This document has been created as a part of the Erasmus+ -project “Developing Digital Physics Laboratory Work for Distance Learning” (DigiPhysLab). More info: www.jyu.fi/digiphyslab

Uncertainty analysis

Student version

6.2.2022

Co-funded by the Erasmus+ Programme of the European Union

Uncertainty analysis – Student version

To be done in groups of 3+ students

Motivation

Practically every smartphone these days has an accelerometer. Mobile phones use accelerometers, sometimes in conjunction with a gyroscope, for many things: for example, automatically switching the screen from vertical to horizontal along with the phone's orientation, motion controls like opening the camera by shaking the phone, performing actions in mobile games, or counting the number of daily steps in an app. Here we will look into the numerical data given by the accelerometers of the groups' phones and examine their precision and accuracy to see if we are happy with their performance in our scientific studies.

In this task you will get to see how the accelerometer in your phone performs in comparison with others. We will explore the systematic and random uncertainties inherent in the choice of our measuring device.

Equipment list

Smartphones with the app phyphox (RWTH Aachen University), and a computer for graphing and analysis.

Experimental skills in focus

Uncertainty analysis, data collection, data representation, data analysis, planning an experiment

Safety

With great acceleration comes great force. Make sure to take any necessary precautions to keep your phone safe while experimenting!

Task description

1. Getting to know the gear

Make simultaneous measurements of acceleration with all of the groups' phones lying flat on the table using the Acceleration with *g* tool in phyphox. Decide on the specifics of the measurement in the group to get a fair comparison between phones. Make a graph of the results, allowing you to compare the absolute acceleration measured with each phone. What can you say about the differences between devices and their accuracy? Does the orientation of the phone affect the measured results?

After this, download the tool Accelerometer statistics from the QR code below (you can add measurement tools to phyphox from the '+' sign on the front page by choosing Add experiment from QR code):

Alternatively, you can find the tool at https://phyphox.org/wiki/index.php/Sensor_Statistics.

First explore the Accelerometer statistics tool freely to understand what it measures and what the distribution that it shows is. Then use to tool to make a quick estimate of the gravitational acceleration g in the following scenarios:

a) The phone is in the hand of the person making the measurement
b) The phone lies flat on a steady table
c) The phone lies on a table and the group causes as much disturbance to the measurement as possible without directly touching the phone.

Make observations and notes about the obtained distributions and compare the distributions and the obtained results for g between each scenario. What systematic and random uncertainties are present in each scenario? What uncertainties are present regardless of how the measurement was done?

2. Experimentation

Keeping in mind the observations made in part 1 above, design new measurements from which you can determine the gravitational acceleration g as precisely as possible by using data taken with all phones in the group. Give a best estimate for the value of g and an estimate of its uncertainty.

Assessment

List all sources of random and systematic uncertainty that you find in your experiment, and for each source, explain how you accounted for, minimized, or eliminated the uncertainty in your experiment. Use graphs to back up your argumentation. Describe your measurements and give your best estimate for g with an uncertainty estimate.