Gravitational Acceleration

Purpose

Using Arduino accelerometer with "Lab in Your Pocket" app to investigate gravitational acceleration.

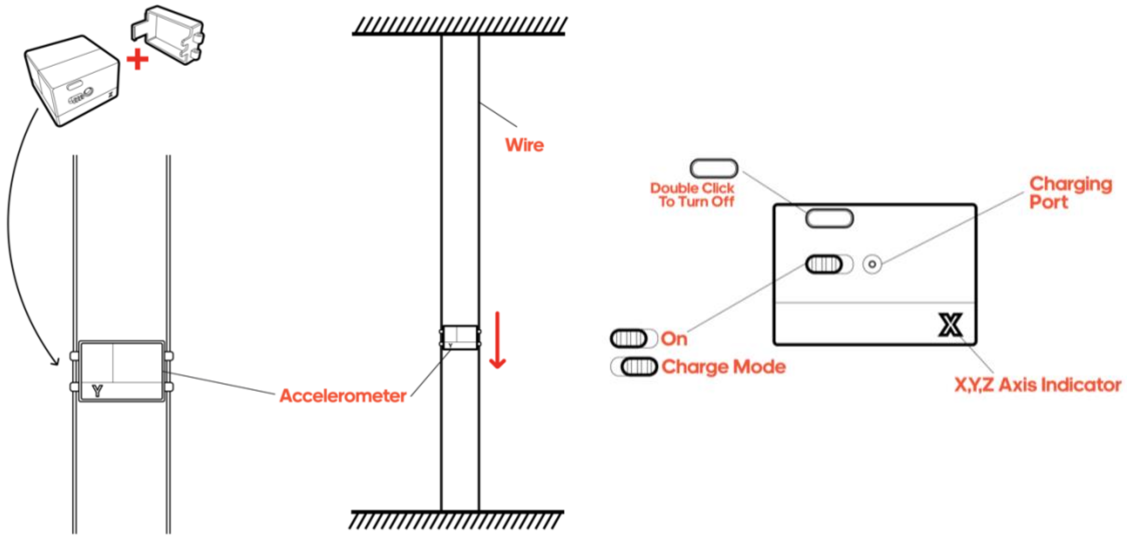
Theory

- Gravitational force is a fundamental force existing among all matters in the universe. The force *F* is given by $F = \frac{GM_1M_2}{r^2}$, pointing towards each other.
- *G* refers to universal gravitational constant. Its value is 6.67 x $10^{-11}m^3kg^{-1}s^{-2}$. M_1 and M_2 stand for masses of two bodies. *r* is the distance between two bodies.
- From the equation and the constant, you can tell that the gravitational attraction between small masses in our daily life is very trivial. It becomes more significant when we consider huge masses, such as planets, that are not too far away from each other.
- Applying Newton's Law where *F* = *ma*, the acceleration due to gravity is given by $g = \frac{GM}{r^2}$. Putting Earth mass 5.97 x 10^{24}kg and Earth radius 6371000m, the value of *g* can be calculated.
- The Arduino accelerometer is connected to the "Lab in Your Pocket" app to take the reading of acceleration in all axes during free falling.

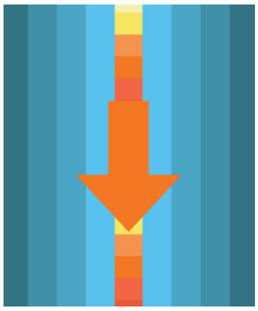
Apparatus

- A mobile device with "Lab in Your Pocket" app
- An Arduino accelerometer (provided by PolyU)
- A cushion
- A wire/ribbon with at least 1m long

Setup

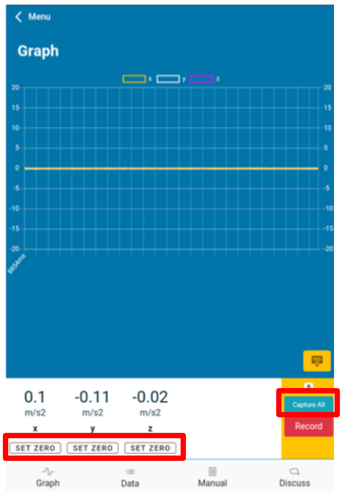


Procedure



Set up the Experiment

1. Place the cushion on the floor.
2. Turn on the Arduino accelerometer at rest by pressing the power button once.
3. Open "Lab in Your Pocket" app in the mobile device and choose "Gravitation".
4. Register the accelerometer with the address printed on it. Press "Connect" to connect the sensors. When the connection finishes, the app will automatically jump into a real-time graph of the acceleration in different axes.



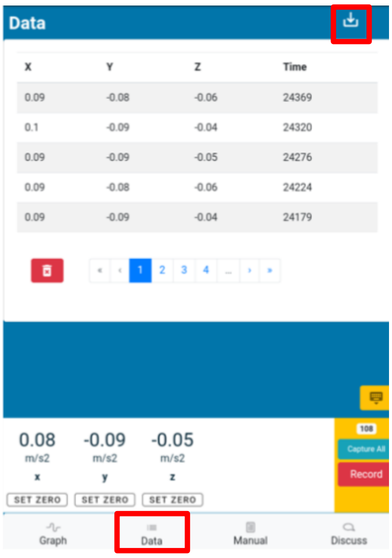
5. If necessary, press "Set Zero" button on the app interface to remove offsets.
6. Find and identify the axes and +/- directions of the accelerometer by moving it in all directions.
7. Optional: Put a wire/ribbon through the holes prepared on the accelerometer. Hold straight the wire/ribbon so that it serves as rails for vertical free falling.

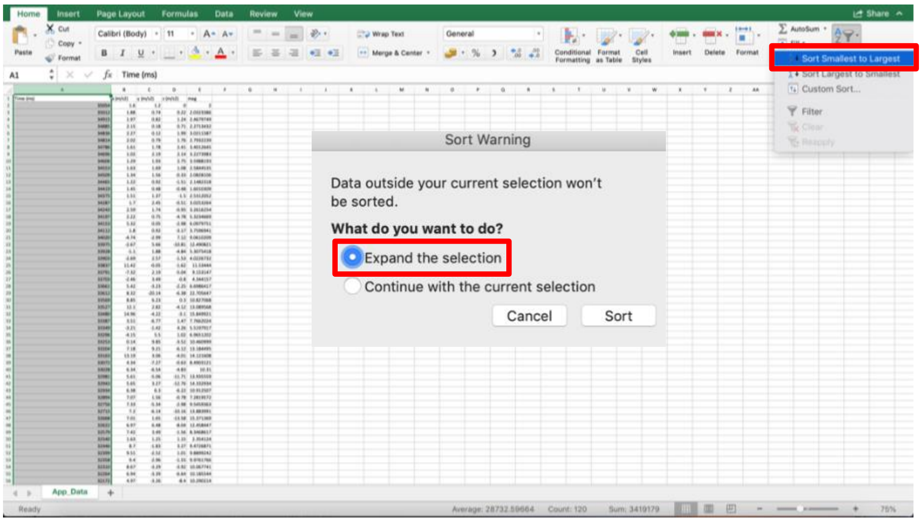
Free Falling

8. Hold the accelerometer such that any axis points towards the ground.
9. Start recording the data by pressing "Capture All" button. The number above the button shows the data points collected.
10. Release the accelerometer to let it free fall to the cushion.
11. Stop the measurement by pressing "Stop" button.
12. Switch off the accelerometer by pressing the power button twice.

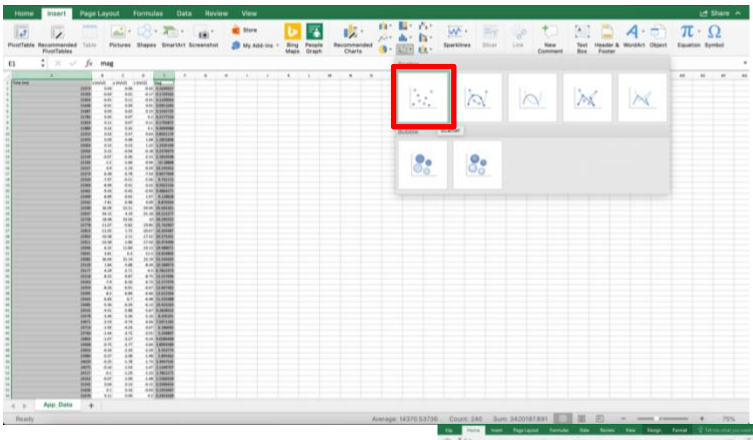
Data Analysis

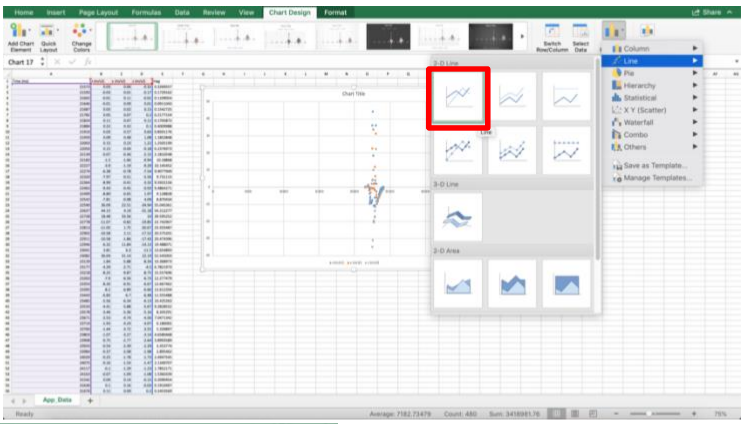
13. In the data page, read the acceleration of all axes.
14. Press the “export” button to export the data as .csv file. Send the file to a computer.

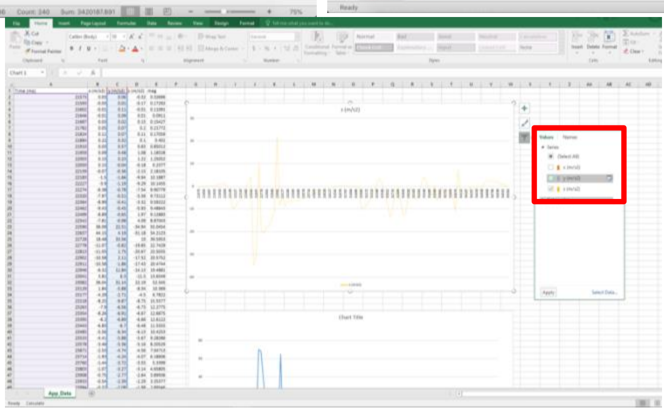




15. Open the .csv file with Excel. (Change the file format to .csv if necessary.) Reverse the time sequence of the recorded data.
16. If this free falling is performed without using a wire/ribbon, calculate the magnitude of acceleration for each set of data.
17. Highlight the needed data columns and plot a “scatter” chart with Excel. Connect the data points as line. Then display the desired axis by filtering out the others.







18. From the graph, identify the acceleration due to gravity during the free falling period.

Data

Acceleration due to Gravity = ____________

Discussion

1. Which axis is the gravitational acceleration along? Is the axis of free falling significant if it is not constrained by the wire/ribbon? Why does magnitude matter more in this case?
2. Is the experimental data of the gravitational acceleration reasonable compared to the literature value? If you carry out the experiment with and without wire/ribbon, which one appears to be more accurate.
3. Did you observe any trend of acceleration when free falling occurs? Why?
4. What are the possible errors of the experiment? How can we improve to reduce the errors?