Lab Seven - The Ballistic Pendulum

Introduction

Versions of the ballistic pendulum date back to 1742. A projectile (bullet) is fired into a larger mass, and an inelastic collision takes place (the bullet is trapped in the target). The combined target/bullet then swings up to a height and then stops. Conservation of energy implies that the final potential energy will equal the kinetic energy just after the collision:

\[(M_t + m_b) g h = \frac{1}{2} (M_t + m_b) v_f^2\]

Where:
- \(M_t\) is the mass of the pendulum.
- \(m_b\) is the mass of the bullet.
- \(v_f^2\) is the velocity of the pendulum and bullet after the collision.

Some people may wonder why we don't simple set the final potential energy to the kinetic energy of the bullet. Since the collision is inelastic, that approach will underestimate the velocity of the bullet.

Even though energy is not conserved in the collision, momentum must be conserved. We can use this to compute the initial velocity of the bullet:

\[m_b v_i = (M_t + m_b) v_f\]

Where \(v_i\) is the quantity we are looking for, the initial velocity of the bullet.

Purpose:
To verify that energy conservation and momentum conservation can be used with a ballistic pendulum to determine the initial velocity of a projectile.

Equipment:
Ballistic pendulum, ruler, balance.

Procedure:
1) Set up: In this experiment a projectile is launched into a hanging “bucket” where it undergoes a perfectly inelastic collision. The projectile transfers momentum to the bucket. The combined mass (bucket + projectile) comes to rest at a height that is measured. This height should represent the potential energy of the system and is equivalent to the kinetic energy of the bucket + projectile immediately after the collision.
3) Measure the mass of the brass ball projectile and the pendulum (it can be removed from the support rod).

4) Data Collection: Fire the projectile into the pendulum bucket and record the height of the center of mass of the pendulum + projectile after it comes to rest. Repeat as many times you find necessary.

5) Calculations: Working backwards, use conservation of energy to determine the velocity of the pendulum + projectile immediately after the collision. Then use conservation of momentum to find the velocity of the projectile before the collision.