M21a: Conservation of Momentum

Introduction:

The data collected during this experiment will permit testing the conservation laws for momentum. The event examined is a collision utilizing an apparatus called a ballistics pendulum. The collision is between a horizontally projected ball and a stationary pendulum. The pendulum for this experiment will catch and hold the ball as the collision occurs. Using a rough approximation model of the pendulum and ball after the collision as a horizontally moving body, allows verification of conservation of linear momentum. The data collected during the experiment will be used to determine the linear momentum before the collision and separately after the collision. Additionally the kinetic energy before the collision and separately after the collision will be determined. Comparison of the data and results, before verses after, will illustrate the conservation principles involved during this type of collision.

Apparatus:

- Ballistic Pendulum
- Computer Timing System
- Digital Calipers
- 2 Photogates
- Ruler
- Plastic ball
- Plastic Container (to catch ball after firing)

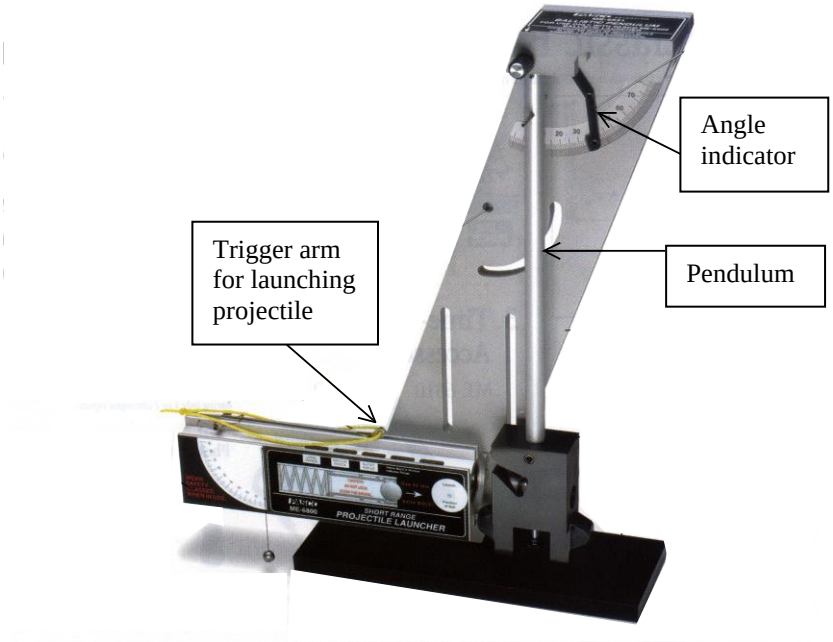

Figure 1

Discussion:

The following equations will prove necessary to calculating out the different velocities and the kinetic energies and momentums for this experiment. For more information on their derivation, please reference the chapter/section of the physics textbook on ballistic motion, momentum, and collisions.

Initial Velocity: $v_i = \frac{d}{t}$

Final Velocity: $v_f = \sqrt{2gR(1 - cos\,\theta\ )}$

Initial Kinetic Energy: $KE_i = \frac{1}{2}mv_i{}^2$

Final Kinetic Energy: $KE_f = \frac{1}{2}(M + m)v_f{}^2$

Initial Momentum: $P_i = mv_i$

Final Momentum: $P_f = (m + M)v_f$

Procedures:

1. Make the following initial measurements: the mass of the ball, the mass of the pendulum, and the radius of the pendulum (from its pivot point to the center of mass).
2. Remove the pendulum from the apparatus and position the photogate assembly in front of the projectile launcher.
3. Open the appropriate data collection program on the computer.
4. Load the plastic ball into the ballistic pendulum.
5. Use the digital calipers to measure the distance from the outer edge of one photogate eye to the 2nd photogate eye, and record this distance as the distance for the first trial.
6. Conduct ten trials firing the ball through the photogate assembly, recording the time that it took the ball to pass through the photogate for each trial. It will also be necessary to re-measure the distance between the photogate eyes for each trial, as this distance will change somewhat each time after the plastic ball is fired.
7. Use the times and the distances recorded in order to calculate the initial velocity of the ball for each trial. Also calculate the mean velocity for all 10 trials, and the standard deviation for each velocity.
8. Make use of this mean velocity from the first ten trials in order to calculate the initial kinetic energy and the initial momentum of the plastic ball as it is ejected from the firing mechanism toward the pendulum.
9. Remove the photogate assembly and mount the pendulum so that it swings freely. Check that the pendulum, when hanging steady-state, is not touching the projectile launcher prior to firing. Move the angle indicator down towards zero.
10. Conduct ten trials firing the ball into the pendulum and measuring the maximum angle of swing.
11. Use the angle for each trial, as well as the equation provided in the discussion section, in order to calculate the final velocity of the ball and the pendulum for each trial.
12. Once the velocities have been calculated for each trial, calculate the mean velocity, the standard deviation of the mean velocity, and also the final kinetic energy and momentum of the plastic ball and the pendulum. How does the initial momentum of the ball compare to the final momentum of the ball and the pendulum.

Experiment M21a: Conservation of Momentum

Student Name_____

*Lab Partner Name*_____

*Lab Partner Name*_____

Physics Course_____

Physics Professor_____

Experiment Start Date_____

Lab Assistant Name	*Date*	*Time In*	*Time Out*

Experiment Stamped Completed

Data Sheets: M21a: Conservation of Momentum

NAME: _____ DATE: _____

Mass (*m*) of the ball:_____

Mass (*M*) of the pendulum:_____

Radius (*R*) of pendulum (pivot to center of mass):_____

trial	time (t) (s)	distance (d) (m)	velocity (v_i)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
mean velocity v_i			
standard deviation			
KE_i			
P_i			

trial	θ *(degrees)*	velocity (v_f)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
mean velocity v_f		
standard deviation		
KE_f		
P_f		