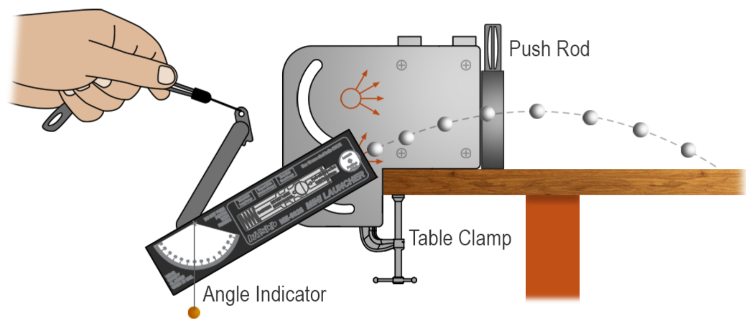
Investigation 6B: Projectile motion

Essential questions: What is the angle that maximizes the range of the projectile?
How are the projectile motion equations used to calculate a projectile's range?

Projectile motion occurs whenever a moving object is under no force except gravity. The equations of motion for each coordinate axis are different—and independent of each other—so *you can analyze them separately*. Combined, the equations are used to describe the range of a projectile.

Part 1: What angle launches projectiles the maximum distance?



1. Set up your equipment like the picture so the projectile will land on the lab table.
2. Press-in the projectile TWO clicks using the push rod, and then pull up on the string to launch it.
3. Launch the projectile at different angles such as $\theta = 20°, 25°, 30°, 35°$ and so on. Include 30° and 60° in your data.
4. Use the same initial speed v_0 (two clicks) for every launch.
5. Measure the range of the projectile for each angle. Tabulate your data in Table 1.

Table 1: Range and launch angle for a projectile with constant initial speed

θ (°)												
Range (m)												

Questions

a. What angle θ launched the projectile furthest? _______________
Provide a conceptual explanation for why you think this angle gives the maximum range.

b. Provide a conceptual explanation for why the range was approximately the same when $\theta = 30°$ and $\theta = 60°$.

Part 2: Hitting a target using projectile motion

1. Adjust the launcher to launch the projectile horizontally ($\theta = 0°$) onto the floor.
2. Launch the projectile using THREE clicks instead of two.
3. Measure the range of the projectile along the floor and the height of the launcher, and then use those values and the projectile motion equations to calculate the projectile's initial speed v_0 when leaving the launcher. Show your work below.

4. Adjust the launcher so the projectile will land on the table again. Set the launch angle to 60°.
5. Use the range equation and your values from the previous steps to calculate the new range of the projectile. Show your work below.

$$\text{Range} = x = \frac{2v_0^2 \sin\theta \cos\theta}{g}$$

6. Place an empty cup at your calculated range and attempt to launch the projectile into the cup using THREE clicks.

Questions

a. Did the projectile land in the cup first try? If not, what factors may have caused the projectile to miss the cup?

b. Neglecting air resistance, in which direction was the net force acting on the projectile while it was in flight? In which direction was the projectile accelerating when it was in flight?

c. Describe how the projectile's x-direction velocity and y-direction velocity changed during its flight.

Applying new knowledge

1. A projectile is fired horizontally off the top of a cliff with an initial velocity of 30 m/s. It hits the ground after 2.0 seconds.
    a. What is the initial *x*-component of velocity when the projectile is initially fired? What is the initial *y*-component of the velocity?
    b. How far from the base of the cliff does the projectile land? (Hint: How far does it go in the *x*-direction?)
    c. How high is the cliff? (Hint: How far does the projectile go in the *y*-direction?)

2. A projectile is shot at an angle of 45° with velocity components v_x and v_y both equal to 10 m/s.

    Sketch the trajectory of the projectile.