Lab 9:

The Ballistic Pendulum

Physics 203

Prof. Daniel A. Martens Yaverbaum, Prof. Max S. Bean

John Jay College of Criminal Justice, the City University of New York

Part A] Theory-Based Prediction

Behold the familiar yet daunting device on your lab table – this time equipped with a vital organ that had been removed for our introduction to the device.

The device is called a "Ballistic Pendulum"; it was originally developed and used in order to determine the speed at which ammunition exited the chamber of a firearm, i.e. to figure out the 'muzzle speed' of a bullet from a gun. Today, more sophisticated methods are available. The Ballistic Pendulum cannot truly be regarded as a new generation development. The physics principles driving this classic forensic tool, however, have barely suffered flesh wounds.

USING ANY/ALL OF THE BALLISTIC EQUIPMENT PROVIDED, DESIGN and IMPLEMENT ANYTHING/EVERYTHING NECESSARY in order to:

***** Retrodict the *horizontal velocity* of the bullet right before it hits the pendulum *****

Your SUGGESTED RESEARCH QUESTION is, therefore, something of the following *3-part* form:

1. Given a horizontal ballistic that collides ***inelastically*** with a freely hanging pendulum, what is the 'muzzle' (pre-collision) speed of the ballistic?

2. That is, how does the pre-collision *horizontal velocity* of a ballistic depend on the *maximum angle* to which the ballistic/pendulum combination rises after they collide and stick together?

3. During which intervals (segments of space and/or time) of a ballistic pendulum's operation is

   energy conserved?

   During which intervals is ("linear")

   momentum conserved?

   In facing a new device, phenomenon or final exam problem, how might we be able to recognize which concept applies when?

For the experiment you design and perform, you should

Assume:

1. ***Conservation of Energy*** (or at least the Work-Energy theorem) will apply to some stage of your experiment, but not to every stage.

2. ***Conservation of*** Linear ***Momentum*** will apply to some stage of your experiment, but not to every stage.

3. The mass of the pendulum rod can be initially treated, for this purpose, as negligible. Be aware, however, that this approximation is a bit of a stretch. In the back of your (uncertain) mind, remind yourself from time to time that the pendulum rod is not, in fact, a light string. What difference might this make?

   *** Your experiment should ultimately involve all the elements of any typical Physics 203 experiment: multiple trials, data tables, uncertainty analysis, a conclusive finding and, of course, a full report. ***

   Part B] Experimental Measurement

   Using a laptop, photogate, *Logger Pro* software and multiple trials, TEST your prediction! (Experimentally verify your prediction.) Deploy careful uncertainty analysis in order to evaluate the accuracy of your prediction.

   NOTE 1: If your calculations assumed the conservation of energy (for any interval), that means that they implicitly assumed that the pendulum rod did no work on the pendulum bob.

   That is, whether or not you consciously considered it, your calculations treated the rod as though it were an approximately massless string. This approximation is just that: an approximation. You might find this observation useful when you are writing up a comparison between your prediction and your measurement.

   NOTE 2: You WILL write a full (and typical) formal lab report for this experiment.

   You DO NOT need to submit a "triple-star" (informal) report for this experiment.