. Use the AVERAGE and STDEV functions in Excel to determine the average and standard deviation of v_{th}. **If your standard deviation is ridiculously low, assume the precision of the experiment is given by the %error in your R_{cm}.**
11. Calculate the initial theoretical kinetic energy of the ball before the collision (using v_{th}).
12. Calculate the final experimental gravitational energy of the pendulum with ball in it (using Δh_{cm}).

Experiment 2 -Measuring the muzzle velocity directly.
1. Connect both photogates to the end of the spring gun using the special adapter. The ball will pass though the beams of the photogates just as it leaves the spring gun.
2. Assume the diameter of the ball is 25 mm.
3. Measure the distance between gates and enter that data on the constants page of DataStudio so the computer will compute the velocity for you.
4. Measure the “Velocity Between Gates”.
5. Shoot the ball several times and record the average value as your experimental velocity.

Conclusion:
1. Compare experiment 1 to experiment 2 with a %difference. Do you find that conservation of momentum and energy theories, when used appropriately, accurately determine the muzzle velocity? Compare %difference to %precision to discuss.
2. Friction tends to slow motion of both the ball and the pendulum. Will this cause your experiment to have more positive or more negative percent differences?
3. Compare the initial kinetic energy of the ball as it exits the cannon to the final potential energy. Is energy conserved? Should mechanical energy be conserved in this experiment? Should energy be conserved in the universe as a whole? Explain where the lost energy goes.
4. When one considers the ball and the pendulum as the system, are there any external forces acting on the system? Are there any NET external forces on the system during the collision?
5. To apply conservation of momentum to this problem, one must assume that the collision time is short. Explain why. Hint: think about the net external force after the rod starts moving upward…

Going Further: In this lab we see that the pendulum is swinging (which implies rotational motion). A better treatment is given on page 5 of: ftp://ftp.pasco.com/Support/Documents/English/ME/ME-6830/012-05375B.pdf.