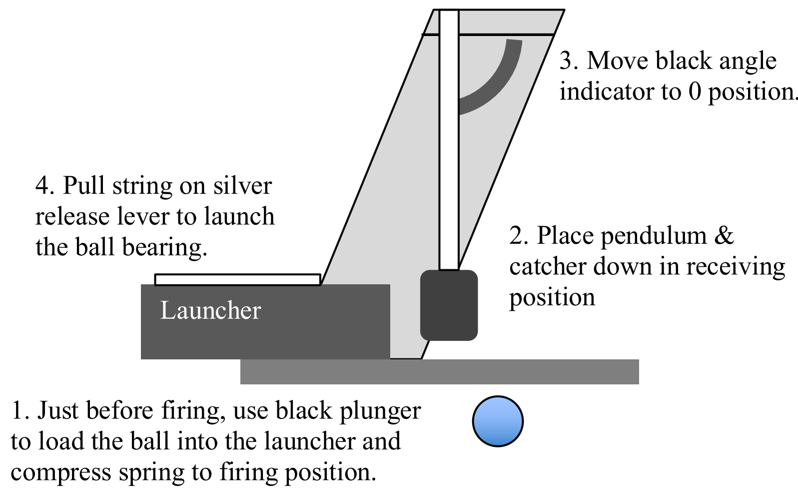
The Ballistic Pendulum
(or Conservation of Energy and Momentum in One Problem)

Background
Conservation of momentum and conservation of energy are two fundamentally important physics laws, and many common problems require the appropriate application of both.

Objectives
To experimentally determine, in two different ways, the "muzzle velocity" of a bullet leaving a gun. One approach will use a classic projectile-based, kinematics approach to finding v_{bullet} The other approach will involve using a "ballistic pendulum."

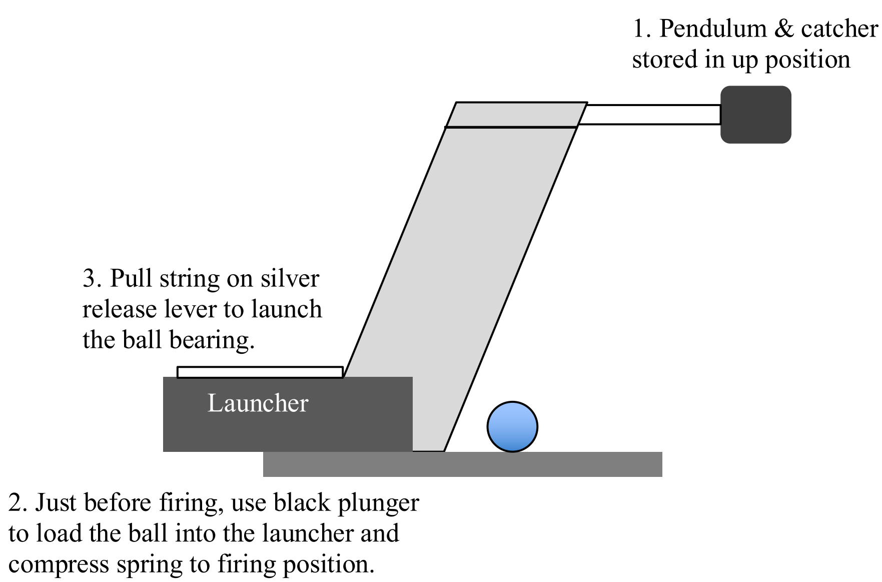
Equipment
Ballistic pendulum unit, w/steel ball (the bullet)
Meter stick
Balance

Procedure: Data Taking: This is two labs in one.



__Part A__ (the ballistic pendulum):

1.) In the first part, the ball will be forced down the barrel of the launcher. The pendulum arm with a catch at its end will be positioned so as to grab the ball once the launcher is fired. Once caught, the pendulum arm will swing upward executing some measurable angular displacement. The data required for this part is:
   a.) The mass of the ball;
   b.) The mass of the pendulum arm;
   c.) The length of the pendulum arm;
   d.) The angle the arm swings up after catching the ball.
2.) Following the instructions in class, collect and record the four bit of data required for this section.



__Part B__ (the device used as a gun to shot the ball out into the room):

1.) In the second part, a ball will again be forced down the barrel of a launcher. In this case, though, the pendulum arm will be removed so that when the launcher is fired, the ball will fly out into the room. The initial velocity, assumed in the horizontal, will be the launcher's muzzle velocity. The data required for this part is:
   a.) The ball's initial y-coordinate;
   b.) The ball's final x-coordinate.
2.) Following the instructions in class, collect and record these data.

Calculations:

Part A. Muzzle Velocity of the Ball using the Ballistic Pendulum;

1. When, during the experiment, is energy conserved? When is it NOT conserved?
2. When, during the experiment, is momentum conserved? When is it NOT conserved?
3. Use *conservation of momentum* and *conservation of energy* to derive a general algebraic expression for the muzzle velocity of the launcher. Blurb well, and be very careful about labeling your velocities.
4. Use you data to come up with a numerical value for the muzzle velocity of the launcher.

Part B. Muzzle Velocity of the Ball using kinematics:

5. Noting that the initial velocity in the x-direction was the muzzle velocity of the launcher (where the initial y-velocity was zero), use kinematics to derive a general algebraic expression for the muzzle velocity of the launcher.
6. Use your data to come up with a numerical value for the launcher's muzzle velocity.
7. Do a % comparison between the two muzzle velocities in #4 and #6.

Questions

1.) In a real CSI lab, which approach would be most reasonable to use in determining the velocity of a bullet coming out of a gun? Briefly explain.
2.) Was much energy is lost in the collision? Determine how much kinetic energy the ball had just before the collision and how much KE the ball and catch had just after the collision (OR the amount of potential energy the catch and ball had at the top of their arc). What % of energy was lost in the collision? What do you results tell you about energy loss in collisions of this sort?