AP Physics C
Precision Measurements of Acceleration

Name:
Group:

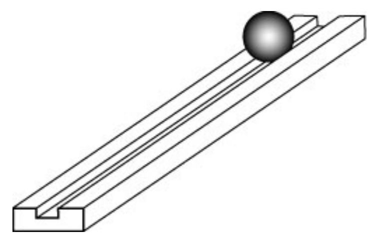
Objective

The goal of this exercise is to

- verify the theoretical prediction for the acceleration of a rolling sphere on an inclined ramp
- solidify your understanding of the relationship between acceleration, velocity, and time
- give you experience with the experimental apparatus
- introduce you to graphing noisy data with error bars and finding best fit lines

Materials

- Vernier Lab pro and photogates
- Solid ball-bearing or marble
- Ramp
- Ruler & protractor

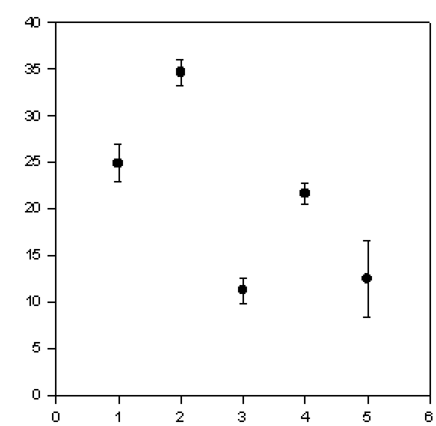


Theoretical model

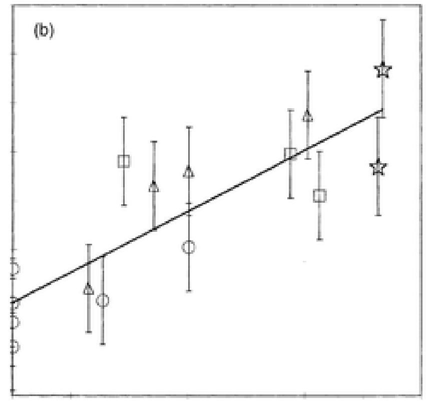
A theoretical model that takes into account the rotational kinetic energy of the marble (and neglects rolling friction) predicts an average acceleration $a = {}^{5}/_{7}g\sin(\theta)$, where *g* is the magnitude of the gravitational field (9.8 m/s^2 on Earth) and θ is the incline angle of the ramp. (Note that the theoretical material for this begins under 'The Great Downhill Race' on p. 395 of the Knight textbook – it is not necessary that you understand this material now, just the prediction for acceleration.)

Procedure

- Using multiple photogates to directly measure the position of the marble at several points in time; use these to determine the average acceleration of a marble rolling down an inclined plane.
- Estimate the measurement error in the velocity of the marble; it is likely dominated by the measurement of the width of the marble at the height at which it interrupts the photogate beam.
- Make a hand-written plot of velocity magnitude (vertical axis) vs. time (horizontal axis) with appropriate values and units. Include vertical measurement error bars. See example.



- Use a ruler to sketch in a 'best-fit line' to the data. This is the line that aims to best describe the underlying phenomenon. Roughly speaking, the line should pass as close as possible to the data points – it could go above some, but then it should go under others. The line need not pass through every (or *any*) data points, if it fits better just missing some. See example.



- Calculate the measured average acceleration. The slope of the best fit line you made is your measurement of average acceleration, since $a_{avg} = \Delta v/\Delta t$. Compare this value to the theoretical model by computing a percent discrepancy. Let's call the measured value A and the theoretical value B. Then, the percent discrepancy is the *absolute value* of the difference between A and B divided by the maximum of the two numbers. The formula looks like this:

$$\% \text{ discrepancy} = (| A - B | / \text{Max}(A,B)) \times 100\%$$

(Here's an example of the use of this concept: say you ordered a table that was supposed to be 32 inches wide, but the delivered table was only 30 inches wide. The manufacturer of your table messed up by making the table 6.25% too short, since $|32 - 30|/32 = 0.0625$.

Post-lab & writeup

- Attach this sheet as a cover sheet. Do not feel you need to duplicate the information in this cover sheet in your write-up.
- Attach the generic laboratory rubric and checklist ([grayscale *.pdf*]) as an appendix. Your instructor will refer to those when grading.
- A photo or careful sketch of your experimental apparatus can be very useful to the reader.
- Answer the following question: at what ramp angle is the acceleration of the marble "equivalent to" the acceleration due to gravity on the surface of the Moon (1.6 m/s^2)?