

## Notes from the ballistic pendulum lab:

Goal: To measure the exit velocity of the cannon ball from the cannon using two distinct methods, and then, to compare the two measured values. The two methods are:

1. By measuring the trajectory through space (4 different heights, 5 trials for each height).
2. By using the ballistic pendulum (5 trials).

In your data and analysis section, you should provide a derivation of the formulas you use to measure this initial velocity, one derivation for each method.

### Hints on the derivations:

- In the first method, you must consider the separate x & y motion of the projectile. This is a review of 2D projectile motion, so you can look back in your notes to find the method. This will allow you to relate the initial velocity to the two measured distances, being the range and the initial height.
- In the second method, you must consider the full motion in two segments: a first segment (before and after the collision) where you use conservation of momentum, and a second segment where you use conservation of energy. This will allow you to relate the final height achieved in the ballistic pendulum to the initial velocity, and the masses of the two parts (the ball and the catcher).

### Data analysis:

- For the projectile analysis, you will end up with four measurements of velocity, one for each range. Report these four values, together with the uncertainty in each measurement of velocity. For each measurement of the velocity, use the average values of the range (so, in the end you need to calculate  $v_i$  only 4 times, not 20 times).
- For the ballistic pendulum analysis, you will have only one measurement that is based on the average measurement of the height from the 5 trials you completed.

### Uncertainty analysis:

- Using the uncertainty analysis we discussed in lab for propagation of uncertainty, calculate the mean value and standard deviation for the projectile measurements. That is, calculate the mean and standard deviation of the five trials of the projectile motion at a single height. Since you probably only measured the height once (which is fine and reasonable), make an estimate of your uncertainty of this quantity based on your measurement tool and how accurate you believe that you were when using it. Use these combined uncertainties to estimate your uncertainty in the velocity, as discussed.
- For the second method (ballistic pendulum), combine your equations from the momentum analysis and the kinetic energy analysis to get one equation that relates the initial velocity to the measured height. Use the same uncertainty propagation method, only using it for a single variable (just consider the second variable to be absent, or if you prefer, consider what happens if you take  $\Delta x_2=0$ ).