Conservation of Momentum

Objective: To study the conservation of energy and momentum using projectile motion.

Theory: The ballistic pendulum is a wonderful way of demonstrating both the constant horizontal velocity in projectile motion and the conservation of momentum. Because there is no acceleration in the horizontal direction, the horizontal component v_x of the projectile's velocity remains unchanged from its initial value throughout the motion. In a closed isolated system if no net external force acts on a system of particles, the total linear momentum of the system cannot change. There are two simple types of collisions, elastic and inelastic. If the total kinetic energy of the two systems is conserved then the collision is known as elastic. If the kinetic energy is not conserved then the collision is inelastic.

$$H = \frac{g}{2} * t^2$$

$$x = v_x * t \qquad \rightarrow \qquad t = \frac{x}{v_x}$$

$$v_x = \sqrt{\frac{g}{2 * H}} * x$$

$$m_b * v_x = (m_b + m_p) * V$$

$$V^2 = 2 * g * h \qquad \rightarrow \qquad h = l * (1 - \cos\theta)$$

Apparatus: PASCO Ballistic pendulum, meter stick, level, carbon paper, sheet of white paper, plumb bob, clamp.

Procedure:

<u>Warning: Do not under any circumstance look into the barrel of the launcher. The people carrying out the experiment should wear safety googles at all times.</u>

Part 1: Projectile Motion – The goal is to determine the initial velocity v_x of the ball

1. Make sure the pendulum is secured by the clamp and does not slide on the table.
2. Lift the pendulum arm until it is fully horizontal so that the ball can freely fire from the spring gun.
3. Set the apparatus near the edge of a table and level the apparatus. If the plump bob is fully vertical and overlapping with the 0 degree line it means it is properly leveled. To secure the apparatus, make sure the clamp is properly positioned and tightened and the apparatus does not slide on the table.
4. Be sure that a clear path is set for the projectile "ball" to assure accurate results in the calculation of the distance.

5. The gun has three range settings (short, medium and long) and will make a clanking sound each time the spring reaches a range setting. Load the ball into the gun and push it to medium range setting using the plunger. (Note: The ball might come loose from the spring so make sure that it is properly secured in the hole by pushing and retracting the plunger softly)
6. Fire the gun by pulling on the trigger located above the cylindrical gun and locate an approximation of the impact on the floor.
7. Use two sheets of stapled paper with a carbon sheet in between. With the carbon sheet facing down, tape the sheets to the floor where the ball struck. Make at least three trials in the same range setting
8. Measure the horizontal distance from the muzzle of the launcher to the paper. (Note: The launch position of the ball is labeled on the side of the launcher)
9. Measure the vertical distance from the floor to the muzzle and record the height.

Part 2: Pendulum Swing – The goal is to determine the velocity V of the ball+block system

10. Release the pendulum to allow the ball to be fired and caught by the pendulum. Ensure that the angle dial is placed fully against the pendulum (Note: In some cases the needle will not go all the way to zero, in this situation, adjust your angle after collision by the value your needle is offset by.)
11. Fire the ball (using the same range setting as Part 1) into the ball catcher and record the readings on the angle dial to obtain the angle the pendulum rose to. Repeat this process three times.
12. Measure the mass of the ball and use the provided length (l_p=30cm) and mass (m_p=248g) of the pendulum.
13. Determine the horizontal speed of the projectile.
14. Calculate the momentum of the ball before collision and compare it to the momentum after collision.
15. Calculate the kinetic energy of the ball before impact and the kinetic energy of the ball and pendulum after the collision.
16. Compare the quantities and explain any discrepancies.

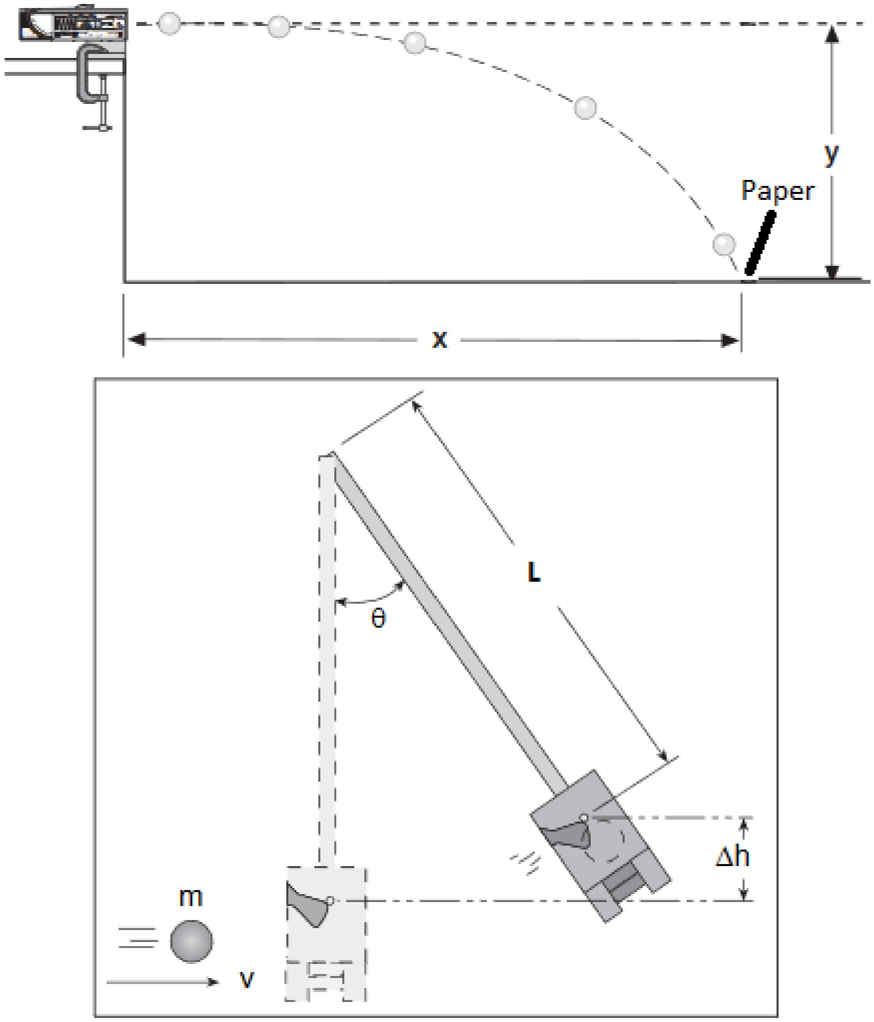

Figure 1. Trajectories for Part 1 (top) and Part 2 (below)