LAB 06: WORK AND ENERGY

The Objectives

What is the relationship between the release height and travel distance of a bowling ball?

Specifically:

- Observe energy conversion from potential to kinetic
- Observe the relationship between kinetic energy and work
- Analyze the work-energy theorem quantitatively
- Design and collect a data set that addresses multiple random error issues
- Perform statistical and graphical analysis on the data
- Examine experimental results for evidence of missing physics or inaccurate assumptions
- Determine the accuracy of the results

The Procedure

We will use a bowling ball rolling down a ramp to observe the transformation of potential energy to kinetic. When the ball leaves the ramp, it will roll across a rough carpet. As the friction between carpet and ball does work on the ball, it will slow down and eventually stop, its kinetic energy dissipated.

If we assume no energy lost on the ramp, then the amount of potential energy to begin is the same as the amount of work required to stop the ball. By comparing the release height to the travel distance, we can verify the relationship.

The Data

Measure and record the ball release heights and horizontal travel distances. Details of the measuring process will be discussed in class. The entire class will collect and share a single data set.

The Reduction

1. Calculate the average horizontal distance for each recorded release height.
2. Prepare a graph of the **release height (y–axis) vs. the distance (x–axis)**.
3. Find the slope and intercept of the best-fit line.

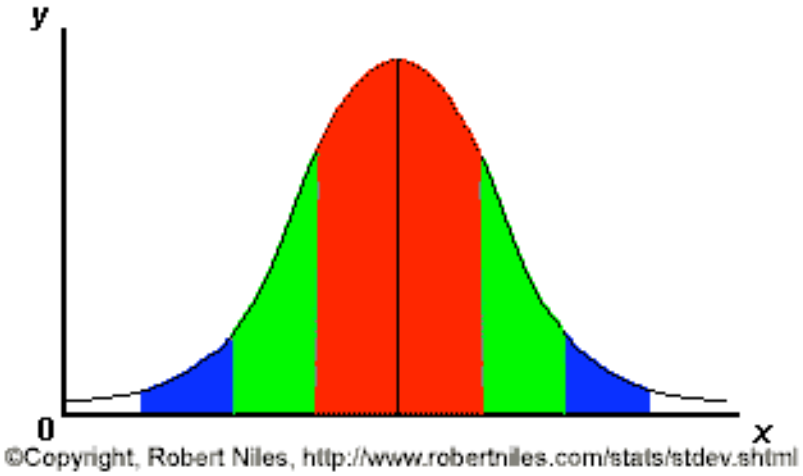
The Analysis

Error Propagation

4. For each release height, calculate the standard deviation in the horizontal distance data:

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(x_i - \bar{x}\right)^2}$$

This is the formula for the standard deviation of a sample set of data containing N members, where x_i represents each individual data, and x the average of the set.



The standard deviation represents the spread of the data: for normally distributed data, you would expect 68% of the values to fall within ±1σ deviation of the average value, and you would expect 95% of your data to fall within ±2σ deviations. This is similar to the % difference that we have previously calculated, but more statistically accurate.

Random Error

Discuss the effect of measuring error on your results. Which has a bigger impact, an error in measuring height or an error in measuring distance? Why? Explain why it was necessary to perform multiple trials at each release height, and collect data for multiple release heights.

Systematic Error

What should the y-intercept of your graph be (hint: if the release height is zero, how far across the carpet should the ball roll?)? Why isn't this your graphical intercept? Does your calculated range of intercepts include this value?

Explain how systematic measuring error in the release height could result in the observed intercept. Based on the technique you actually used, is this a possible cause of your intercept?

Is the assumption that no energy is lost as the ball rolls down the ramp valid? If energy is lost, explain how this affects the horizontal distance traveled by the ball. Could this systematic effect be responsible for your graphical intercept? Explain.

The Conclusions

Comment on whether your experiment concluded successfully. Does your slope seem really small (considering that last week's cork on aluminum was about 0.35 and waxed wood on snow is about 0.10)? Any ideas? Have you adequately explained your graphical intercept? Are there any data points that seem to need an extra explanation, or was there any data that you eliminated when you performed your calculations?