**The Accelerometer in Your Phone: Part 2 (Two weeks, At-Home)**

# Notes:

1. This is a two-week lab; you will still be collaborating with your lab group.
2. This lab can be done anywhere as long as you have an appropriate smartphone and a soft surface to drop it on (bed, couch, etc.). The app you will be using is very easy and is available for both iPhones and Android.
3. I strongly recommend doing the lab early in the week, rather than waiting until it is almost due. If you have computer trouble, you will want to have plenty of time to fix it before the deadline. No excuses!
4. Turning in your report:
   1. Collaborate with your partner(s) on data collection, analysis, and report.
   2. When working in a group, turn in only one report and make sure it lists all group members as authors.
   3. Lab reports should be uploaded to Canvas in .pdf format by the deadline in the course calendar.
   4. Do not include raw spreadsheets in the Canvas submission or final report. You may want to use figures generated from the spreadsheet(s) in your summary.
5. Getting help:
   1. Your lab TA can answer questions by email or during their office hours listed in the syllabus.
   2. You can also ask advice from lab partner(s) and/or other students.

# Objectives of this lab:

In this experiment, you will explore motion in one dimension using a smartphone.

In “Accelerometer in your Phone: Part 1”, you learned to measure acceleration with your phone, and explored what the data looked like when the phone was still. This week, you are going to make a measurement as your phone actually accelerates. The “location” of the acceleration is up to you. Our goal is for you to be as innovative as possible! Solving problems like this is part of being an engineer, scientist, etc. However, we DON’T expect you to spend any money on this. Please make do with what you have!

These are things you will do:

1. You will use the accelerometer in your phone to investigate motion during the time your phone is accelerating (rather than remaining still – as was done in part 1).
2. You will gather data and transfer to Excel for analysis.
3. Identify the errors that can occur in your experiment.
4. Identify the sources of noise in your experiment.
5. Minimize the noise in your experiment.

# What you will learn:

Please review the learning goals for the semester in lab in the handout from the first week. In addition, this lab has several specific goals:

1. You will practice keeping lab notes in a paper notebook, computer file, or other format.
2. You will enhance the data analysis skills you learned previously, by applying them to real data.
3. You will learn to distinguish between two types of errors that occur in data: systematic errors and random errors.
4. You will enhance your understanding of how noise arises in data, and how to account for that noise when interpreting experimental results.
5. You will practice scientific communication skills by preparing graphs and writing a formal lab report.

## What goes in my lab notes, and what about my report?

The purpose of lab notes is to enable you or a colleague to reconstruct what was done and why.

* They don’t have to be neat, in complete sentences, etc., but they do have to be useful.
* In a case like this, they should include things like what as the setup for measuring acceleration and what you did while recording data.
* Did you try different setups (pulley vs dropping phone on bed), or take multiple data sets for same setup?
* If you store multiple files, record what filenames correspond to what conditions.

The purpose of a **report** is to explain what you learned and how you learned it. The sorts of things that belong here are

* A description of each step you did as part of each activity.
* Any graphs to show to your results.
* Explain how you determined the maximum velocity.
* Explain differences between calculated (integrated) distance and the actual measured distance.
* Your conclusions about any relevant and useful information you were able to extract from the data.
* An analysis of the errors of the in your experiment including an explanation of how calculated average acceleration, found the standard deviation, and determined the standard error.

# EQUIPMENT

A smartphone with an accelerometer[[1]](#footnote-1) and one of these apps:

* phyphox https://phyphox.org/. (We think this one is a bit easier to use)
* physics toolbox sensor suite. https://www.vieyrasoftware.net/

Excel, Numbers, or other graphing software

Word or other word processor to prepare your report

Any setup you choose to build, in which to measure the acceleration of your phone

**DOs & DON’Ts**

* Decide where you want your phone to accelerate. There are many choices! You could simply drop it onto a soft surface, say, your bed. You could also build a ramp by using a board, a shelf removed from a bookcase, etc., and propping up one edge. You could attach your phone to a weight using string and loop the string over a shower rod if you haven’t got a pulley. You could slide your phone down the inside of a tube, or on a stretched piece of fabric. There are just a few rules:
* ***Don’t*** break your phone! Make sure it doesn’t go too fast, and lands on a soft spot. IUPUI, the Department of Physics, your instructors, etc., cannot be held responsible for your choices here.
* ***Don’t*** do this while driving your car. If you want to measure the acceleration of a car, you MUST have a friend act as lab assistant to drive while you take data.
* ***Do*** use your imagination and have fun.

# ACTIVITY 1 (Week 1): Measure *acceleration versus time*

*Figure 1. Example data from Activity 1. (Top) Acceleration measured along the phone’s z-axis during the drop. (Bottom) The absolute acceleration measured during a phone drop.*

* Decide how and where you want your phone to accelerate. You can simply drop it onto a soft surface: bed, couch, etc. You could also build a ramp by using a board, a shelf removed from a bookcase, etc., and propping up one edge. (Don’t damage your phone -- Make sure it doesn’t go too fast, and lands on a soft spot. IUPUI, the Department of Physics, your instructors, etc., cannot be held responsible for your choices here.)
* Practice: You need to be able to start the app recording, begin the acceleration, and stop the app recording.
* Document your procedures, take pictures of your set-up.
* Now take your data. You might want to do multiple runs.
* Now, your job is to *make sense* of the data. Below are some things you should do.
* Open your data file in Excel to make graphs, do analysis, etc. You have practiced this last week.
* Your data probably looks very messy! Figure 1 shows sample data from dropping the phone onto a bed. The features include the actual fall, some bounces, picking the phone up, stopping the recording, etc.
* Think about how to analyze your data. Some of the data you might want to discard, but you should show the whole thing and do your best to describe what you think is happening at various times. Explain what you are and are not using, and why.
* If there is a constant portion, you should find the average. What is the standard deviation and uncertainty in your measurement? If there is a linear portion, you could find the slope. Your write-up should explain what you are analyzing, why you think that is justified, and what it means. If you can fit to a line (or curve), do so and give the function you are fitting in your report.

# ACTIVITY 2 (Week 1): Obtain *velocity* versus *time* and *distance* versus *time*

* Always analyze your data to extract every bit of useful information and discuss in your report! For instance, if you integrate the acceleration, you get the velocity. Try to find the max velocity of your phone during the experiment, and the distance travelled. (Hint: in the “rectangle approximation you learned in calc class, the integral is a sum of *a\*dt*, where *dt* is the time difference between successive data points).
* Next, do another integration to obtain the distance versus time. Use a tape measure or ruler to compare against your calculated distance. Discuss in your write-up any differences you discern between the calculated (integrated) distance and the actual measured distance.

**Note: Write a draft report on what you did during week 1 and submit to TA before lab of week 2. TA will give you feedback which you must incorporate in your final report submission at the end of week 2. The draft you submit must have almost all of the elements mentioned in the handout “Lab Overview”. A portion of that is reproduced here: “…………***your report should be typed, in essay form (not bulleted lists), and contain the following sections: title, abstract, introduction, theoretical background, experimental procedure (including any re-design or refinements), data (in tabular form or a format that makes sense for that lab), analysis of data including errors, your interpretation of the results,…….”.*

# ACTIVITY 3 (Week 2): OPEN ACTIVITY

Your data is likely to be noisy. Propose an explanation (a hypothesis) of the source of noise in your experiment. Your last objective is to test your explanation. There are many possibilities. Consider a few (don’t forget to put the possibilities down in your notebook) then try a few and report on those as well.

1. [↑](#footnote-ref-1)