Experiment 3: Projectile Range Versus Angle

EQUIPMENT NEEDED

- Mini Launcher and steel ball
- Measuring tape or meter stick
- Graph paper
- Plumb bob
- Carbon paper
- White paper

Purpose

The purpose of this experiment is to find how the range of the ball depends on the angle at which it is launched. The angle that gives the greatest range is determined for two cases: launching on level ground and launching off a table.

Theory

The range is the horizontal distance, x, between the muzzle of the Launcher and the place where the ball lands. The range is given by $x = (v_0\cos\theta)t$, where v_0 is the initial speed of the ball as it leaves the muzzle, θ is the angle of inclination above horizontal, and t is the time of flight. See figure 3.1.

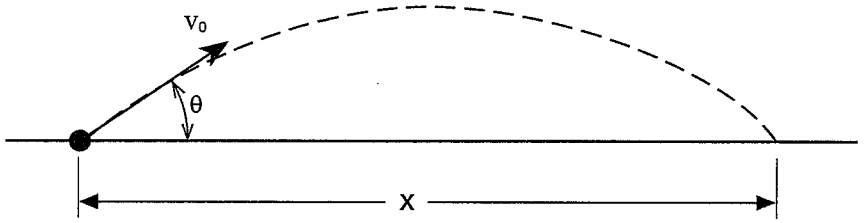

Figure 3.1: Shooting on a level surface

For the case in which the ball lands at the same elevation from which it was launched, the time of flight of the ball will be twice the time it takes the ball the reach the peak of its trajectory. At the peak, the vertical velocity is zero so

$$v_y = 0 = v_0 \sin\theta - gt_{peak}$$

Therefore, solving for the time gives the total time of flight as $t = 2t_{peak} = 2\,\frac{v_0 \sin\theta}{g}$.

For the case in which the ball is launched at an angle from a table onto the floor, (See Figure 3.2) the time of flight is found using the equation for the vertical motion:

$$y = y_0 + (v_0 \sin\theta)\,t - \frac{1}{2}\,gt^2$$

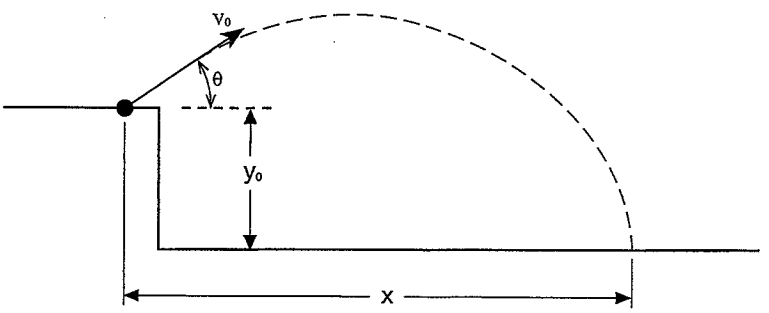

Figure 3.2: Shooting off the table

where y_o is the initial height of the ball and y is the position of the ball when it hits the floor.

Setup

① Clamp the Mini Launcher near one end of a sturdy table with the Launcher aimed so the ball will land on the table. The square nut in the T-slot should be positioned near the muzzle.

② Adjust the angle of the Mini Launcher to ten degrees.

③ Put the steel ball into the Mini Launcher and cock it to the chosen position.

Procedure

SHOOTING ON A LEVEL SURFACE

① Fire one shot to locate where the ball hits the table. At this position, tape a piece of white paper to the table. Place a piece of carbon paper (carbon-side down) on top of this paper and tape it down. When the ball hits the table, it will leave a mark on the white paper.

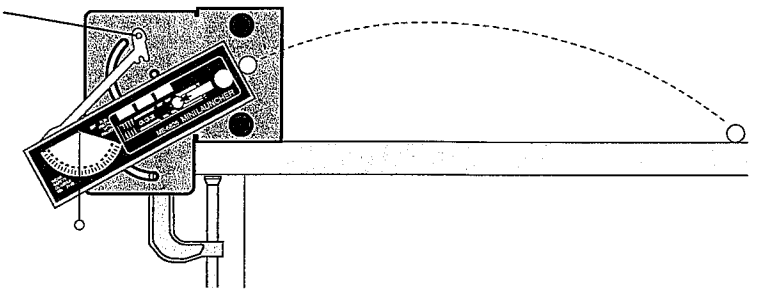

Figure 3.3: Setup to shoot on level surface

② Fire about five shots.

③ Measure the horizontal distance from the launch position of the ball to the leading edge of the paper. Record in Table 3.1.

④ Measure from the leading edge of the paper to each of the five dots and record these distances in Table 3.1.

Table 3.1 Shooting on a Level Surface

Horz. Distance

Angle	10	20	30	40	50	60	70	80
1								
2								
3								
4								
5								
Average								
Paper Dist.								
Total Dist.								

⑤ Increase the angle by 10 degrees and repeat all the steps.

⑥ Repeat for angles up to and including 80 degrees.

SHOOTING OFF THE TABLE

Clamp the Mini Launcher as shown in Fig 3.4 so that the ball will hit the floor. Repeat steps 1 through 6 and record the data in Table 3.2. You can use a plumb bob to find the point directly beneath the launch position of the ball.

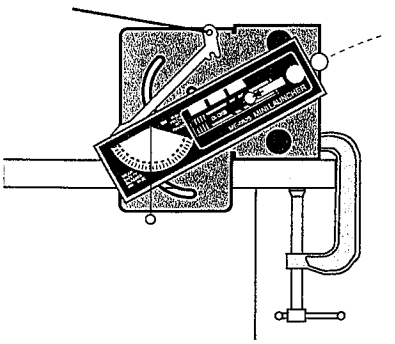

Figure 3.4: Setup

Analysis

① Find the average of the five distances in each case Àand record in Tables 3.1 and 3.2.

② Add the average distance to the distance to the leading edge of the paper to find the total distance (range) in each case. Record in Tables 3.1 and 3.2.

③ For each data table, plot the range vs. angle and draw a smooth curve through the points.

Table 3.2 Shooting Off the Table

Horz. Distance

Angle	10	20	30	40	50	60	70	80
1								
2								
3								
4								
5								
Average								
Paper Dist.								
Total Dist.								

Questions

① From the graph, what angle gives the maximum range for each case?

② Is the angle for the maximum range greater or less for shooting off the table?

③ Is the maximum range further when the ball is shot off the table or on the level surface?