Lab 4

Projectile Motion

Overview

The goal of this lab is very simple: predict the motion of a launched projectile in order to knock down some Jenga blocks.

Quantitatively, this means predicting Δx based on the angle of the launcher θ and the initial velocity $v_i = |\vec{v}_i|$. Theoretically, you can find Δx using equation 3 below. Experimentally, you can use the taped down carbon paper to mark where the ball hit and measure Δx using a meterstick.

Theory

In order to make your predictions, you should assume that the launched projectile is subject only to the constant gravitational force $\vec{F}_g =< 0, -mg, 0 >$, where $g = 9.8\ \text{m}\cdot\text{s}^{-2}$.

$$v_x(t) = v_{x,i} + \frac{F_x}{m}t \tag{1}$$

$$v_y(t) = v_{y,i} + \frac{F_y}{m}t \tag{2}$$

$$x(t) = x_i + v_i\cos(\theta)t + \frac{1}{2}\frac{F_x}{m}t^2 \tag{3}$$

$$y(t) = y_i + v_i\sin(\theta)t + \frac{1}{2}\frac{F_y}{m}t^2 \tag{4}$$

The time of flight τ is given by setting equation 4 equal to zero and solving for t. This results in a quadratic equation, the roots of which are given by:

$$\tau = \frac{v_i\sin\theta + \sqrt{v_i^2\sin^2\theta - 2\frac{F_y}{m}y_i}}{g} \tag{5}$$

Setup

This lab uses use a metal ball of unknown mass and a projectile launcher. The launcher has three settings (slow, medium, and fast) as indicated by the number of clicks you hear when pushing the ball down the barrel. **Do not use the fast setting!** The only measured quantities will be the horizontal distance Δx from the launcher to the landing point of the projectile, the launch angle of the projectile launcher, and the vertical distance Δy from the ground to the barrel of the launcher. The time of flight is difficult to measure, so we will use equation 5 to "measure" the time of flight. To measure the initial velocity, consider setting the projectile launcher at a very special angle.

Note that if you miss, the ball will roll through the blocks without knocking them down. You can use the stools around the lab as a backboard.

You can use the meterstick to mark where the initial x position (x_i) is on the carpet below the projectile launcher. Do not measure from the end of the barrel! Instead, measure from the crosshairs on the barrel.

You should knock over the blocks two separate times, varying either v_0 or θ or both.