Report on projectile motion

Engineering, Aviation

Abstract

The objective of this laboratory experiment is to examine the qualities of projectile motion. Considering the movement of a steel ball in the horizontal plane, the initial velocity that is possessed by the steel ball can be ascertained from the assessed range. Considering the assumed initial velocity of the steel ball, the range of the projectile will be assessed for a variety of initial angles. The initial angles and will be computed by the application of the theory with regards to motion for constant acceleration.

THEORY

Considering a given initial speed demonstrated by v0→, with an initial velocity demonstrated by s0→ that is also the location of a particle s→, that is a function of time that is experiencing a constant acceleration, a→ is detailed by:

s→ = s→ + v0→ t + ½ a→t2

The mathematical equation is a vector equation and can be decomposed into its components in the x, y, and z planes. Considering the motion is taking place in a plane, only the x and the y components will be considered. In the event that the air resistance is not considered, the acceleration in the y plane would be equivalent to – g. The – g represents the force of gravity upon the projectile. . The acceleration that is being manifested in the x plane is zero. Consequently, the vector equation is decomposed into two scalar equations:

x = x0 + v0xt

y = y0 + v0t – ½ gt2

In the context of the angle θ, with an initial speed v0, the initial sped components are represented by the equations:

v0x = v0cos θ

v0y= v0ysin θ – gta.

The mathematical formula is considering that then angle of projection is represented by θ, the component of the gravitational acceleration is represented by g, where g is equivalent to 9. 8 m/ s2 in a direction towards the center of the Earth. The coordinates in the horizontal and vertical planes are demonstrated as the following:

x(t) = x0 + v0xt = x0 + v0cos θt

y (t| = y0 + v0t –gt2/ 2 = y0 + v0 sin θt –gt2/ 2

The trajectory of the projectile is derived and time is eliminated by the application of the following formula;

y= y0 + tan θ * x – g * (2v02 cos2 θ)-1

This is applicable for the circumstance where x0= 0 (Lea & Burke 2. 1. 4; Lea & Burke, 3. 1).

Next the phenomenon of air resistance will be considered. The friction that is provided by the air responds in order to decelerate objects. An effective estimate of the force that is experienced as a result of the air resistance is correlated to the speed of the object. . The equation that represents air resistance is delineated as f →air = -cv→. In the event that there is no additional force besides the friction of the air that is exercised upon the object, Newton’s second law becomes applicable in the expression

-cv→ = m dv→/ dt

This expression is considering that c is the correlated constant that is assumed by the dimensions and the form of the object in addition to the viscous nature of the atmosphere. Consider that the minus sign manifests that friction is an opposing force with regards to the component ds of velocity. In performing division upon the two sides of the equation by the weight provides:

$-c\vec{v}/ m = m\, d\vec{v}/dt$

The final form of the equation is demonstrated as;

$v\vec{a} = c\vec{v}\ at / m$

The objective of the experiment is to formulate a two dimensional paradigm of the projectile's motion in the x and y planes by applying Excel. The correct time step for the graphical model will be delineated in the absence of the consideration of the friction that is exerted by the air. . In the second activity, the air resistance will be considered and the resistance provided by the air as a coefficient manifested by c/ m (Lea & Burke 2. 1. 4; Lea & Burke, 3. 1).

Procedure

Data collection

One of the laboratory associates will propel the ball from the barrel of the Pasco ball launcher. The other laboratory associate positioned a clean piece of paper on the place where the ball hits the ground. The upper portion of the sheet of paper will be positioned with a segment of carbon paper. The carbon paper was applied in order to document the ball's concluding position as a mark on the carbon paper. There were a total of ten launches conducted in this laboratory experiment.

1. 2

The associates ensured that the following items of information are documented in the laboratory book

- The weight of the ball (m) = 9. 6 g

- The angle of the initial launch θ. = 40. 1°

- The height that is manifested by the launcher. This is the distance from the floor to the launcher = 0 121. cm

- The elapsed time in order for the ball to pass the interval of the photo grate.

- The ball was loaded on the aperture of the launcher as demonstrated in figure 1.

Figure 1: Pasco ball launcher

http://www. ayva. ca/images/products/me/ME6800_330_34733. jpg

The ball was placed into the barrel of the Pasco ball launcher. In order to modify the launch angle or the elevation, the vertical clamp was unscrewed on the launcher base. The desired angle was determined by viewing the angle from the scale that is inscribed on the lateral façade of the launcher. The clamp was fastened. The photo gate was inspected that was positioned at the aperture of the launcher. The light bean was eniusr4ed to time the ball as it passed.

1. 4

The photo timer was connected to the instrument panel. It was reviewed that the Input holding switch was positioned on the inactive position. The power for the launcher was ensured, and the timer was positioned to the gate setting.

Figure 2: estimating the trajectory with a dotted line.

http://www. Pascocanada. com/images/site_images/diagrams/ME-8930-Illus3-4_275_39890. jpg

1. 5

The next step was to test the system. The timer was ensured to be maintained on in the rest position n subsequent to each of the launches. The associates made sure to maintain distance from the barrel of the Pasco Ball launcher. The yellow lever designated l was pulled in order to act8vate the release of the launcher spring. The ball flew freely until landing on the floor. The projectile was installed on the table as demonstrated in Figure 2. . The landing of the steel ball was observed. A pace of carbon paper that had a piece of white paper on top was positioned on top in order that the horizontal distance that extended from the mouth of the Pasco ball launcher to the positioned where the ball made contact with the ground could be assessed with a meter measuring stick .

1. 6

A total of ten launches were conducted at identical angles and spring locations.

1. 7

The time t0 was measured for the ball to intersect the light beam of the photo flashes. This was conducted while considering the most expansive cross sectional segment, d. The st6arting velocity for each of the trials was calculated by applyy9ing the following equations

V0 = d/ t0

1. 8

Subsequent to extracting the paper from the floor, the associates placed a reference mark labeled R on the upper side of the paper and inscribed a line representing the x- axis opposite the launcher. The lateral shifts of the spots with regards to x were not considered.

1. 9

In order to measure the complete horizontal distance that had been traveled by the steel ball, the laboratory associates proceeded as follows. A meter measuring stick was applied in order to determine the distance from the position on the floor that was directly beneath the mouth of the Pasco ball launcher. This distance was measured from the location that was beneath the Pasco ball launcher to the initial point that was drawn on the laboratory floor. The x- coordinates were placed at each of the ten marks in relation to the initial origin x R. The mathematical formula was given:

X = 1+ xR

This mathematical formula was applied in order to ascertain the range.

2.

A spreadsheet was subsequently established that demonstrated the mathematical coordinates of the ball’s trajectory. The pertinent formulas were entered into the computer. The distinct parameters for the behavior of the system that was predicted matched the actual measurements. . In the first activity, the time step was adjusted in order to establish that the uncertainty possessed the identical minute uncertainty as the actual s system.

Stdev. = (1/ 10 Σ (7. 5 + 6. 2 + 7. 9 + 8. 5 + 8 + 7. 5 + 6. 35 + 9 + 7. 8 + 8. 5) ½ = 2. 77938842194 cm.

The terminal speed of the steel ball is 33 m/s. It takes abou6t 9 seconds for the steel ball to reach the terminal speed.

- .(Appendix)

All objects will not have the same terminal speed. Terminal velocity is acknowledged as when the dragging force that is a result of the object experiencing movement through the air is equivalent but opposed to the force of gravity. Considering that the gravitational force is in a proportion to the mass of the object, the dragging force is independent of the mass of the object. The dragging force pertains to the quality of streamlining that an object may have. It can be assumed that an item A possesses twice the weight of object b. In the event that item A undergoes two times the dragging force as object B, the assessed terminal velocities will be equivalent (Lea & Burke 2. 1. 4; Lea & Burke, 3. 1).

In other words if the two objects possess identical weights they wail experience the identical gravitational forces. The inquiry remains: would the two objects possess identical drag forces? The dragging force is derived from the resistance of the atmosphere to the movement of the item. Therefore, considering all things equivalent, an item that possesses a more streamlined quality will manifest less resistance. In the event that an object is formed in the shape of a bullet and another item has the form of a hollowed ball, the hollowed ball will possess an identical characteristic of drag at the lower velocities as the bullet would possess at the higher speeds (Lea & Burke 2. 1. 4; Lea & Burke, 3. 1).

Consequently, the terminal velocity of the hollowed ball would be significantly less. A hammer will have greater terminal velocity than a feather. This is attributed to the streamlined shape and the mass of the hammer. A baseball will have a greater terminal speed than a basketball. This is attributed to the effect that the basketball has a larger surface area. Consequently, the basketball would experience a greater force of drag (Lea & Burke 2. 1. 4; Lea & Burke, 3. 1).

Error Analysis

The error in the laboratory experiment could have been attributed to a number of causal attributed. The Pasco ball launcher could have a lag in reading the movement of the items that pass the photo counter. In addition, there is a margin of error that must be considered for the use of the meter stick. This margin of error for a meter stick is usually ± 1mm. In addition, the gram scale could have a margin for error of ±0. 1 grams. All of these uncertainties could have contributed to the error in the laboratory experiment.

APPENDIX

Works Cited

Lea, Susan and John Robert Burke. Physics: The nature of things, Volume 1. Brooks/ Cole Publishing Company, 1998. Print.