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Subject: Lab 1: Identifying and Evaluating Error in 1D Motion

The purpose of this memo is to identify and discuss two different sources of error that occurred in an experiment using a camera to capture data. The two sources of error include random human error in selecting the points from the video and errors resulting from improper calibration. Our results show that human error in selecting the points contributes a small random error, and improper calibration can produce a very large systematic error. Identifying and evaluating error is important to presenting accurate results. Minimizing systematic errors, namely poor calibration, is crucial to presenting reliable results.

Experimental Results and Analysis

Random human error in point selection could cause a small random error in our evaluation of acceleration.

Table 1 shows the measured values of acceleration based on data points selected by each of 3 members in the group. A comparison of individual results from the table shows the difference from the mean to be less than 0.06 m/s^2 for each trial. If precision is defined as close replication of results, then these data include random human error and lead to the conclusion that acceleration due to gravity (g) is -9.84 m/s^2 . The accepted value for (g) at sea level is 9.81 m/s^2 . Since this value for acceleration is within our range of error, the random human error is the dominant error for this particular experimental arrangement. Therefore, this method correctly evaluates acceleration to within $\pm 0.06 \text{ m/s}^2$.

Who Selected Points	Formula From Trendline	Corresponding Acceleration (g)
Joe Brinkley	$y = -4.933x^2 + 4.689x + 0.182$	-9.866 m/s^2
Dee Smith	$y = -4.940x^2 + 4.687x + 0.186$	-9.880 m/s^2
Joong Byeon	$y = -4.885x^2 + 4.649x + 0.184$	-9.770 m/s^2
Mean	$y = -4.919x^2 + 4.675x + 0.184$	-9.838 m/s^2

Table 1: Comparison of the acceleration measured based on the same event, but analyzed by each of 3 members of our group

Improper location of our calibration marks produces a noticeable systematic error in our evaluation of acceleration.

Table 2 shows how much the position of the calibration marks impact systematic error. The difference in our estimation of acceleration was $\pm 0.5 \text{ m/s}^2$ from the mean. This difference depends on whether the calibration marks were in front of or behind the projectile. This corresponds to a surprisingly large 5% error for just being 10 cm away from the plane of motion. Since this error shifts the data in a predictable direction, it is called systematic error. Identifying systematic error is important because these errors can make the data appear deceptively accurate.

Location of Meter Stick	Formula from Trendline	Corresponding Acceleration
10 cm closer	$y = -4.674 x^2 + 3.824 x + 0.011$	-9.348 m/s ²
10 cm further	$y = -5.192 x^2 + 3.982 x - 0.024$	-10.38 m/s ²
Mean	$y = -4.933 x^2 + 3.903 x - 0.007$	-9.866 m/s ²

Table 2: Comparing acceleration with the calibration marks in front of and behind the plane of motion.

Conclusion

This experiment demonstrated that data must be calibrated carefully and accurately in order to minimize systematic error. If possible, experimenters should use multiple calibrations in different positions and quantify the errors for all future experiments. It should also be noted that random human error can be estimated by simply taking the data a few times and evaluating the difference between measurements, which results in a clear numerical value for this type of error. Knowing errors and their sources allows us to present our findings with confidence.