**Determining the Initial Velocity of a Projectile**

**Abstract**

The purpose of this lab was to experimentally determine the initial velocity,  of a projectile fired from a spring gun. This was done by two different methods. Method one involved the capture of a projectile in the bob a ballistic pendulum, and measuring the angle created by the force using conservation of linear momentum. The second method involved measuring the horizontal distance traveled by the projectile using kinematic equations.

**Introduction**

In this lab, the initial velocity of an approximately spherical ball shot from a spring gun, was experimentally measured by observing the angle created by the ballistic pendulum, through an inelastic collision and application of conservation of linear momentum, achieved though mechanical energy transferred to a ballistic pendulum. Using the equation , which gives us the initial velocity .

(1)

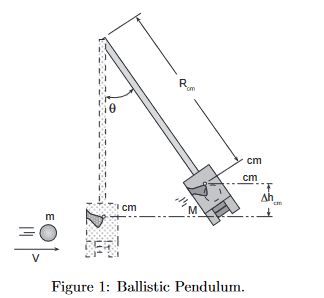
However, we do not yet have a solution for . After the projectile impacts, the pendulum leaves its rest position and swings up with the force imparted by the inelastic impact to a position . The kinetic energy of the system can be measured by the formula . When the pendulum reaches its highest position, a marker is left indicating the angle it forms with the vertical. At this point the kinetic energy is zero and is converted to gravitational potential energy . In this experiment we consider the energy lost to friction negligible, then the kinetic energy is equal to the potential energy, and therefore , and we can solve for the velocity .

(2)

Next, we measure the distance *R* from the pivot point to use the center of mass (cm) of the pendulum, and the angle *θ* which the pendulum creates from the vertical. The relation between *θ* and the vertical position of the pendulum is measured as . From this we derive the equation.

(3)

By using the equations, we have gathered so far, we can derive . From here we can enter the values retrieved through experimentation.



**Data**

For method one, the angle measured *θ* from ten shots was recorded. This angle was measured using the indicator attached to the ballistic pendulum and is accurate to ± 0.5°. The uncertainty in *θ* indicates the precision of the scale on the ballistic pendulum.

In the first part of the lab the position of the ballistic pendulum was fixed and measurements were taken visually according to the scale on the pendulum. The projectile was fires ten times and the angle was measured. The table below gives the values of the angle in degrees and the measure of rounded to four decimal places.

|  |  |  |
| --- | --- | --- |
| Shot number | Θ° |  |
| 1 | 49.5° | 0.3506 |
| 2 | 50° | 0.3572 |
| 3 | 49° | 0.3439 |
| 4 | 49° | 0.3439 |
| 5 | 50° | 0.3572 |
| 6 | 49.5° | 0.3506 |
| 7 | 48.5° | 0.3374 |
| 8 | 49.5° | 0.3506 |
| 9 | 49.5° | 0.3506 |
| 10 | 49° | 0.3439 |

In the second part of the lab the height was fixed at , and the projectile was fired ten times. was measured with a meterstick and was 0.0005 m. The distance to impact was also measure by meterstick and was again 0.0005 m. The distance is given by the table below.

|  |  |
| --- | --- |
| Shot number |  |
| 1 | 2.263 |
| 2 | 2.266 |
| 3 | 2.270 |
| 4 | 2.271 |
| 5 | 2.277 |
| 6 | 2.284 |
| 7 | 2.285 |
| 8 | 2.293 |
| 9 | 2.282 |
| 10 | 2.282 |

The uncertainties in the values above are ±0.0005 m for the lengths. These uncertainties indicate the precision of the instruments used to take the measurements.

**Data Analysis and Results**

For the first part of the lab, the data shown in Table 1 was used to find the average angle = 49.35° and precise to. Because multiple measurements were made for the angle, its uncertainty is found by dividing the standard deviation, σ, by the square root of the number of trials, in this case. The standard deviation is given by the equation

Using the standard deviation, the uncertainty in angle is is 0.15°. The uncertainty in (1-cosθ) was found using a similar method to give us = 0.0018°

The length of R was then measure to be 0.2656 m with an uncertainty δR of 0.0005 m using a ruler. (1-cosθ) = 0.3485 and δ(1-cosθ) and the average initial velocity is given by the earlier equation

The uncertainty in is given by error propagation rule 4

=

This yields the result

For part one of the lab.

In order to determine in part tow of the lab, we made a table of values for the distance the ball traveled from the spring gun to the impact on the floor. This was given in Table 2. The uncertainties in ( the height to the floor) was taken from the meterstick ruler which hold a precision of 0.0005 m

The average distance the ball traveled was taken from the average of ten shots and used the standard deviation, σ, to find the uncertainty

=

Because we took multiple measurements of error of propagation rule 4 was used

The result was an uncertainty in

Using the formula for velocity

We get the resultant

**Conclusions**

The purpose of this lab was to experimentally determine the initial velocity of a projectile using the laws of conservation of momentum and conservation of energy. This was in two ways, first by firing a ball into a ballistic pendulum and using conservation of momentum to measure its initial velocity, and second by measuring the horizontal distance when launched from a measurable height to find its initial velocity. The result for part on does not agree with the second experimental initial velocity because the uncertainty falls outside of the range of the two answers.