PS 12A Names:

Lab 3: Motion, Statistics, and Models

Part I: Model Prediction

Based on the apparatus on the bench, can write down a model that will predict the speed of the ball as it rolls across the flat section of track?

Draw a labeled diagram of the apparatus:

What is your model to predict the speed?

Q1: How will you determine the initial height of the ball? Write down your measurement. How large do you estimate the measurement uncertainty to be?

Q2: Calculate the predicted velocity, based on the hypothesis presented above. Don't forget to account for the uncertainty! Hint: you can use the uncertainty propagation reference sheet on the Lab Materials page (under Lab 5) on the course site to figure out the uncertainty on the velocity.

Part II: Experimental data with using a stop watch

Keep the ball at the same height that you used to predict its speed in part 1. Roll the ball a few times to make sure your track is nice and level. Take measurements until you are confident in your technique, and continue until you have enough data to characterize the random error.

Q4: Plot these data in a histogram and overlay with an appropriate function (hint: type doc histfit in the command window). Be sure to include labels! Save the graph and insert it below or attach separately.

Q5: How will you determine the time and error on time from this plot? Explain your reasoning. Do you expect this error to get smaller as you take more data?

Q6: What distance did you measure? What is the error on the distance, and how did you determine the error?

With your measured time and distance the velocity calculation should be straightforward. However, you also need to calculate the error on the velocity! If the error on measured time T is σ_T and the error on measured distance D is σ_D, then your error on the velocity V is

$$\frac{\sigma_V^2}{V^2} = \frac{\sigma_T{}^2}{T^2} + \frac{\sigma_D{}^2}{D^2}$$

Q7: What velocity did you measure, and with what error? Write it as $V \pm \sigma_V$. What factor contributes the most to the error?

Q8: Compare the velocity calculated from your distance measurements, using the stopwatch, to the velocity calculated from the height measurement. How well do these values agree?

Q9: Calculate their statistical significance. How likely is it that your model and experiment agree?

Part III: Improve your measurement with photogates

Now we are going measure the velocity using a pair of photogates to measure the time. A photogate consists of a little light emitting diode and a photo detector. If the space between the emitter and detector is blocked, an electronic signal is generated and read by the computer. Logger pro will then record the difference between the times of the ball passing through each photogate.

Set up the pair of photo gates. Use Logger pro to record your data. Export this data as a .csv file and then import the data in this file into MATLAB. Save your workspace. Repeat your measurement of the velocity using the Logger Pro data.

Q10: Measure the speed of the ball using the photogates. What is your distance and its uncertainty? Time and its uncertainty? Measured velocity and its uncertainty?

Q11: Compare the velocity calculated from your distance measurements, using the photogate, to the velocity calculated from the height measurement. How well do these values agree?

Q12: Calculate their statistical significance. How likely is it that your model and experiment agree?

Q13: What assumptions are being made, or not made, in the model? If these assumptions are false, how would you expect the predicted value to change?