**1.Theory:**

**Projectile Motion:**

Projectile is defined as any body is thrown with some initial velocity, which is then allowed to move under the action of gravity alone without being propelled by any engine or fuel. The path followed by a projectile is called its trajectory. A projectile moves at a constant speed in the horizontal direction while experiencing a constant acceleration of 9.8 m/s2 downwards in the vertical direction. To be consistent, we define the up or upwards direction to be the positive direction. Therefore the acceleration of gravity is, -9.8 m/s2.

As the fig.1 shows the trajectory of a projectile is parabolic. A research on projectile motion helps in a through understanding of the basic concepts in kinematics like accelerated motion, uniformed motion and so on.

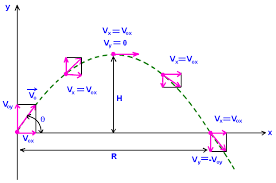


Figure 1: In x-y plane there is the parabolic trajectory of a projectile. The projectile is thrown with an initial velocity v0 and angle ϴ with the x-axis. R and H respectively represent the range and maximum height of projectile.

**Collision:**

We know that collision occur when one object hits on anther object. We are familiar with two types of collision. Inelastic collision and Elastic collision. When inelastic collision occur then only momentum preserved. But when Elastic collision occur then momentum and kinetic energy preserved. The figure which is the bellow show the elastic collision between a ball and a fixed smooth surface.

Figure 3.2: An elastic collision between a smooth ball and a table

In the figure we saw an elastic collision between a smooth ball and a table. After the collision velocities are same as before. We know that for an elastic collision, both the momentum and kinetic energy are conserved. We can impulse in any dimension (x or y) which defined as Impulse, J = Change in momentum, Δ p = 𝑝𝑓 − 𝑝𝑖 where 𝑝𝑖 and 𝑝𝑓 are the initial and final momentum, respectively.

**2. Apparatus**

1. Marble

2. Ramp

3. Clamp

4. Recording paper

5. Carbon paper

6. Meter scale

7. Weighing scale

**3. Procedure**

**1.** Firstly, we set up the apparatus as like shown in fig. 3.3. We properly make sure that the end of the ramp looks level with the table. Otherwise, we will not get the perfect result of our expectation. Then we lay down a piece of recording paper on the floor and next we place a sheet of carbon paper on top. So, each bounce of the ball will leave a mark on the recording paper.

**2.** Once the apparatus is fixed perfectly, then we do not move the recording paper until the data collection is completed. If we do that, we will not get the ideal value. However, our carbon paper can be lifted at any time to inspect the collision points. The we locate the position O on the floor using the marble ball and collect measure the distance from O to a reference point on the recording paper. After doing that, this allows the paper to be moved after the data collection is completed to a more suitable location for the measurements of S1 and S2.

**3.** So, after collect the data, we release the ball from a point near the top of the ramp, being careful not to impart spin on the ball. Because this allows us to find the ball to roll down the ramp and bounce on the floor with minimal spin. We do that procedure repeatedly 10 times always releasing ball from the same point on the ramp.

**4.** Finally, we get the measure of the heights h and H with the help of a meter scale as accurately as possible.

**5.**From the recording paper, we obtain the average values of S1 and S2 in the following way. By eye, we able to determine the circular region that include most of the marks on the paper (ignore any points that are obviously anomalous). Next, we draw the accurate circle around this region. Then we determinate to take the center of the circles for S1 and S2. So, the radius of the circles as the uncertainties in S1 and S2.

**6.**At last, we measure the mass of marble.

**4.Experimental Data:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Height h    (cm) | Height H    (cm) | Average Distance,  S1  (cm) | Uncertainty in  S1  (cm) | Average Distance,  S2  (cm) | Uncertainty in  S2  (cm) | Mass of  Marble m  (gm) |
|  |  |  |  |  |  |  |

**5.Analysis and Calculation:**

Keep in mind that the horizontal velocity 𝑣𝑥of the ball before impact at 𝐴equals the horizontal velocity immediately after the rebounds from 𝐴. This is a good assumption providing the working table-floor is smooth. Using table 3.2 according to the fig. 3.3 calculate the quantities in table 3.3 and 3.4. Table 3.2: Equations of motion for one dimensional and two-dimensional (projectile) motion.

|  |  |  |  |
| --- | --- | --- | --- |
| **Quantity** | **Straight line (one dimensional) motion** | **Projectile (two dimensional) motion** | |
| **Horizontal component** | **Vertical component** |
| Initial velocity | u | v0x=v0cosθ0 | v0y= v0sinθ0 |
| Acceleration | a | ax= 0 | ay= -g |
| Velocity at any point | v = u + atv2= u2+ 2as | vx= v0x | vy= v0y–gt  vy2= v0y2–2gy |
| Distance | s = vt (constant velocity)  s = ut + ½ at2 | x = v0xt | y = v0yt –½ gt2 |

|  |  |  |  |
| --- | --- | --- | --- |
| SN | Quantities | Corresponding Equations | Values with Units |
| 1 | Time for the ball to leave the ramp and hit the point A |  |  |
| 2 | Constant Horizontal velocity of the ball |  |  |
| 3 | Vertical velocity just before it strikes the point A |  |  |
| 4 | Velocity of the ball just before it strikes the point A in vector form |  |  |
| 5 | Range of the second projectile = Distance between point A and B |  |  |
| 6 | Time of the ball spends between point A and B |  |  |
| 7 | Maximum height for the projectile between point A and B |  |  |

**6.Results:**

Table (3.3): Some basic quantities related with projectile motion

|  |  |  |  |
| --- | --- | --- | --- |
| SN | Quantities | Corresponding Equations | Values with Units |
| 1 | Magnitude of the velocity before/after impact at point A |  |  |
| 2 | The angle that the ball makes with the surface just before/after the collision at point A |  |  |
| 3 | Kinetic energy of the ball before the collision at A |  |  |
| 4 | Kinetic energy of the ball after the collision at A |  |  |
| 5 | Horizontal impulse that the floor gives to the ball |  |  |
| 6 | Vertical impulse that the floor gives to the ball |  |  |

Table (3.4): Some basic quantities related with elastic collision between ball and the fixed surface

**7.Discussion:**

It is normal thing that if we going to do some experiment, we face some difficulties. Here we also face some difficulties. Most of the uncertainty in recording time of flight came from deciding the time for the first data point when the ball is in the air and the last data point before it hit the ground. We estimated that we could be off by one frame. To get a better estimate of this uncertainty, we repeated each measurement many times. The average deviation served as our experimental uncertainty. Our experiment indicates that the time of flight is independent of the ball’s initial horizontal velocity. Air resistance was another obstacle while taking the value. Sometimes we were unable to find out the accurate value. After doing everything properly we were able to get every measure value perfectly and do the experiment accurately

**8.References:**

• Lecture Slide

• Lab Manual

**9.Appendices:**

In conclusion, we can confirm that the equation properly predicts the trajectory of an object with 2-dimensional projectile motion. This means that only the initial velocity and launch angle of an object are needed to predict its trajectory. In addition, to confirming this, we now know that there are mathematical relationships between various aspects of the object’s trajectory and the launch angle of the object. These mathematical relationships include a quadratic relationship between range and launch angle, a cubic relationship between maximum height and launch angle, and a radical relationship between flight time and launch angle.