The Accelerometer in Your Phone

At-Home | One Week | Summary Submission

Introduction

This lab is designed to provide students with the opportunity to explore one-dimensional kinematics using their phone as the measurement device. This lab is meant to be done at-home, but it is important that students get started as early as possible so questions can be answered before submitting the final assignment. This is a one-week lab, and a lab summary will be due one week after the usual lab time. Students will (a) determine the free-fall acceleration of a phone and (b) practice identifying and quantifying possible sources of error.

Theory

Kinematics – the physics of motion – is one of the foundational concepts of physics. This lab is designed to provide students with the opportunity to explore kinematics in one-dimension (1D) when an object is moving in a straight line. Introductory physics courses usually use three equations (though not limited to only these three) to describe a wide variety of motion. These three equations are:

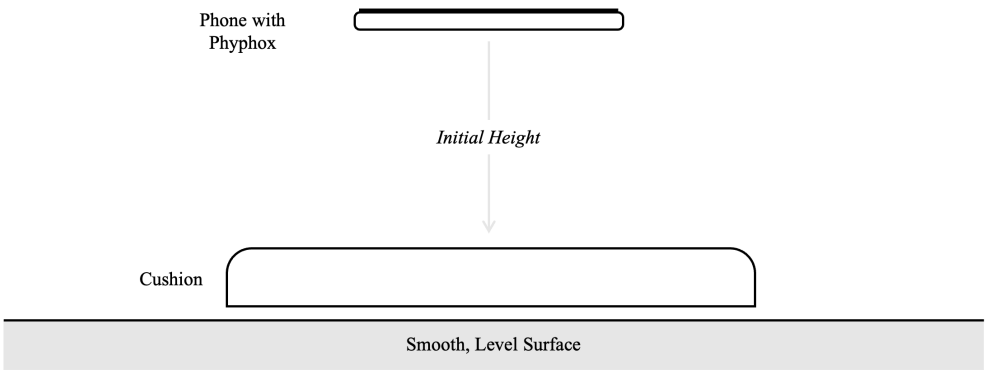
$$v = v_0 + at$$
$$v^2 = {v_0}^2 + 2a(x - x_0)$$
$$(x - x_0) = v_0 t + \frac{1}{2}at^2$$

From these three equations, most situations where an object is in motion can be described. It is important to note that you should be familiar with these equations and how to use them. An object in "free-fall" is an object falling with only the force of gravity acting on the object to bring it "down."

Procedure

For this lab, we will utilize the following equipment:

- A smartphone with Phyphox installed. You can find the Phyphox app in any app store, or by visiting the website: https://phyphox.org/. If you struggle with this, please let your TA know ASAP.
- A smooth, level surface (tabletop, countertop, uncarpeted floor, etc.)
- Excel (or equivalent) for data analysis and making graphs.
- Word (or equivalent) for writing up your report.



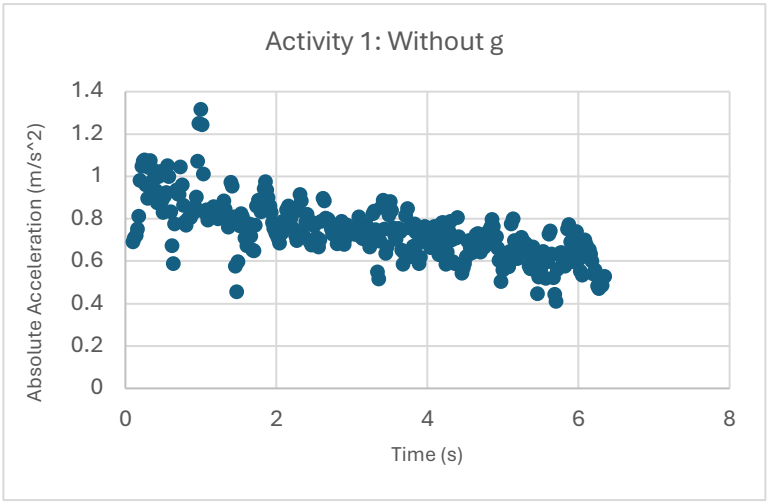
Activity 1: Getting Comfortable with the App

The goal of this activity is to gain comfort with the app and perform some basic data analysis.

1. Begin by bringing up the Phyphox app on the phone and choose the "Acceleration (without g)" sensor from the Raw Sensor list.

2. Record data by pressing the play button at the top. While holding the phone still, record data for approximately 5 seconds, then hit pause. Practice exporting this data to yourself (if you hit the three dots at the top right, you can export it as an Excel file). Phyphox measures the *linear acceleration* for the *x-, y-,* and *z*-axis as well as the absolute acceleration (the vector sum of each linear component). Try to figure out which axis corresponds to which side of your phone.

3. Make a graph of the absolute acceleration vs time using your data. You will notice that there are a lot of data points, so we'll be getting some practice with larger data sets. Your graph should look something like this:



4. Repeat steps 1-3, choosing “Acceleration with g” this time in step 1.

5. Be ready to discuss both graphs in your summary. What is different about them? Why? Is this expected? What value(s) do they seem to hover around? Is this expected for both? Why or why not? We will not utilize “acceleration with g” for the data collection/analysis in further activities. Why do you think this is?

Activity 2: Measure Acceleration vs Time for Free-Fall

The goal of this activity is to find the free-fall acceleration of the phone by making a graph of the acceleration vs time.

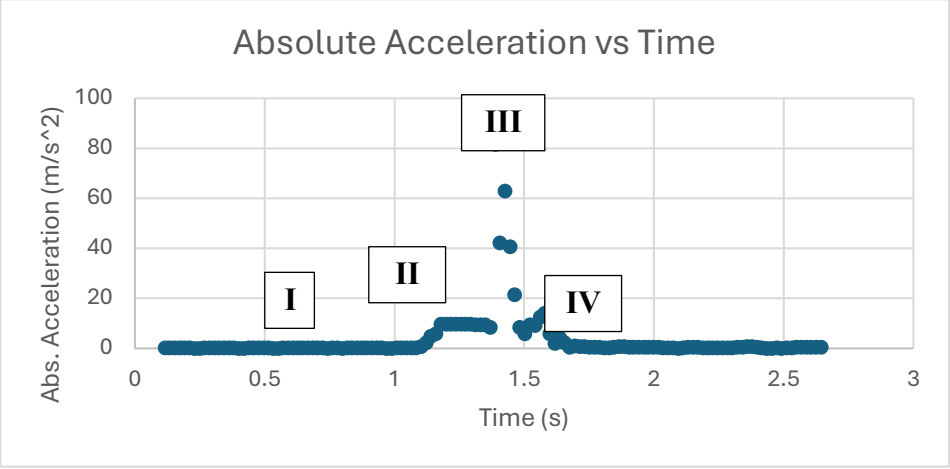
1. Design your setup. Your goal is to drop your phone from a fixed height and measure the acceleration of the phone while in free-fall. You will want to have something like a pillow or balled up jacket underneath the phone to catch it. **Don’t break your phone!**

2. Measure the height above the cushion of your phone.

3. Choose the “Acceleration (without g)” sensor from Phyphox.

4. Hit collect on the phone and release it, allowing it to impact the cushion. Stop data collection.

5. Export this data (like you practiced in activity 1). Make a graph of the absolute acceleration vs time. It should look something like this:



6. On the graph, notice there are 4 labeled regions. Your graph should have similar regions, in your summary, these regions should be labeled, and you should identify what is happening to the phone in each region.

7. Identify the region of the graph when the phone is in "free-fall." Average these data points to give you one acceleration. This is the "free-fall" acceleration of your phone.

8. Compare this value with what you expect it to be (% error).

Activity 3: Measure Height of Drop Using Accelerometer Data

The goal of this activity is to measure the height the phone fell during the time it was in "free-fall."

1. Using only the data from the region the phone was in free-fall and the kinematics equations find the height the phone fell.

2. Compare this with your measured height from the beginning (% difference).

Analysis

In your submission, please include:

- All graphs made in Excel

- The data table from the free-fall section of the graph in Activity 2.

- A summary data table that includes your average free-fall acceleration from Activity 2, the accepted value, the % error between them, your measured height using both methods in Activity 3 and the % difference between them. Note: % error and difference are *different* so they require *different* calculations.

Discussion

As *parts* of your discussion, please make sure to include:

- A discussion of the graphs in Activity 1. Use Step 5 in Activity 1 as a guide.

- A discussion of Activity 2. What did you find, was this expected, what is the % error?

- A discussion of Activity 3. Again, what did you find, etc.?

You must discuss the possible sources of error in your report. You should be considering what could have caused your experimental values to not match up exactly. Why would this happen? Think about systematic vs. random errors and how they could apply in this experiment. This is one of the most important aspects of performing an experiment and is integral to each lab in this course.

FAQ's & Recommendations

How should I prepare for lab time?

You only have so much time in lab each week, so proper preparation makes a huge difference in what you're able to accomplish! Read the handout ahead of time so that you can ask clarifying questions immediately and get started as soon as you arrive!

What goes in my lab notes?

The purpose of lab notes is to enable your or a colleague to reconstruct what was done and why after you've left the lab and are performing analysis or writing a submission.

- You can use any form you like to record experiment information: notebook, spreadsheet, etc.
- They don't have to be neat, in complete sentences, etc., but they do have to be useful!
- Make sure to take detailed notes about your setup, how to use the equipment, what results you found, measurements related to the environment you may need, etc. You may not be able to get back into the lab later in the week if you miss something, so record as much detail as possible!
- When storing multiple data files while in lab, make sure to name the files clearly so they're easy to find later.

When should I work on the experiment and analysis?

We strongly recommend doing the lab as early in the week as possible, rather than waiting until it is almost due. This is just so that, if you run into trouble and need help, you'll have plenty of time to talk to your TA and get issues resolved before the deadline.

How do I turn in my results?

After leaving lab, performing your analysis, and completing your submission, you're ready to turn in your work!

- Every lab session requires submission of either an assignment, summary, draft report, or report.
- Collaborate with your partners on data collection, analysis, and writing.
- Turn in a single group submission and make sure the names of all group members are included.
- Upload your submission to Canvas/Brightspace as a .pdf by the deadline in the course calendar.
- Other than the spreadsheet assignment, you will not upload any spreadsheets. Just copy and paste figures and other elements from your spreadsheet into your formal submission as needed.

Where can I get help?

Your lab TA can answer questions during the lab, by email, or by setting up a time to meet. You can also ask advice from lab partners and/or other students.

General DO's and DON'T's

- *DON'T* break the equipment – always be careful when using lab supplies!
- *DO* consult with your lab TA before leaving a lab session about your experimental method, the validity of your results, and any confusion you have about the analysis process.
- *DON'T* forget to record all the parameters and measurements for your experiment, including saving files.
- *DO* be creative in your experimental design and enjoy!