CERN Open Data Group

CERN HST WG5β

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Analyzing Smartphone Data with Jupyter Notebooks

Summary

The activity described in this document is intended to be used as an introduction to using Python, python modules, and Jupyter Notebook to import, display, and analyze large data sets. The data set(s) included for analysis are larger than those typically hand-graphed, but considerably smaller than even small particle physics data sets such as that which WG5α is including in their analysis.

Objectives

1. The student(s) will open and examine the **elevator_student** Jupyter notebook.
    a. Students will  each cell of the notebook in sequence, waiting for and observing the output (if any).
2. Students will explore and learn to use the Phyphox android or iOS app (or any similar data collection app) to collect barometric data and will export that data to a CSV file.
    a. *Note: Android may download your data as a .zip file; if so, you will need to unzip and extract the file first. This may depend on the phone or operating system (Android, iOS).*
3. Students will use their data collection app to take barometric data for an 'interesting' situation, such as elevator, stairs, hills, or other situation that includes changing elevation over a relatively short (minutes) period of time.
4. The students will create a new Jupyter notebook, or copy and modify the **elevator_student** notebook, to load, analyze, and display their dataset.
5. The students will run each part of their new Jupyter notebook and verify that it runs without errors and produces output they understand.
6. The students will answer questions about the height of the hotel based on the barometric data.
7. The students will take data with a physics app (such as Phyphox, Physics Toolbox, or other) and will export that data to a CSV file.
8. The students will modify (or copy) the Jupyter notebook to load and display their data.
9. The students will describe the graph features and meaning for their data set.

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Resources Provided

The following resources will allow students to work with provided data.

1. Data file 1 elevator ascending, Floor 0 (ground) to Floor 4, CERN Building 39.
2. Data File 2, elevator descending, floor 4 to -1 (basement), CERN Building 39.
3. Sample Jupyter Notebooks elevator_student.ipynb, elevator_teacher.ipynb, gps_teacher.ipynb (alternative data -- GPS sensor) and merry-go-round_teacher.ipynb (alternative data -- magnetic field sensor in rotational motion).
4. Sample Data
    a. phyphox_39_0_to_0_with_stop.csv (barometric data, building 39 elevator, starting at floor 0 and ending at floor 0 with intermediate stops);
    b. phyphox_39_1_to_4.csv (barometric data, building 39 elevator, floor 0 to floor 4);
    c. phyphox_39_4_to_neg1.csv (barometric data, building 39 elevator, floor 4 to floor -1);
    d. phyphox_B.csv (magnetic data in circular motion);
    e. phyphox_gps.csv (position data for a short path).
5. Instructions for students are provided in the relevant Jupyter notebook.

Background Knowledge Needed

- Barometric pressure: origin, calculation, change with altitude, Stevin's Law;
- Linear functions, linear regression.
- Some beginner's familiarity with programming is helpful.

Instructions for Teachers

Procedure

1. Introduction from the teacher.
2. Students complete the **elevator_student.ipynb** Jupyter notebook activity. All data is provided in the activity.
    a. Targeted questions for this activity are in the **elevator_teacher.ipynb** activity.
3. Teacher Instructions on installing and using Phyphox (Android, iOS) or similar data collection application.
    a. Students download/install application to their smartphones.
    b. Students in small groups collaborate to collect barometric data that will be "interesting", such as their own elevator ride, stairs, hills, or something similar.
    c. Students upload data (directly to Github repository or to another accessible location chosen by the teacher) or give data to the teacher to be uploaded to their Github repository.

4. Teacher reviews the **elevator_student.ipynb** notebook students have completed, pointing out sections of code that import and analyze data, calculate height, and display graphs.
5. The teacher will need to provide students access to a Github repository or other data repository online where students can upload their data. The teacher may choose to receive files by email or on a flash drive and control the uploading of data to a repository.
6. Teacher will give students instruction on good data taking skills prior to student groups taking their own barometric data.
7. Students start a new Jupyter notebook (or make a copy of the previous one) and build/modify it to analyze and display their barometric data.
    a. Students may review Stevin's Law and its use in finding the height using fluid pressure during or as reflection after this exercise.
    b. Students may review the relation between position-time-speed.
8. Conclusion: the teacher can control the work of the student and discuss the more important topics. Please note that targeted questions for this activity are in the **elevator_teacher.ipynb** activity and/or listed below in this document.

Differentiation

- High Task: given a dataset of an elevator ride that went to multiple floors, display the dataset and determine to what floors and in what order the elevator went.
- High Task: Group "A" use barometer or accelerometer to create a data set that can be described simply (such as "Walked up and down the hill" or "ran car down ramp"). Group "B" has to examine the data and propose how the data was originally created.
- High Task: Write a short essay answering the following question.

    Elsa's group started collecting barometric data yesterday to determine the height of a hill in their town. Unfortunately, it started to storm, so they only made it halfway up the hill. It is a big hill. The next day it was sunny and clear, so they returned to the middle of the hill and continued taking data. When they plotted their data, it didn't look right. What do you think it might have looked like, and why did it look that way?

Student Final Product and Evaluation

The teacher may choose to evaluate students based on the following suggested products and/or criteria.

1. Answers to questions given in the Jupyter notebooks, such as:
    a. Looking the graphs make some consideration between pressure and time. Can you describe this relation from a mathematical point of view? Can you explain why pressure changes in the time from a Physical point of view? Which laws are involved?

b. Looking at the graphs, can we describe how the altitude of the elevator changes in time?
c. Is it possible to calculate the speed of the elevator?
d. Refer to the graph of pressure vs. time. When the elevator changes elevation, how does the pressure change? Explain from first principles how your explanation fits with the kinetic theory of matter.
e. Does using a computer and program like your Jupyter notebook have any advantages over taking and graphing data manually? Explain your answer fully.