Walk-in Lab 3
Projectile Motion
Physics 121

CID(s): ______________________

Description

In class we talked about the problem of launching a projectile at an angle from a cliff. The solution strategy was to solve the $y$ equation with constant acceleration to find how much time the projectile spent in the air, then to solve the $x$ equation with constant velocity to find the horizontal position at which the projectile lands. In this lab, you get to do this experiment yourself. There are probably more exciting ways to do this, like shooting water balloons off the roof of the ESC, but you’ll have to settle for this lab today; you can try the other activity on your own.

You can work in groups of up to 3 people. Have fun and email me with suggestions on how to improve the lab. See you in class, and have a fun day.

Objective: To both compute and measure the range ($x$ distance) of a projectile fired at an angle from the table.

Equipment: A tape measure that reads meters, a micrometer, a spring-loaded projectile launcher, a projectile, a catcher (short piece of rubber tubing), and a laser timer.

Part A – Measuring the initial speed, $v_0$

This is the one tricky part of the lab. It will take a little patience, but if you get it right, your results will be quite good. The projectile launcher is a spring loaded gun. You cock the gun (get it ready to fire) by using the metal rod with the plastic handle to push the metal sleeve of the gun down against the spring until it locks into place. There are three different places at which the sleeve might catch. If you push the rod down slowly you will catch the first one. Pushing in on the metal piece attached to the blue gun (this is the trigger for the gun) while still pushing on the rod will release the catch and allow the sleeve to go down to the second setting. Doing this again will allow the sleeve to go all the way down to setting number 3. As you do this lab choose one of these three settings to use and stay with it for every shot you take. The easiest setting is the third one; just jam the sleeve all the way down every time, checking each time that it really is all the way down.

There is a laser timer like the one you used in Lab 1 that will help you measure the launch speed of the projectile (the ball with a hole drilled through it). The projectile passes through the laser beam and the timer measures how long the laser beam is interrupted by the projectile. The speed $v_0$ (in meters per second) is equal to the length of the projectile $L$ (in meters) divided by the time on the timer $\Delta t$ (in seconds).

Procedure

1. Make sure that you use SI units throughout this exercise.

2. Use the micrometer to measure the length of the projectile. Make sure that the micrometer is set to millimeters and zero it by closing the jaws and pushing the zero button. Measure the length of the ball along the direction of the hole drilled through it.

Write your answer: $L =$ ________

3. Set the angle of the projectile launcher by loosening the knob that holds the launcher to the metal plate and set the mark on the rotating piece to the desired angle using the degrees markings on the metal plate. Notice that the angle on the plate is not the angle with respect to the horizontal used in
your textbook, but is instead the angle measured with respect to the vertical. When you use formulas from the book you will need to convert this vertical angle to the horizontal angle used in the book ($\theta_h$ below).

Write your answers: vertical: $\theta_v =$ ___________ horizontal: $\theta_h =$ ___________

4. Use the metal rod to cock the launcher to the desired setting and then slide the projectile onto the launching rod.

5. So that you don’t have to chase the ball across the room there is a flexible plastic catcher which you should now slide into the oval hole at the end of the launcher. The catcher will slide into this hole if you squeeze it a little and slip it in from the backside. Once the catcher and the ball are in place reset the timer and push the trigger mechanism on the launcher to shoot the ball. A sharp rap with the cocking rod is a good way to launch. Read the time the ball spent blocking the laser beam, $\Delta t$ and record it in step 5 below.

6. Repeat the launch 2 more times, and write below all three measurements and the average of these measured time intervals.

$\Delta t =$ ___________, ___________, ___________, average $\Delta t =$ ___________

7. Calculate your initial speed and write it here:

$v_0 = L/\Delta t =$ ___________

Part B – Predicting the range

Follow the solution strategy we outlined in class (and briefly sketched in the opening paragraph of this lab).

• Measure the distance from the floor to the bottom of the ball when it is sitting in the launcher without being cocked. This is the position at which the ball is launched into the air with initial speed $v_0$.

Write your answer here: $H =$ ___________

• With $v_0$, $H$, $g = 9.8 \text{ m/s}^2$, and $\theta$, you can predict the range of the projectile. Do the math on the back of this page and write your predicted horizontal range here:

$D_{\text{calculated}} =$ ___________

Part C – Measuring the range

Now you are totally ready! Load the launcher again, remove the catcher, set the launcher spring, DON’T CHANGE THE ANGLE, and FIRE! Repeat 2 more times and write your three measurements and their average here:

$D_{\text{measured}} =$ ___________, ___________, ___________, average $D_{\text{measured}} =$ ___________

Calculate your absolute and relative error. If things go well, your measured range should be within about 15 cm of the predicted range. How did you do?

Absolute error: $D_{\text{measured}} - D_{\text{calculated}} =$ ___________

Relative error (percent): $100 \times (D_{\text{measured}} - D_{\text{calculated}})/D =$ ___________%