MAD 10/96
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Experiment 6 – Ballistic Pendulum

Equipment

- Ballistic pendulum apparatus.
- Meter stick, 2-meter stick.
- Balance.
- $8\frac{1}{2} \times 11$ paper.

Introduction

The ballistic pendulum involves firing a projectile at a pendulum which is free to rotate. The change in height of the pendulum plus projectile can be translated back into the initial kinetic energy of the pendulum plus projectile. Then, knowing that the collision between the projectile and pendulum is inelastic, the initial velocity of the projectile can be calculated. Whether or not this velocity has anything to do with reality can be tested through some simple projectile motion tests.

Theory

If the pendulum plus projectile (total mass $M = m_1 + m_2$ rises to some height Δh, conservation of energy tells us that

$$Mg\Delta h = \tfrac{1}{2}MV^2.$$

Furthermore, in an inelastic collision between a projectile (mass m_1) moving with some velocity v and the pendulum (mass m_2) at rest, conservation of momentum tells us that

$$(m_1 + m_2)V = MV = m_1 v.$$

These two equations allow us to relate the change in height of the pendulum plus projectile to the initial speed of the projectile.

Q1. Solve these two equations to determine v in terms of the quantities we will be measuring [that is, m_1, m_2 (or M), and Δh] and g.

Procedure

1. Remove the pendulum arm from the ballistic pendulum apparatus. There is a knurled nut that allows for easy removal. Using a balance, measure the mass of the metal ball as well as the mass of the pendulum arm to the nearest 0.05 g. Reattach the pendulum arm.

mass of ball	
mass of arm	
mass of ball+arm	

2. Measure the initial height of the pendulum using some convenient reference point (such as the tabletop) and some easily recognizable point on the pendulum itself.

3. Cock the gun, place the pendulum in front, and fire when stationary. Measure the final height of the pendulum.

4. Repeat steps 2 and 3 *at least 10 times.* Compute the average values for the initial and final heights and use them to determine Δh.

Trial	initial height	final height
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
Average		

$\Delta h =$ _____

5. Using the values of Δh and the masses, compute the initial velocity of the projectile. Pay attention to units and significant figures.

computed velocity of projectile	

6. Using the desk in the front of the lab, set up your pendulum apparatus to fire the projectile horizontally (remove, or otherwise get the pendulum out of the way). Measure the initial height of the projectile above the floor.

initial height of projectile	

Q2. Using the velocity found in step **5** and the usual kinematic equations (you do remember chapter 2, right?), calculate how far the projectile will travel horizontally. (HINT: First find out how long the ball will be in the air. Then determine how far it will fly.)

predicted range of projectile	

7. Place an $8\frac{1}{2} \times 11$ sheet of paper at that point and fire the projectile. When measuring the horizontal distance, don't forget to include the distance along the top of the table to the point where the ball is being fired from in addition to the distance from the edge of the table.

Q3. Did you hit the paper? If not, did the ball hit sooner or later than expected?

8. When you find the correct place for the paper, tape it down, and repeat several times. Record the horizontal position where the ball hits the ground. You should be able to measure this easily by looking for the mark that the ball makes on the paper.

Trial	measured range of projectile
1	
2	
3	
4	
5	
Average	

9. Use the kinematic equations, the initial height, and the measured range of the projectile to compute the initial velocity of the ball. (HINT: For a horizontal launch, the time of flight of the ball depends only on its initial height, not its initial velocity.)

computed velocity of projectile	

Q4. How do the velocities computed in steps **5** and **9** compare?

Q5. Does the fact that the entire mass of the pendulum is not rising to the same height affect the velocity you calculate the first way?

How would you have to adjust the placement of the paper in step **7** to correct for this effect?

Is this the same as the adjustment you actually had to make?