24th July,2023

Analyzing Motion Patterns in a Pendulum

Aim:

To examine the motion patterns of a pendulum by analyzing the data collected from the acceleration sensor (Accelerometer) and gyroscope.

Experimental Setup:

1. The experiment involved creating a simple pendulum with a 30 cm string attached to a fixed point. At the other end of the string, a 180gm cell phone was suspended using a cardboard holder.
2. To ensure free and unobstructed motion, the pendulum was set up to swing without any hindrance. Data acquisition was facilitated using the PhyPhox application

Experiment Procedure:

1. Securely attach your smartphone with the PhyPhox app installed to the pendulum weight.
2. Launch the PhyPhox app and access the experiment creation section.
3. Create a new experiment, selecting "Accelerometer" and "Gyroscope" options in the experiment settings.
4. Ensure that the sensors are calibrated and ready for data acquisition.
5. Configure the Timed Run section of the experiment: set a start delay of 3 seconds, experiment duration of 10 seconds, and activate all acoustic signals.
6. Begin the experiment and release the pendulum to enable free swinging motion.
7. The Accelerometer and gyroscope will record the motion data as the pendulum swings.
8. After the predefined 10-second duration, stop the data acquisition in the PhyPhox app.
9. Export the recorded data and take screenshots of the graphs from PhyPhox to your computer.

Data Analysis:

1. For data analysis, Python scripting was utilized on the Google Colab platform, leveraging essential libraries like 'pandas' and 'matplotlib' to ensure enhanced and streamlined scripting.
2. To ensure data accuracy and eliminate any undesirable artifacts, the first and last '1 second' of obtained data were removed.
3. After eliminating initial and final artifacts, comprehensive statistics such as the average value and standard deviation were computed for all axes of the Accelerometer and Gyroscope data.
4. The motion insights were visually presented by generating line plots for the accelerometer data (x, y, z) and gyroscope data (x, y, z) over time.
5. To retain the visual representations, the plots were saved as PNG files for further reference and analysis.

A. Accelerometer

An accelerometer is a sensor that measures linear acceleration along one or several axes

Axis	Average Value	Standard deviation
X	-0.928014	0.220082
Y	0.810828	0.629884
Z	9.896177	0.215362

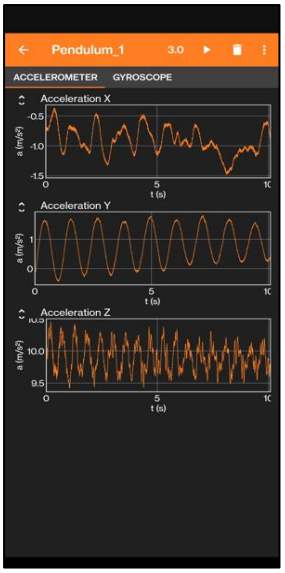

Figure 1: PhyPhox Graph

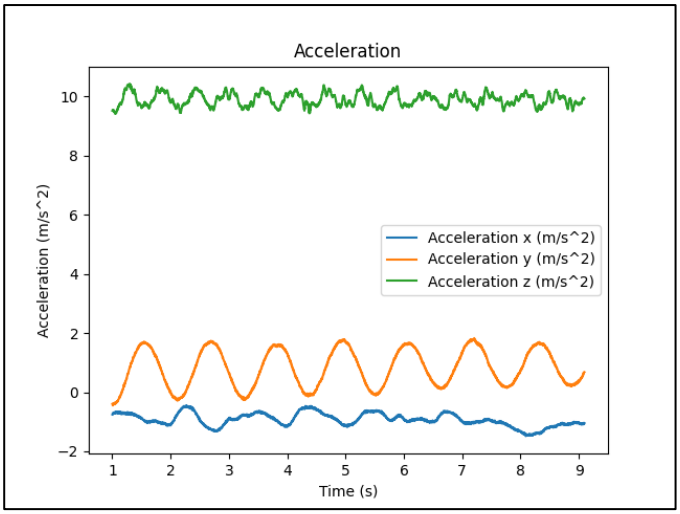

Figure 2: Graph from Python

X axis	The X axis corresponds to the horizontal position, aligned parallel to the base. Some distortion is noticeable on the X axis, which resulted from non-ideal conditions and human error during data acquisition.
Y axis	The Y axis represents the vertical position, perpendicular to the base. A consistent pattern observed throughout the duration indicates the smooth functioning of the pendulum.
Z axis	The Z axis denotes the rotational axis or rotational centerlines. It captures the acceleration generated during the swing due to gravity, with values ranging from approximately 9 (m/s^2) to 10 (m/s^2). The ideal acceleration due to gravity is 9.8 m/s^2.

B. Gyroscope

A gyroscope is a sensor that measures angular velocity around one or several axes

Axis	Average Value	Standard deviation
X	-0.005325	0.319354
Y	0.002932	0.099621
Z	0.007039	0.210955

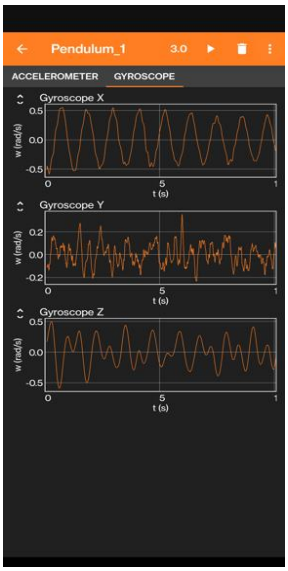

Figure 3: PhyPhox Graph

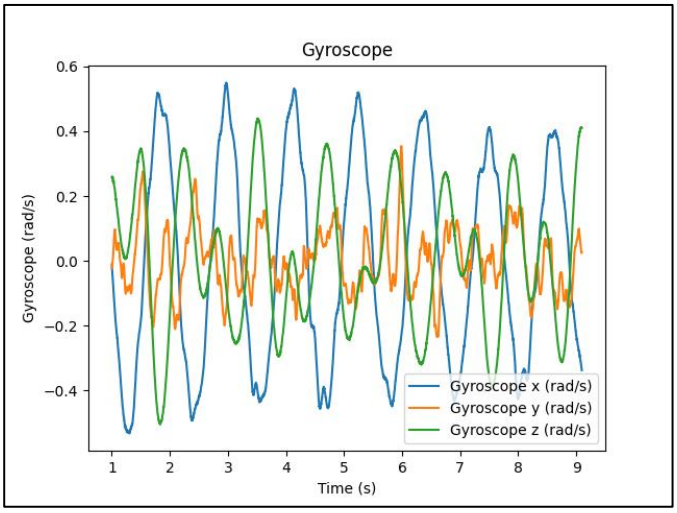

Figure 4: Graph from Python

X axis	As the phone swings back and forth along the x-axis, the gyroscope detects the angular velocity around the x-axis. It measures the rate at which the phone is rotating around this axis
Y axis	As the phone swings back and forth along the y-axis, the gyroscope detects the angular velocity around the y-axis. It measures the rate at which the phone is rotating around this axis.
Z axis	As the phone swings back and forth along the z-axis, the gyroscope detects the angular velocity around the z-axis. It measures the rate at which the phone is rotating around this axis.

Conclusion:

1. During the pendulum motion of the phone, both accelerometers and gyroscopes serve as sensors capable of measuring its motion along the x, y, and z axes. However, these sensors capture distinct aspects of the motion.
2. As the phone swings in pendulum motion, the accelerometer precisely records the linear acceleration along the x, y, and z axes, whereas the gyroscope focuses on measuring the angular velocity about these axes