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**AMERICAN INTERNATIONAL UNIVERSITY–BANGLADESH (AIUB)**

**FACULTY OF SCIENCE & TECHNOLOGY**

**DEPARTMENT OF PHYSICS**

**PHYSICS LAB 1**

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**Section: J , Group: 1**

**LAB REPORT ON**

***Study of projectile motion and collision****.*

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1. **Theory:**

**Projectile Motion:**

The motion of projectiles, known to mankind since the times of Archimedes, is an example of

two-dimensional motion. This motion occurs in a vertical plane defined by the direction of

launch. In the simplest case (when air resistance is neglected and motion occurs close to the

surface of earth), the projected body experiences a uniform acceleration along the vertical

direction and a uniform velocity along the horizontal direction.

The trajectory of a projectile is parabolic as the fig. 3.1 shows. A study on projectile motion

helps in a thorough understanding of the basic concepts in kinematics like accelerated motion,

uniform motion, equations of motion and so on.

**Diagram

Description automatically generated**

Figure 3.1: The parabolic trajectory of a projectile

In the fig we saw that parabolic trajectory of a projectile in the x-y plane. We throw projectile with an initial velocity and angle θ with the x axis. Here we define R and H which are represent the range and maximum height of the projectile, respectively.

**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.

Diagram

Description automatically generated

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 =

where and are the initial and final momentum, respectively.

1. **Apparatus**
2. Marble
3. Ramp
4. Clamp
5. Recording paper
6. Carbon paper
7. Meter scale
8. Weighing scale

1. **Procedure**
2. 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.
3. 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.

Diagram

Description automatically generated

1. 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.
2. Finally, we get the measure of the heights h and H with the help of a meter scale as accurately as possible.
3. 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.
4. At last, we measure the mass of marble.

1. **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)** |
| 53 | 15 | 33 | 5.5 | 72 | 10 | 5.7 |

1. **Analysis**

The horizontal velocity Vx of the ball before impact at A equals 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 to calculate the quantities in table-3.3 and table-3.4.

|  |  |  |  |
| --- | --- | --- | --- |
| **Quantity** | **Straight line**  **(One dimensional)**  **motion** | **Projectile ( two dimensional ) motion** | |
| **Horizontal**  **Component** | **Vertical**  **Component** |
| Initial velocity | u | v0x=v0cos0 | v0y=v0sin0 |
| Acceleration | a | ax=0 | ay=-g |
| Velocity at any  point | v = u+at  v2=u2+2as | vx=v0x | vy=v0y-gt  vy2=v0y2-2gy |
| Distance | s = vt (constant velocity)  s = ut + at2 | x = v0xt | y = v0yt – gt2 |

1. **Result**

|  |  |  |  |
| --- | --- | --- | --- |
| **SN** | **Quantities** | **Corresponding Equations** | **Values with Units** |
| 1 | Time for the ball to leave the ramp and hit the point A | t = | 0.329 s |
| 2 | Constant Horizontal velocity of the ball | vx = | 1.0030 m/s |
| 3 | Vertical velocity just before it strikes the point A | vy = -gt | -3.2242 m/s |
| 4 | Velocity of the ball just before it strikes the point A in vector form | |v| =  Ѳ = tan-1 () | |v|=3.3766 m/s  Ѳ = -72.719⁰ |
| 5 | Range of the second projectile = Distance between point A and B | R = S2 – S1 | 0.39 m |
| 6 | Time of the ball spends between point A and B | tAB= | 0.389 s |
| 7 | Maximum height for the projectile between point A and B | H= | 0.1852 m |

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 | |v| = | 3.3766 m/s |
| 2 | The angle that the ball makes with the surface just before/after the collision at point A | Ѳ = tan-1 () | -72.719⁰ |
| 3 | Kinetic energy of the ball before the collision at A | k.Ei = m|v|2 | 0.03249 J |
| 4 | Kinetic energy of the ball after the collision at A | k.Ef = m|v|2 | 0.03249 J |
| 5 | Horizontal impulse that the floor gives to the ball | *J*x = Pix - Pfx | 0 |
| 6 | Vertical impulse that the floor gives to the ball | *J*y = Piy - Pfy | 0.03676 kg.m/s |

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

1. **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

1. **References**

* **Fundamental of Physics (10th Edition):** Projectile motion (Chapter 4, page 70- 75), Collision and Impulse (Chapter 9, page 266)

· **Video Links:**

* **Projectile motion:** <https://www.youtube.com/watch?v=rMVBc8cE5GU>
* https://www.youtube.com/watch?v=pZZt357pkI&list=RDCMUCX1Hh7CvEc3RUd4NRBWJMw
* https://www.youtube.com/watch?v=WtfVZdpHZ9o
* **Collision:** https://www.youtube.com/watch?v=hZm-DcO2JfA

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