Name: _____

LAB 10. BALLISTIC PENDULUM

Introduction

Physics

A resting ballistic pendulum catches a moving projectile and swings upward from the impact. Using principles of conservation of momentum and conservation of energy, one can predict how high the pendulum will swing. Conversely, from measuring how high the pendulum swings, one can determine the speed of the incoming projectile.

Purpose

Your goal is to deduce the launch speed of a steel projectile at the three different spring settings of the launcher. Derive the theoretical formulas that estimate the launch speed from the horizontal trajectory range and from the swing of the pendulum cradle. Carry out both sets of measurements, deduce the launch speeds, and compare the different results.

Safety

Because this lab involves small projectiles traveling at substantial kinetic energies, all personnel must wear safety goggles while the projectile launchers are in use.

Horizontal Launch

Supplies

Projectile launcher, steel 1" projectiles, table clamps for launcher, plain paper, carbon paper, plumb line, measuring tape, painter's tape, safety goggles

Procedure

Decide how many repetitions of each setting you need to record to obtain reliable estimates of mean and standard deviation of the horizontal range. Fire the projectiles horizontally from the table top and mark their landings by placing blank paper/carbon paper where they land. Record all relevant data in your notebook and explain the calculations in the Theory section of your report.

Ballistic Pendulum

Supplies

Projectile launcher, plastic and steel 1" projectiles, table clamp for launcher, ballistic pendulum, , lab stand, bar clamp, ruler or meter stick, safety goggles

Procedure

Decide how many firings you need at each setting to calculate the launch speed. Clear this with the instructor.

Set up the pendulum so that the cradle catches the projectile fired horizontally from the launcher. Place the monofilament line attached to the cradle through the pair of hook-and-loop (Velcro) strips on the side of the launcher. Do a test firing. Find where the cradle moved to pull the monofilament line where it now sits between the strips. Pull the monofilament line back about one centimeter, so that on the next shot the cradle will be unencumbered by tension in the line through most of its arc.

Now carry out the experimental shots to collect your data. Before each shot, pull in a little of the slack in the monofilament line so that the cradle pulls at the line only at the end of its arc. After each shot, find how high the cradle rose. Ideally, you will run enough launches at each setting to obtain reliable estimates of the mean and standard deviation of the height change for that setting.

Lab Report

Your report should contain the standard parts.

Abstract

Identify the experiments you did, the measurements you took, and the quantities you calculated from your data.

Purpose

Explain why you used two different procedures to find the muzzle speeds.

Theory

Explain how to calculate muzzle speed from horizontal launch measurements. Explain how to calculate muzzle speed from the ballistic pendulum results. In both explanations, derive the formulas you use from fundamental physics principles.

Experimental

Describe the setup of your apparatus for both the horizontal range measurements and the pendulum measurements. Explain how you determined the horizontal range and how you found the height change of the pendulum arc. Report any steps you took to quantify and minimize your measurement errors. Report any concerns with safety or damage to the equipment, and steps you took to ensure safe, proper operation.

Observations and Data

Share your spreadsheet, containing the well-labeled data, with your instructor.

Analysis and Discussion

Find the mean and standard deviation of the horizontal range for each projectile and spring setting, and the mean and standard deviation of the cradle height gain for each projectile and spring setting. Likewise, find the mean and standard deviation of the muzzle speed estimated from each experiment, projectile, and spring setting.

Show your intermediate and final calculated values in a spreadsheet. (It's best for me if the spreadsheet carries out the calculations so that I can follow them.) Identify possible sources of error in your measurements, and estimate the likely magnitude and significance of each error. Explain how you tested your experimental data to verify if the model adequately predicts the behavior of the system. Tell what you found, and the degree to which you are confident in your findings.

Compare the muzzle speeds deduced from the horizontal range experiments to the same speeds deduced from the ballistic pendulum. Are the results the same or similar? How do their means compare? How do their variabilities compare?

Conclusion

What are the advantages and disadvantages of determining the muzzle speed by horizontal range versus by a ballistic pendulum? Under what experimental conditions would one or the other produce a more reliable estimate of muzzle speed?