Physics 12a

Lab 4: Motion, Measurement, and Statistics

Names:  

Lab Section (Day and Time):  

1.  
2.  
3.  

Show all work and calculations

Part I: Overview
You will measure the velocity of a ball that rolls down an inclined surface. The lab setup consists of a tilted plastic ramp with a ball release mechanism connected to a flat plastic plane. The ball's velocity will be measured with a pair of photogates.

Q1: Label the forces on the ball when it is at section A and section B on the lab setup. Describe the motion of the ball for these two sections.

You want to measure velocity of the ball after it has rolled down the ramp and is in section B.
\[ V = \frac{\text{distance}}{\text{time}} \]

Q2: How will you measure the velocity? Roll the ball down the ramp and through the photogates. The photogate reports four time values. Why is this the case? Calculate the velocity and show this calculation.

Part II: How well do we know the velocity?

Set the time in Logger Pro to record data for 300 seconds. Roll the ball 40 times. Copy all of the time data out of the Logger Pro data table and paste it into the matlab script photogate.m. Use the script to create a histogram. Using this you will find the ball’s velocity, standard deviation, and standard error on the mean.

MATLAB Directions:

1. In LoggerPro, File \(\rightarrow\) Export As \(\rightarrow\) CSV
2. Get it into Matlab!

Q3: Where can you control the number of bins created on the histogram?

Try different number of bins. What is the problem with too few or too many bins?

Q4: What is the mean velocity of the ball? \( V = \) \(\underline{\quad}\) m/s

What is the standard deviation? \( \text{STD} = \) \(\underline{\quad}\) m/s

Q5: Do you expect this STD to get smaller as you take more data? Why or why not?

Q6: What do we gain by doing the experiment more times?
Q7: What error can we assign to the ball’s velocity? Show your work

Part II: Theoretical Prediction

We might expect, based on energy principles, that velocity is related to height according to the following relation:

\[ v = \sqrt{2gh} \]

Note that with this formula the speed only depends on the initial height of the ball, not the path that the ball takes!

Q8: Measure the change in height of the ball as it rolls down the ramp. Record your apparatus # and ball’s change in height here. Be careful that you measure to the same reference surface.

Apparatus #:

Change in ball’s height = ________ meters +/- ________ meters

Q9: Calculate the predicted velocity, with uncertainty, based on the hypothesis presented above.

Here is a hint on the error propagation.

If \( q = x^n \) then \( \frac{\delta q}{|q|} = |n| \frac{\delta x}{|x|} \)

Q10: Compare the velocity calculated from your distance measurements to the velocity calculated from the height measurement. How well do these values agree? What does this mean about our model?

Part III: Varying Height

It may be useful to look for a trend in the data to help form our model. All the other groups have released the ball from different heights and measured the resulting velocity of the ball. We will pool all of our data, but first we would like to determine the error in the height measurements.
Go around to the other setups and measure the ball drops independently. Report them in the folded paper on each table. It is important to not look at other measurements before reporting your own.

**Q11:** Calculate the mean height of your set-up and the error found from the data spread for your set up.

Mean change in height = ___________ meters

Assigned error: +/- ___________ meters

Add your ball’s velocity w/ error, and the change in height w/ error to the table on the board.

**Q13:** Report the slope value when the Chi Square is at a minimum

Slope = ___________ Chi Squared = ___________

What is the slope value if you add 1 or subtract one from Chi Squared?

Slope at +1 = ___________ Slope at -1 = ___________

Use this to calculate an error range on the slope

So Slope = ___________ +/- ___________

**Q14:** Based on our model $v = \sqrt{2gh}$ above of what should the slope be?

**Conclusion:** Write a conclusion that tells us if our group data and model agree? How do we know? What does this mean about our model? Can you think of any modifications to the model that could be made?