

# Data and Error Analysis

## 1 Introduction

In this lab you will learn a bit about taking data and error analysis. The physics of the experiment itself is not the essential point. (Indeed, we have not completed our study of constant acceleration in a gravitational field yet in class.) Instead we will focus on ideas such as random vs. systematic error, and precision vs. accuracy in measurements. The equipment is decidedly low-tech; the point of this lab is to focus on understanding the ideas of uncertainties in experiments.

Be sure to read the handout on error analysis before the lab, and ask your instructor if you have any questions. These lab instructions presume you have already read the handout. In this document I will denote the standard deviation of the variable  $x$  by  $\sigma_x$  and the standard deviation of the mean of  $x$  by  $\bar{\sigma}_x$ .

You do not have to write up a formal lab report for this lab (with statement of purpose, description of method etc.). You only need to complete this handout, and answer the questions at the end.

## 2 Equipment

- Rulers/meter stick
- Stop watch
- Inclined metal track
- Ball bearing

## 3 Procedures

Read through the procedures and familiarize yourself with the equipment. This lab write up will provide space for you to record and analyze your data. You will have to do some analytic calculations in the lab itself in order to process the data. Try to work in groups of two or three.

### 3.1 Human Reaction Times

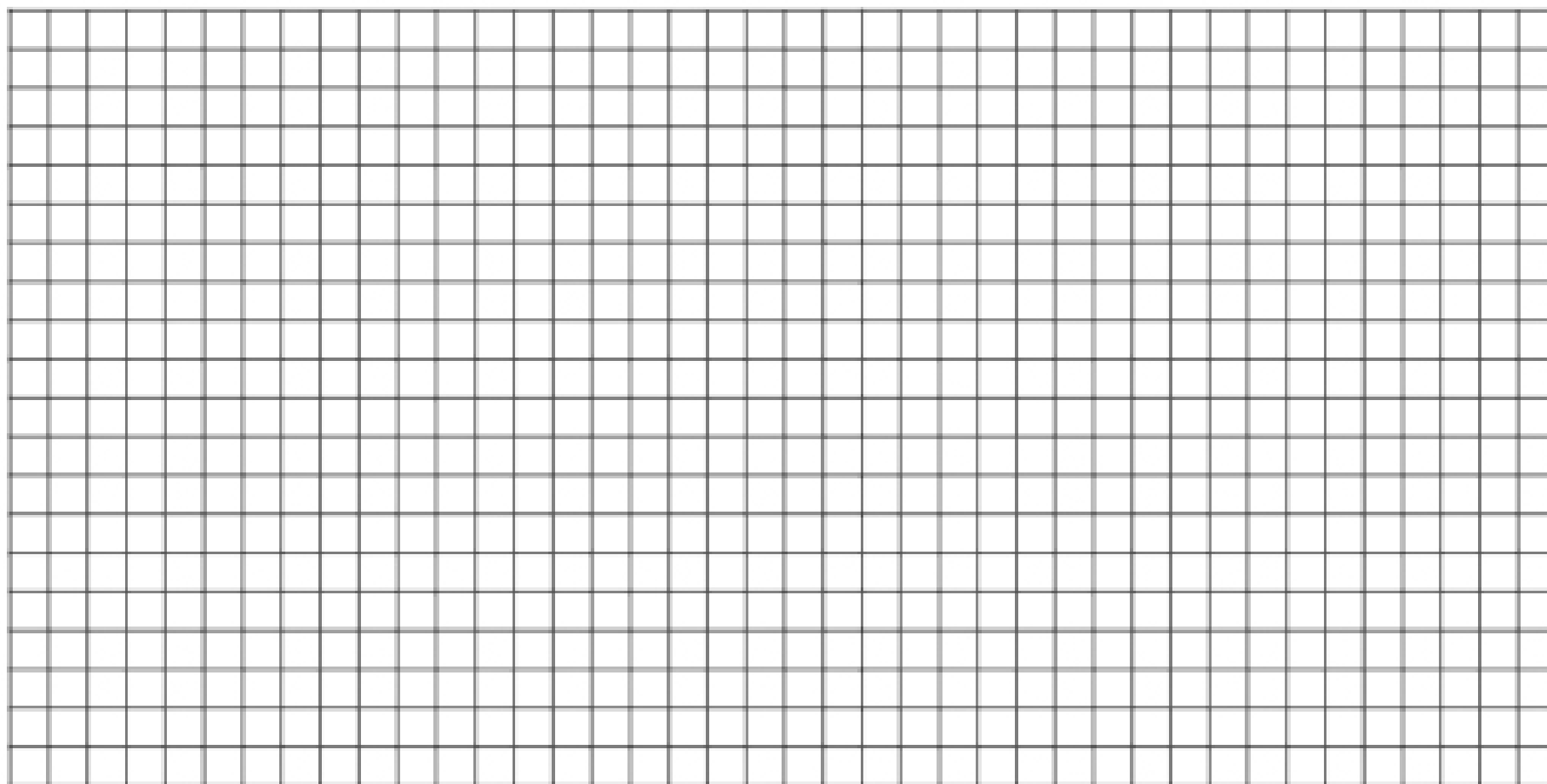
1. One lab partner (A) should hold a ruler such that one end hangs between the finger and thumb of a second lab partner (B). Person A should drop the ruler, and B should try to catch it by pinching their finger and thumb together. Try to avoid anticipation; person A should vary the time they wait before releasing the ruler. Record the distance the ruler falls before person B catches it. (Think about how best to do this.) Repeat this for each person in the group, 15 times for each person in the group.

Calculate the average reaction “distance” for each person,  $\bar{d}$ , and the standard deviation,  $\sigma_d$  (Often your calculator can do this for you. Otherwise, use the formula in the handout.)

Trial #	Distance for A	Distance for B	Distance for C
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
$\bar{d}$			
$\sigma_d$			

**Question:** On a standard ruler it is easy to measure to about half a millimeter (0.0005m). This is the uncertainty in each of your measurements. Which is more meaningful in describing your data, this uncertainty, or  $\sigma_d$ ? Why?

- Histogram your own reaction data on the graph below. You should think how to choose your bins. If they are too big, all the data will fall in one bin. If they are too small, each bin will have only one data point. Mark the average of the distribution,  $\bar{d}$ , and the points  $\bar{d} \pm \sigma_d$  (You have calculated these above, just mark those results here.) Make sure you label your axes!



- The "reaction distance" can be converted to a reaction time via the formula:

$$t = \sqrt{2d/g}$$

where  $g = 9.80 \pm .01 \text{ m/s}^2$ . Using error propagation write down the equation which relates the uncertainty on  $g$  and the uncertainty on  $d$  to the uncertainty on  $t$ . Use the two formulas to calculate your reaction time, and its error.