# LAB3- **<u>IMU Noise Characterization with Allan Variance</u>**

## Introduction:
In this LAB we are using VN-100 IMU sensor. An Inertial Measurement Unit (IMU) is a sensor module that typically combines multiple sensors to measure various aspects of an object's motion and orientation. It commonly includes an accelerometer to measure linear acceleration, a gyroscope to measure angular velocity, and sometimes a magnetometer to detect magnetic fields.

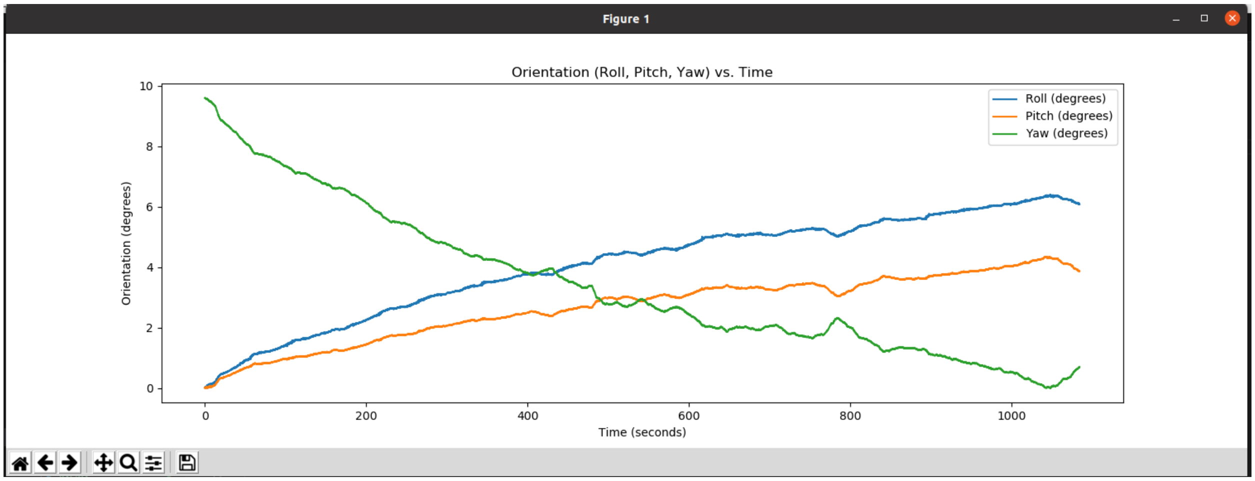

The aim of this report is to analyze the data collected from an IMU sensor within a basement environment over a 15-minute duration. The primary objectives are to perform error analysis on the IMU data and understand trends in pitch, roll, and yaw angles. Additionally, this study aims to visualize variations in angular velocity, linear acceleration, and magnetic field measurements through plotting and data analysis, providing insights into the sensor's performance and understanding errors. And the calculate the Allan variance we have collected data for 5 hours

### Sources of errors

- Inherent Sensor Noise (Random Walk)
- Linear Vibration
- Misalignment Errors
- Input Range
- Bias
- Scale Factor
- Timing Errors (Latency)

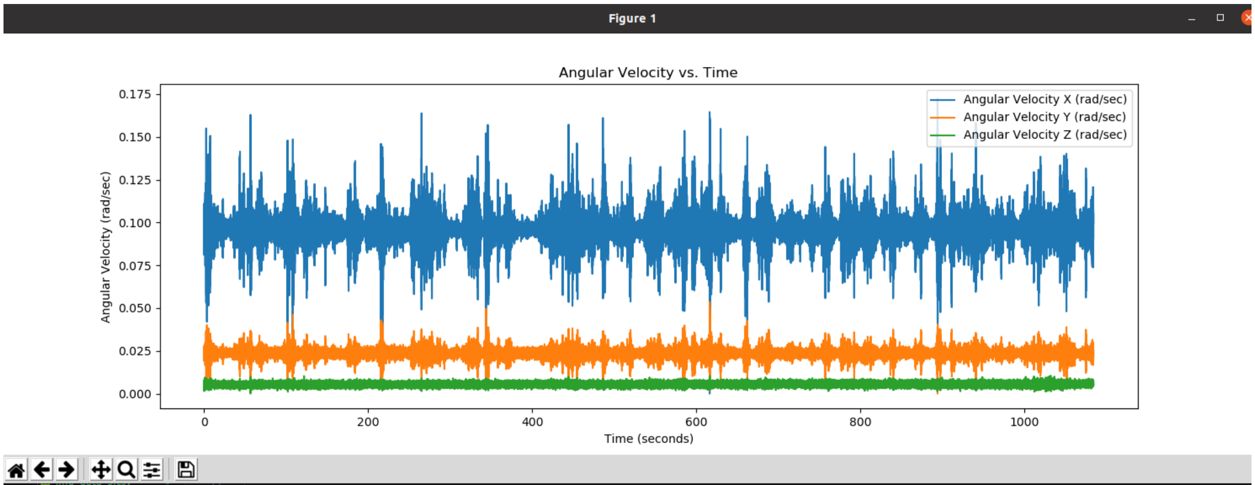
## A] Orientation Plots:

A gyroscope sensor is used to measure angular velocity and orientation, making it useful for tracking changes in an object's rotation or orientation in a variety of applications, such as navigation and stabilization.

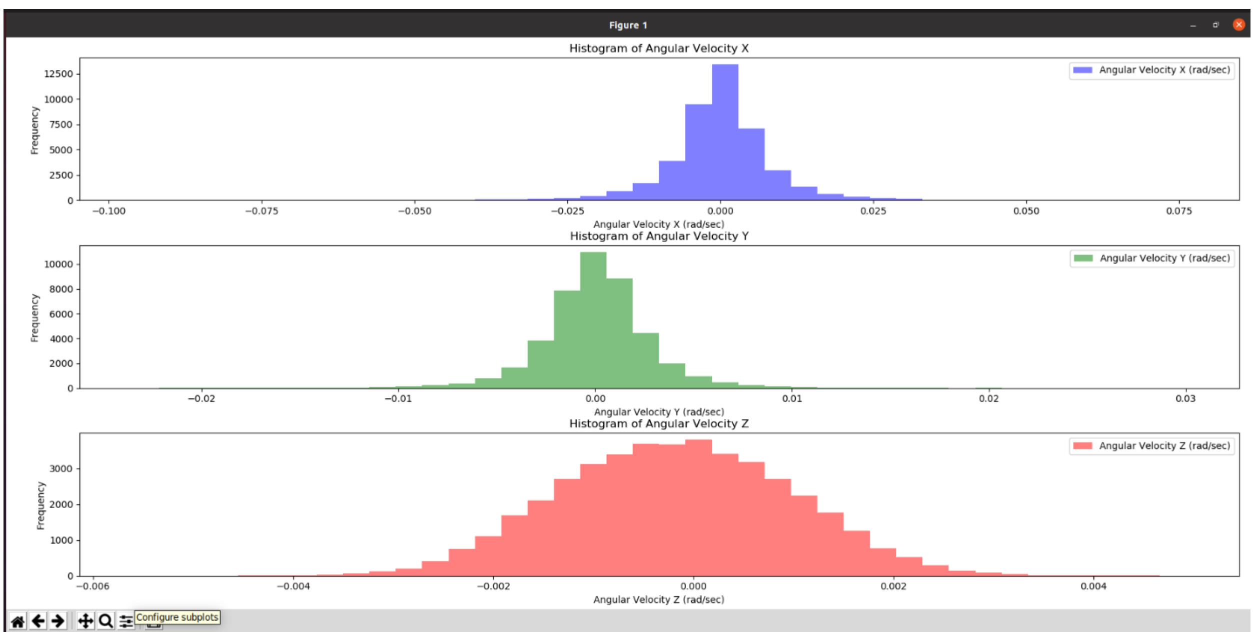



Distribution graph:

## B] Angular velocity plots

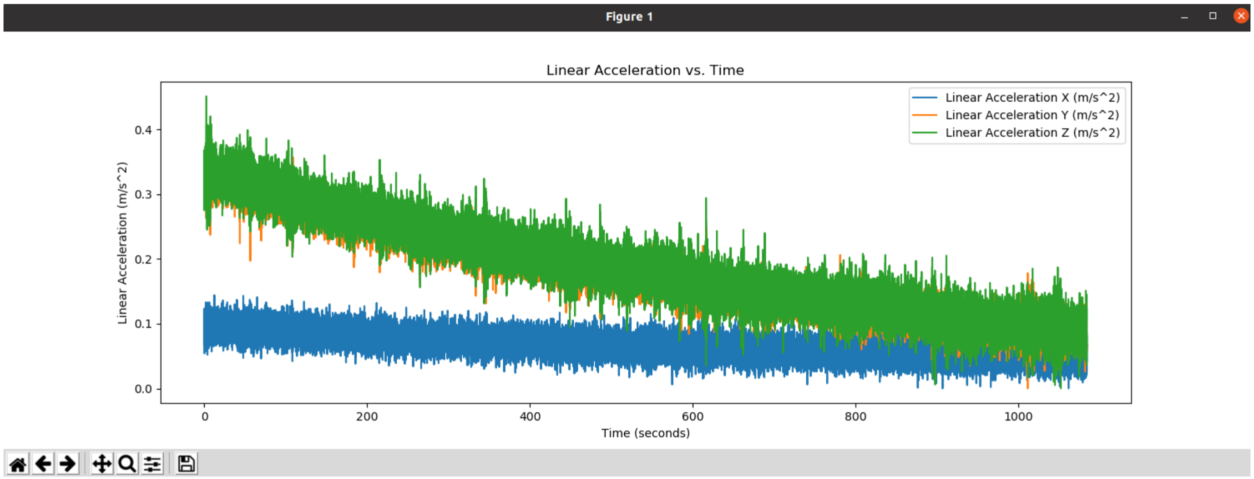


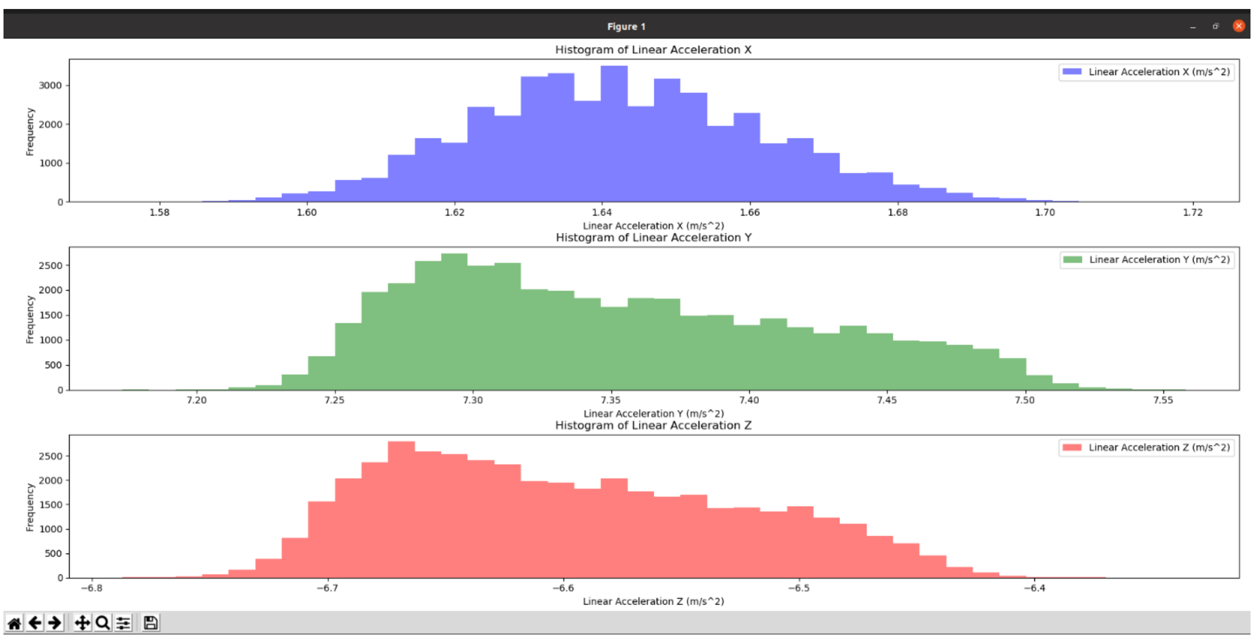

Distribution:



## C] Linear acceleration:

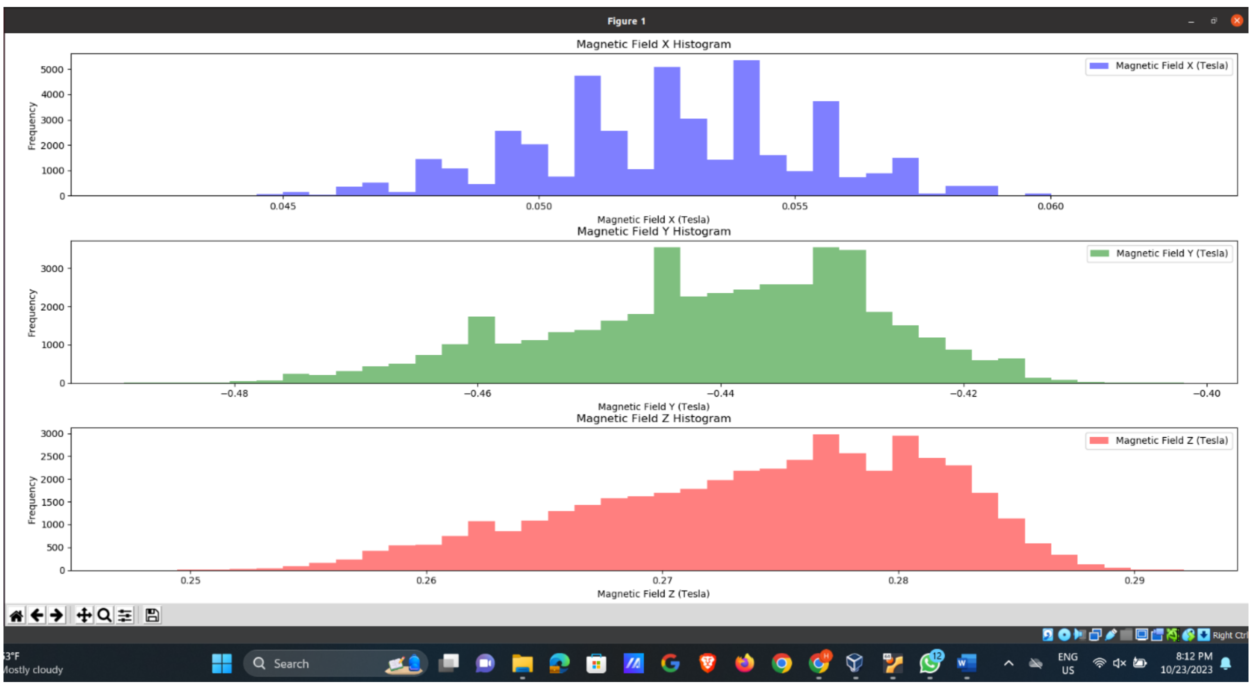
An accelerometer is a sensor we used that measures the acceleration experienced by an object, which includes both the acceleration due to gravity and any additional accelerations the object might undergo. It is used to detect changes in velocity and orientation.

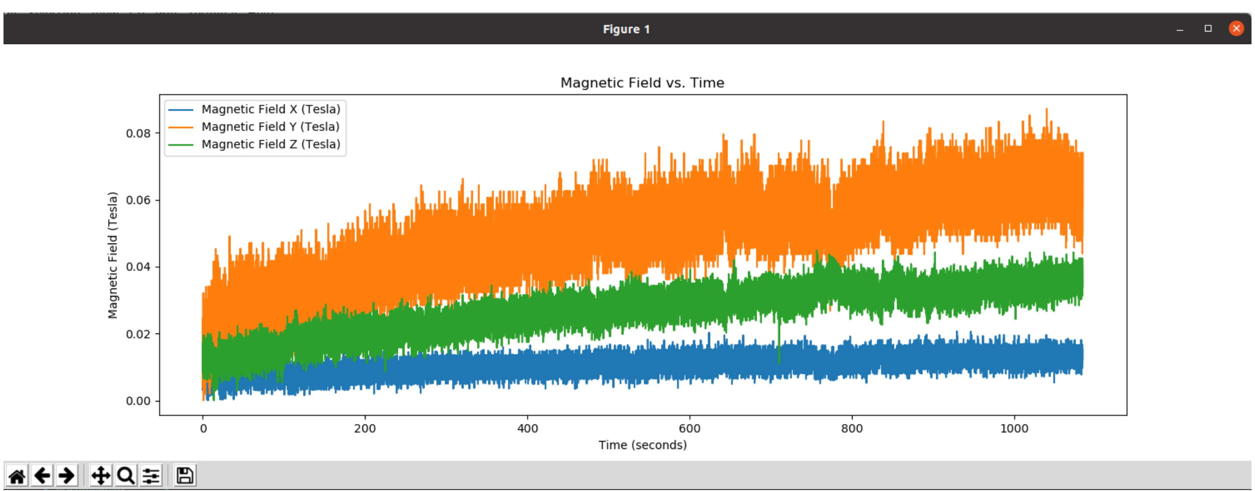


## D] Magnetic field plots:

A magnetometer is a device designed to detect and measure magnetic fields. It aids in determining orientation by utilizing the Earth's magnetic field, much like a compass. Similar to how accelerometer data in the X, Y, and Z axes can be used to calculate pitch and roll, magnetometer readings along these axes can be employed to determine yaw or directional orientation.



**E] ALLAN VARIANCE**

Allan variance is a valuable statistical method used to assess the precision and noise characteristics of sensors and measurement systems as a function of time. It provides insights into how the variance in sensor data changes at different time intervals, making it a vital tool for identifying and categorizing various types of noise, including white noise, flicker noise, and random walk noise. This analytical technique is essential for comprehending sensor performance and determining its suitability for specific applications, with applications spanning diverse fields such as navigation, geophysics, and sensor calibration.

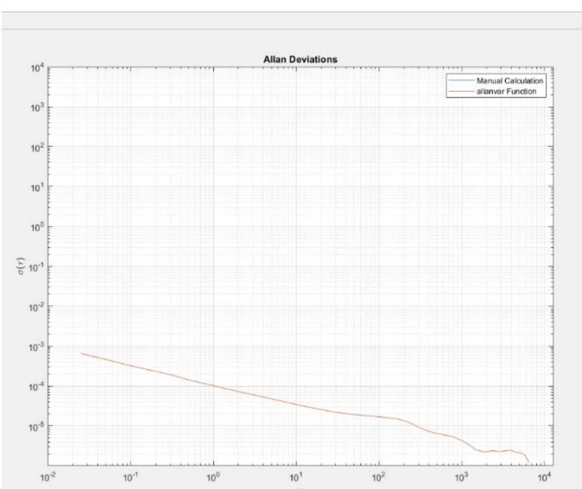
We have recorded 5 hours of data in a basement to minimize errors due to external factors.

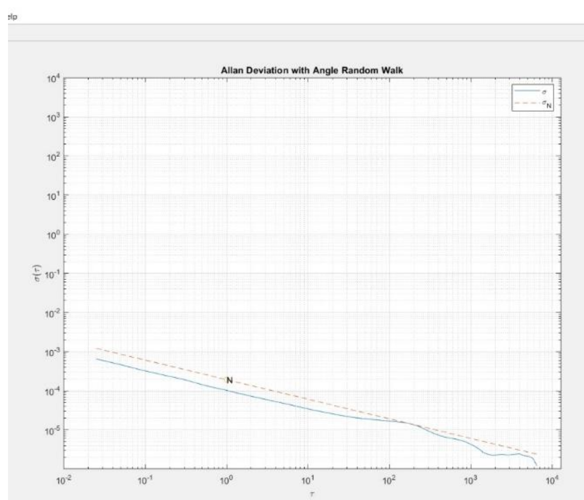
-White noise region: The Allan variance is constant and independent of the averaging time in the white noise zone. At average viewing periods of under 10 seconds, this region is frequently observed.

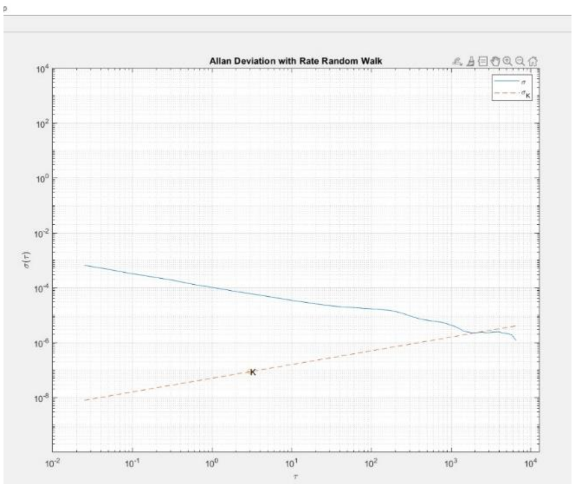
-Region of random walks: In the region of random walks, the Allan variance rises linearly with averaging time. The average period at which this region is visible ranges from 10 to 1000 seconds.

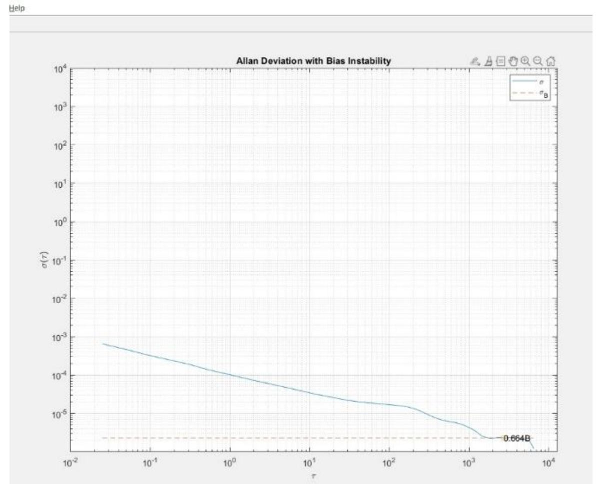
-Bias instability region: The Allan variance increases with the square root of the average time in the bias instability region. At average viewing times of greater than 1000 seconds, this region is frequently observed.

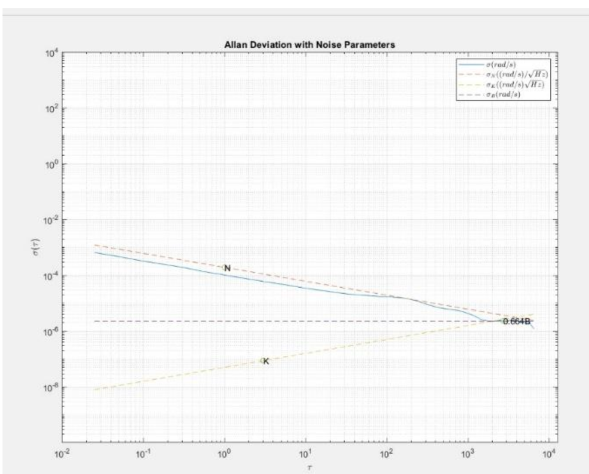
FOR variance in angular acceleration in X

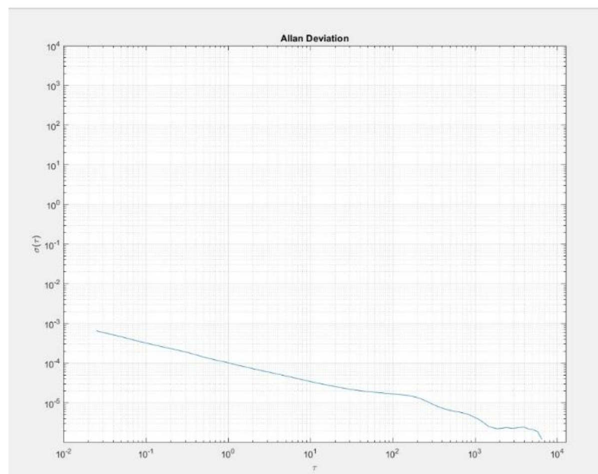


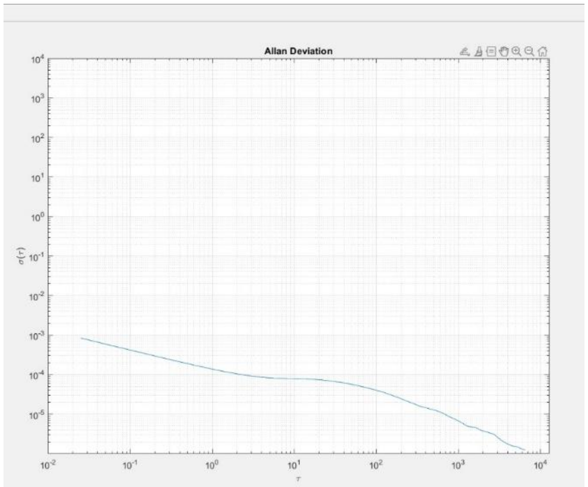


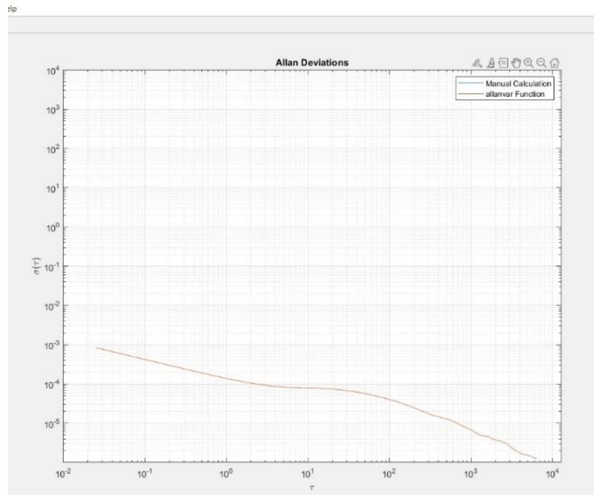



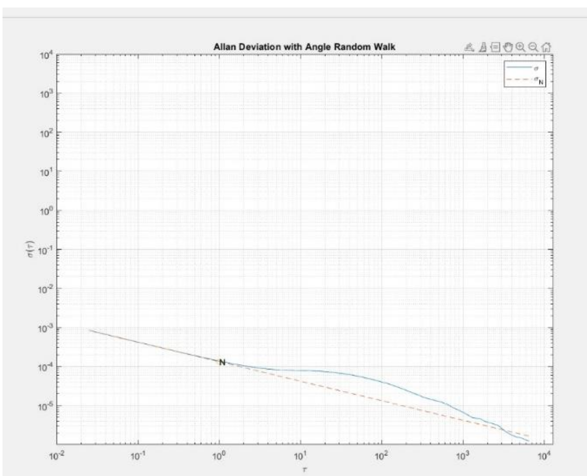



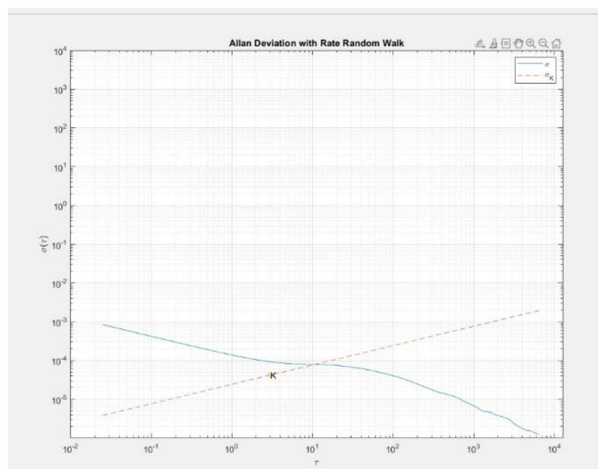



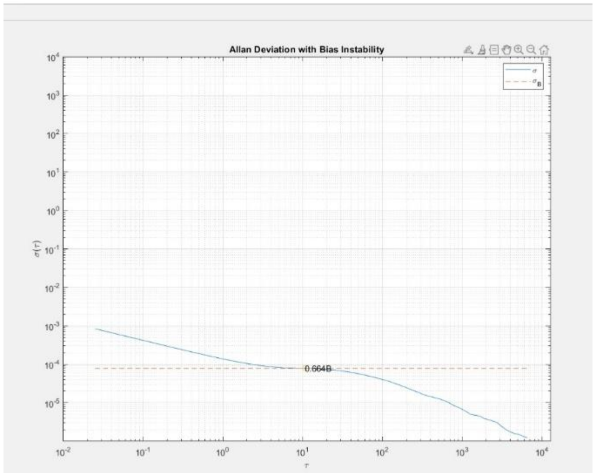

Variance in angular acceleration in Y

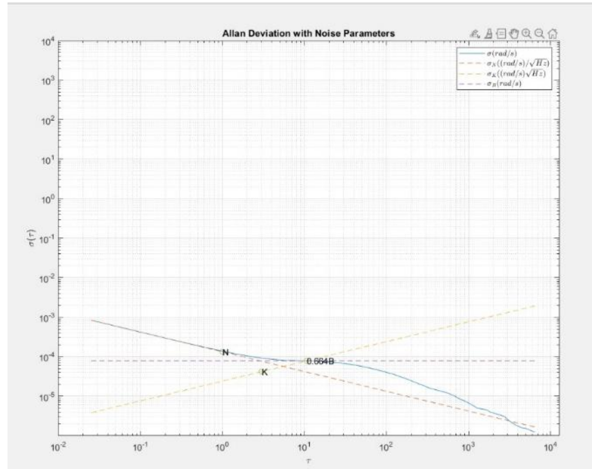

Allan Deviation
σ(τ)
τ


Allan Deviations
Manual Calculation
allanvar Function
σ(τ)
τ

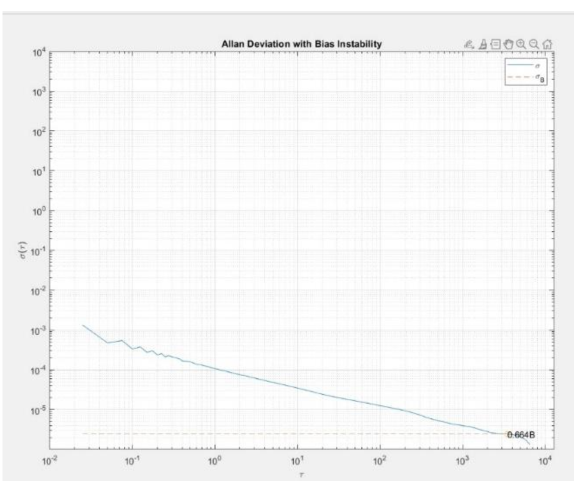

Allan Deviation with Angle Random Walk
σ
σN
N
σ(τ)
τ

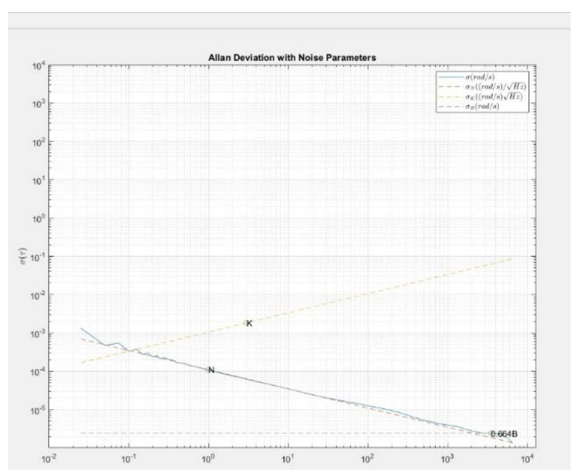

Allan Deviation with Rate Random Walk
σ
σK
K
σ(τ)
τ

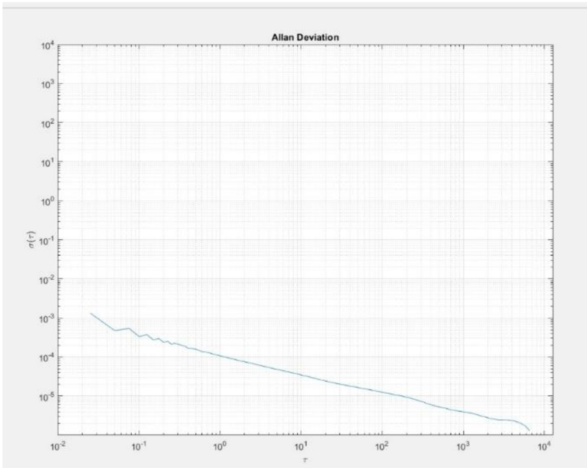


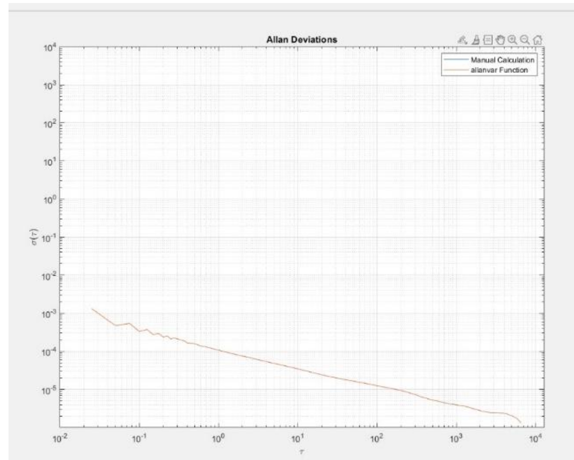



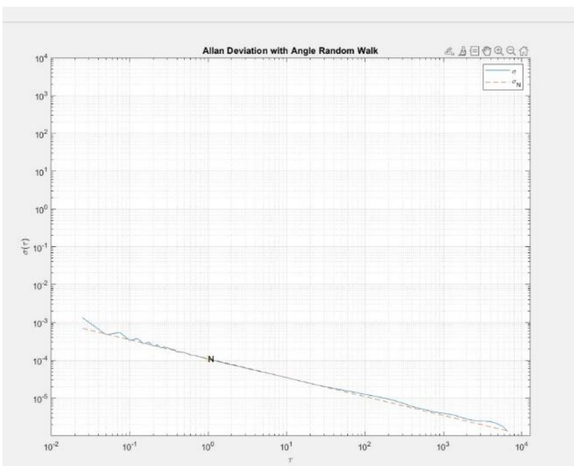

Variance in angular acceleration in Z

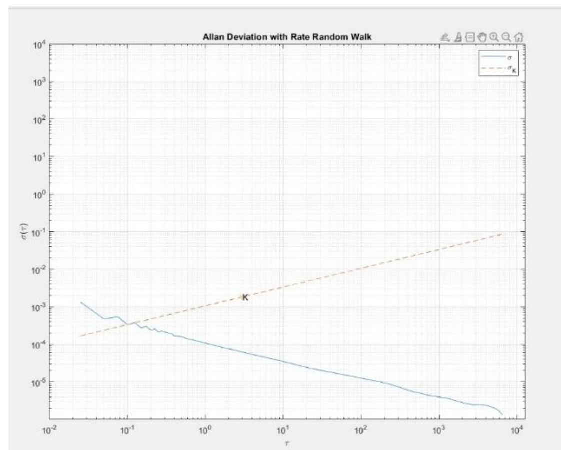



Allan Deviation
σ(τ)
τ


Allan Deviations
Manual Calculation
allanvar Function
σ(τ)
τ


Allan Deviation with Angle Random Walk
N
σ(τ)
τ


Allan Deviation with Rate Random Walk
K
σ(τ)
τ