**The Accelerometer in Your Phone: Part 1**

**(One week, At-Home)**

# Notes:

1. This is a one-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. 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 trouble, you will want to have plenty of time to fix it before the deadline. No excuses!
4. You will prepare a short summary on what you did and submit to your TA on (or before) the due date. Summaries are not as detailed as lab reports. Your TA might (not always) provide feedback which you should incorporate into your later lab reports and/or lab summaries. The short summary should discuss some (not all) elements mentioned in the handout “Lab Overview”.
	1. When working in a group, turn in only one summary and make sure it lists all group members as authors.
	2. Summaries should be uploaded to Canvas in .pdf format by the deadline in the course calendar.
	3. Do not include raw spreadsheets in the Canvas submission or summary. 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 should also seek advice from one another on in person or on CN.

# Objectives of this lab:

These are things you will address in your report

1. You will learn to use the accelerometer in your phone to gather data and transfer it to Excel (or another program) for analysis.
2. Measure the value of the gravitational acceleration constant, *g*, in your specific location.
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 “Lab Overview” document (look in the Syllabus Task on CN). 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.

# Equipment:

* A smartphone with an accelerometer[[1]](#footnote-1) and one of these apps:
“phyphox” https://phyphox.org/. (I think this one is a bit easier to use) or
“physics toolbox sensor suite” https://www.vieyrasoftware.net/ (also good)
* Any smooth, level surface: a table, counter, or uncarpeted floor will do.
* Excel, Numbers, or other graphing software
* Word or other word processor to prepare your report

# ACTIVITY 1: Get comfortable with the app

* If you have not downloaded one of the apps above, now is the time to do it! Open the app and choose “acceleration (without g)” (phyphox) or “Linear Accelerometer” (physics toolbox).
* Familiarize yourself with the controls. Both apps are capable of recording acceleration on three axes vs time. First play around with it. Which axis is which on your phone? You can figure this out by tilting your phone various ways to see which one makes gravity align with each direction.
* Now, take some data. Just put your phone on a solid surface, turn on the accelerometer see what happens. Try tapping on the surface near the phone. Try jumping. What do you see?
* Next, practice sending yourself the data. You can email it to yourself. The format is either .xls (phyphox) or .csv (physics toolbox).
* Finally, practice working with the data. Open the file on your computer using Excel (or Numbers, etc.) Get to know the structure of the data and make a sample graph of acceleration vs. time.

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

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 surface you put the phone on and what you did while recording data.
* Did you try banging the table? What happened to the acceleration?
* If you store multiple files, record what filenames correspond to what conditions.

The purpose of the summary is to explain what you learned and how you learned it. The sorts of things that belong here are

* A description of each thing you did as part of the activity.
* An example graph.
* Your conclusions about how the x-, y-, and z- axes correspond to the front, back, and sides of your phone.

# ACTIVITY 2: Measure *a* on the table

* Record some “good” data with the phone just sitting for a while (1 sec? 5 sec?) and send it to yourself.
* Now, your job is to *make sense* of the data. Here are some things you should do.
* Open your data file in Excel. You will have multiple columns. *ax, ay, az*, and |*a*|. You should be able to create a new column that reproduces |*a*| from the others. It is just the magnitude of a vector!
* You will notice that just sitting on the surface the total acceleration your phone measures not exactly 0. You will see BOTH kinds of errors: random errors (noise in the data) and systematic errors.
* Make some graphs, do some statistics! According to your data, what is the average acceleration? What is the standard deviation and uncertainty in your measurement?
* Repeat this a few more times for runs of different lengths. Again, calculate your averages, standard deviations, and uncertainties.

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* Did you try banging the table? What happened to the acceleration?
* If you store multiple files, record what filenames correspond to what conditions.

The purpose of a summary is to explain what you learned and how you learned it. This lab isn’t a formal written report, but you still need to give a sense of what you did and what you found. The sorts of things that belong here are

* A description of each thing you did as part of the activity
* Explain how you calculated |a| from the components.
* Explain how you found the average value of *g*, the standard deviation in your measurement, and the uncertainty in your average?
* Compare the average, standard deviation, and uncertainties for your different length runs. You should discuss whether the differences you observe make sense.
* Explain how the average, standard deviation, and uncertainty are related to the noise and systematic errors.

# ACTIVITY 3: Open Activity

Consider the sources of noise. Some could be in the sensor itself, but others could be actual vibration in your table. Your last objective is to test this possibility. Can you find a way to reduce the random noise in your experiment? Try it, and report the results.

1. Pretty much all smartphones will work. If you can play a game that involves tilting the phone, your phone has one. [↑](#footnote-ref-1)