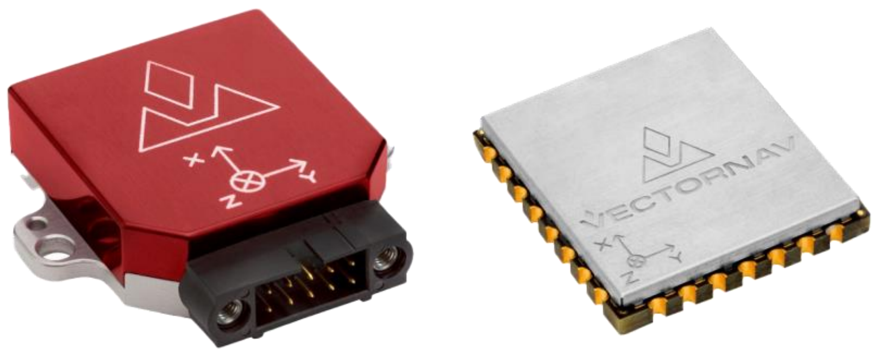
LAB 3 REPORT

In this LAB we have used VN-100 IMU for recording the necessary data. An Inertial Measurement Unit (IMU) is a sensor which is used to measure the motion and orientation of the device. It includes an accelerometer which is used for measurement of linear acceleration, a gyroscope which is used for measurement of angular acceleration, and it may also include a magnetometer which can measure magnetic fields.



The aim of this experiment is to analyze the data collected from an IMU over a 10-15 minute duration. From the data which was recorded in the 15 minute duration, we can perform error analysis on the data.

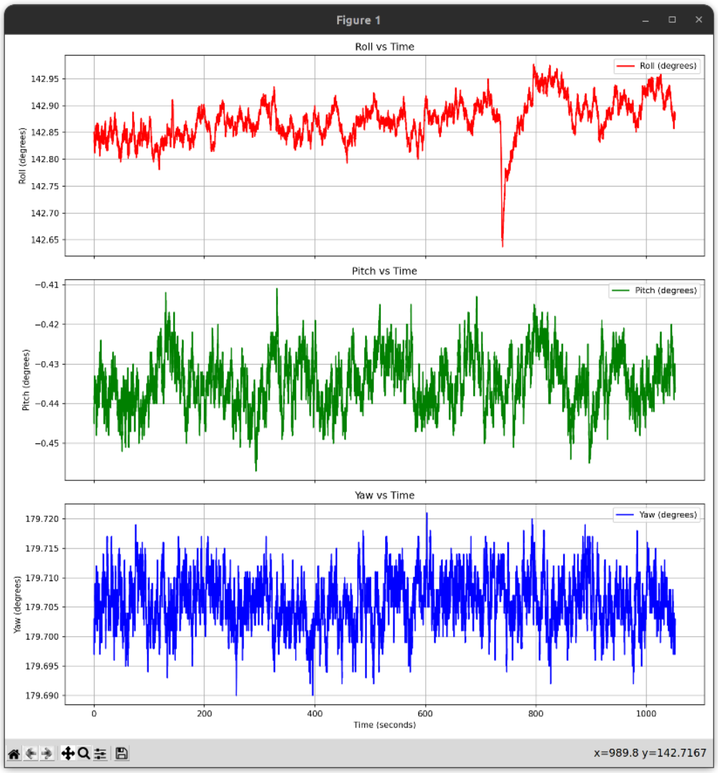
The mean can be calculated by using the formula $\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$. I have used AVERAGE() function in Excel to calculate the mean.

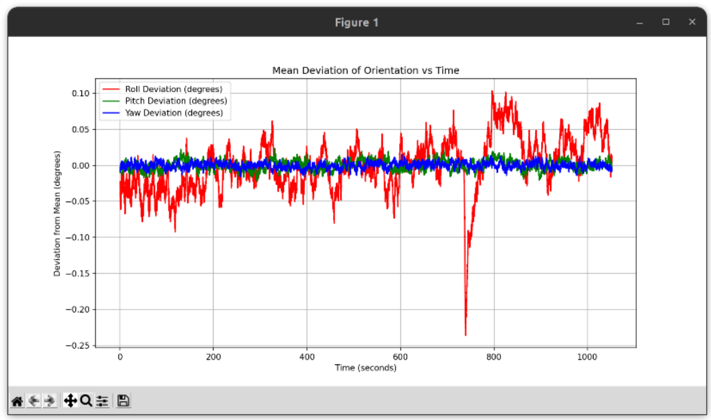
The standard deviation can be calculated by using the formula $s = \sqrt{\frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n-1}}$. I have used STDEV.P() function in Excel to calculate the standard deviation.

We have also recorded a dataset of 5 hours which is used for plotting Allan Variance graphs.

1. Orientation Plots:

A gyroscope is used to measure angular velocity and orientation which is useful for tracking the orientation of the device. With Roll, Pitch and Yaw we can calculate the device orientation in 3D.





Mean of Roll = 142.8732601 degrees

Mean of Pitch = -0.434519326 degrees

Mean of Yaw = 179.7059405 degrees

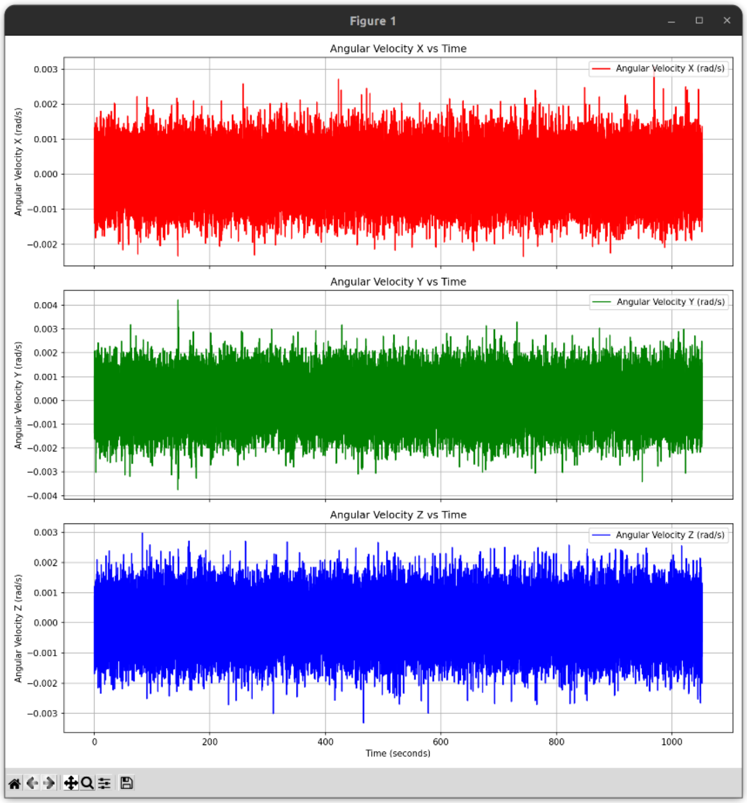
Standard Deviation of Roll: 0.037979376

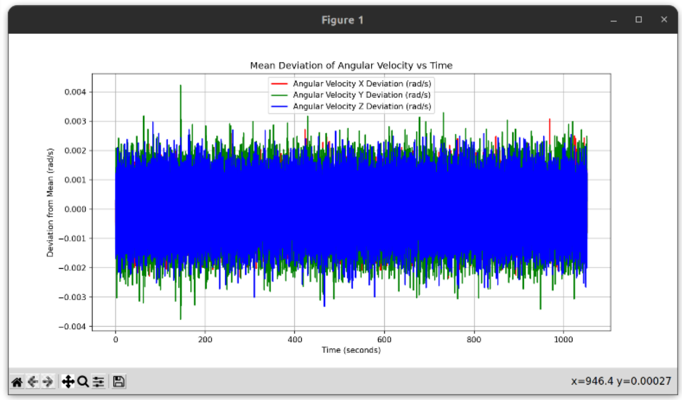
Standard Deviation of Pitch: 0.006768563

Standard Deviation of Yaw: 0.004367135

Histogram: 

2. Angular Velocity Plots:





Mean of Angular Velocity X: -0.00000294 rad/s

Mean of Angular Velocity Y: 0.00000435 rad/s

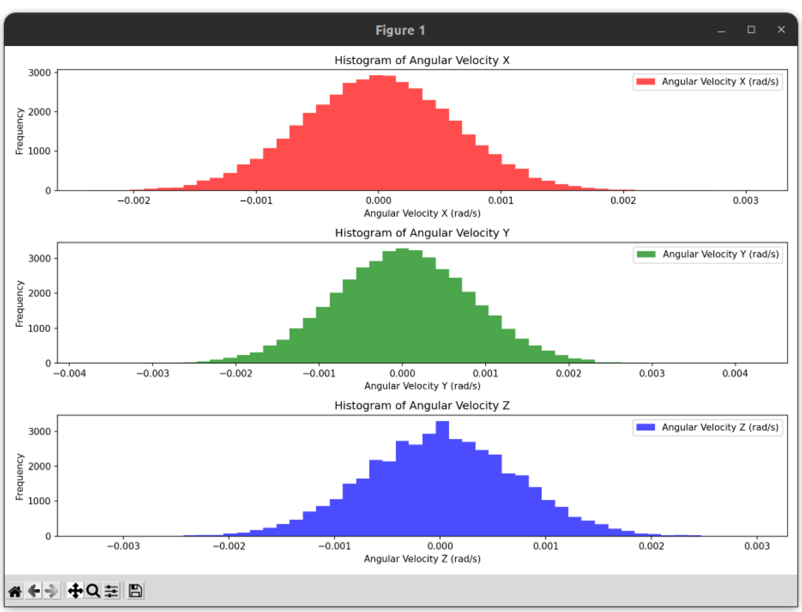
Mean of Angular Velocity Z: 0.000000827 rad/s

Standard Deviation of Angular Velocity X: 0.000625433

Standard Deviation of Angular Velocity Y: 0.00082785

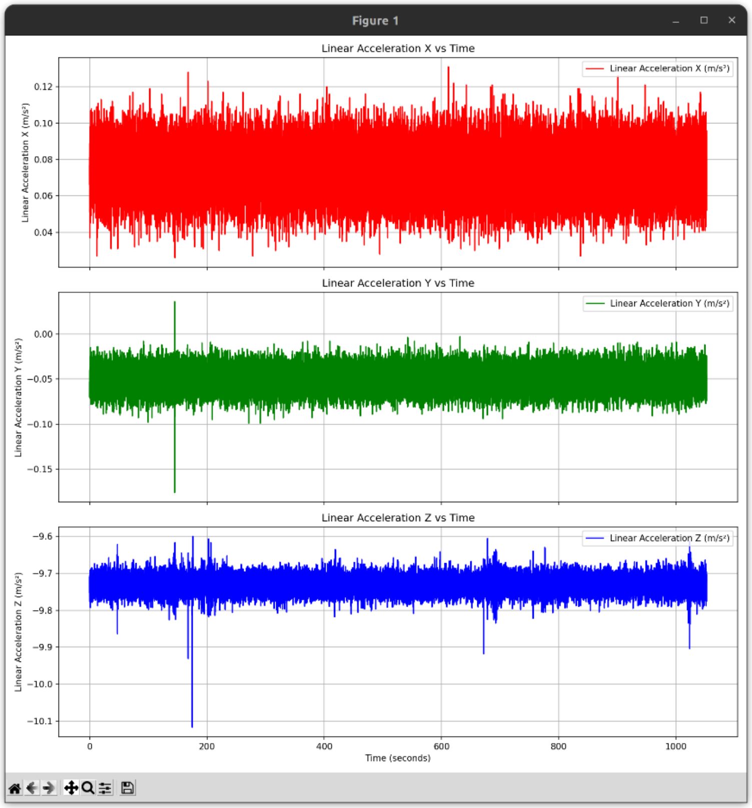
Standard Deviation of Angular Velocity Z: 0.000718659

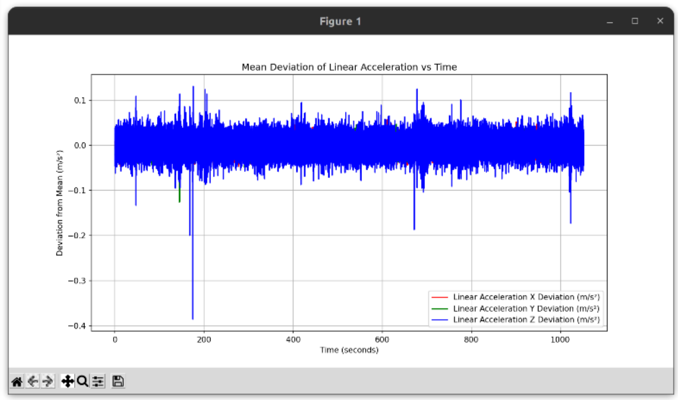
Histogram:



3. Linear Acceleration Plots:

An accelerometer is used to measure the acceleration which is experienced by the device. It is used to detect changes in velocity and orientation.





Mean of Linear Acceleration X: 0.073834699 m/s^2

Mean of Linear Acceleration Y: -0.049946523 m/s^2

Mean of Linear Acceleration Z: -9.730985033 m/s^2

Standard Deviation of Linear Acceleration X: 0.012568917

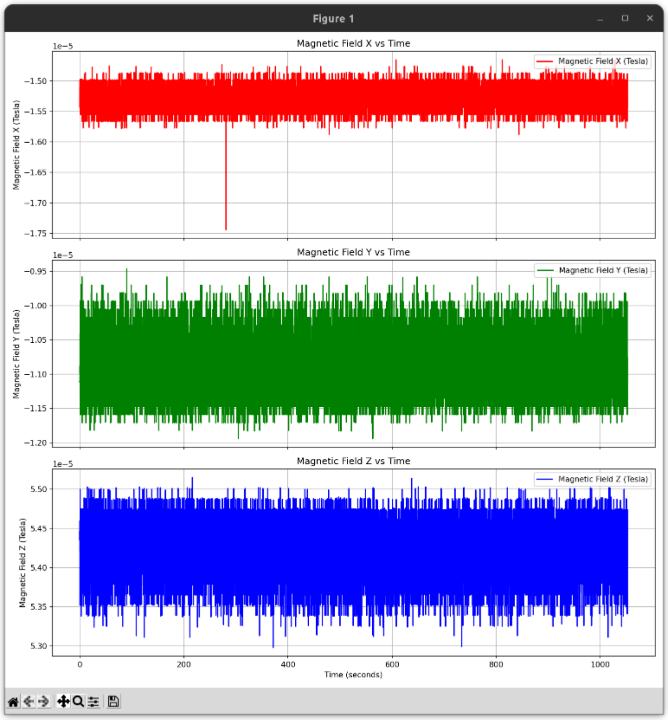
Standard Deviation of Linear Acceleration Y: 0.012108269

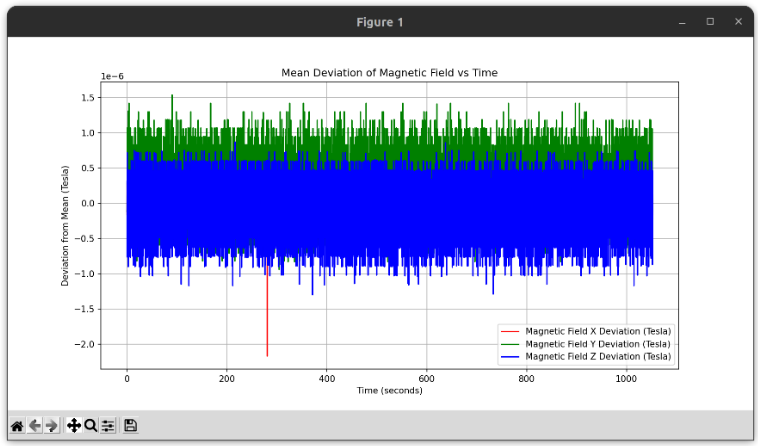
Standard Deviation of Linear Acceleration Z: 0.020625704

Histogram:

4. Magnetic Field Plots:

A magnetometer is used to measure magnetic fields. It helps in determining the orientation by using Earth's magnetic field, like a compass. A magnetometer is used in an IMU to correct the errors in the gyroscope data which is caused by Bias instability.





Mean of Magnetic Field X: -0.0000153 Tesla

Mean of Magnetic Field Y: -0.000011 Tesla

Mean of Magnetic Field Z: 0.0000543 Tesla

Standard Deviation of Magnetic Field X: 0.00000014898

Standard Deviation of Magnetic Field Y: 0.000000320319

Standard Deviation of Magnetic Field Z: 0.00000027744

Histogram:

5. Allan Variance

Allan variance is a statistical tool used to measure the stability and accuracy of time-varying systems. In our system we have used it for analysis of gyroscope and accelerometer data.

We mounted the IMU in an open cupboard at night for 5 hours to record the data. The link to our data files is attached here.

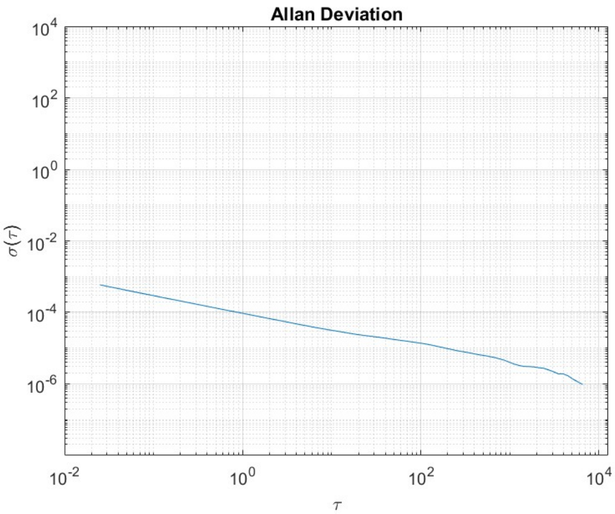
The various sources of error in an IMU are:

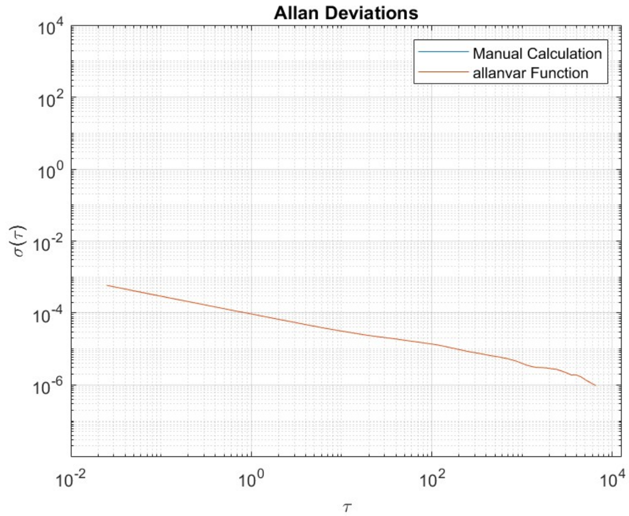
- Random Walk Noise: A cumulative effect of random noise, leading to drift over time. This is typically more noticeable in gyroscopes due to angular random walk.

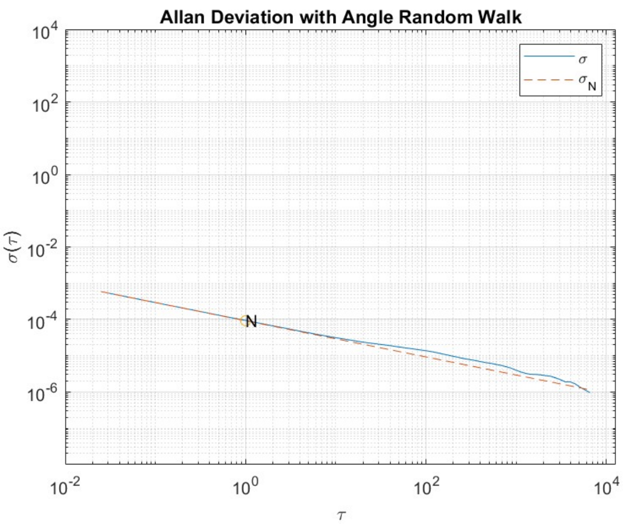
- White Noise: There are random variations in the sensor readings which are observed at short intervals in the Allan Variance plot.

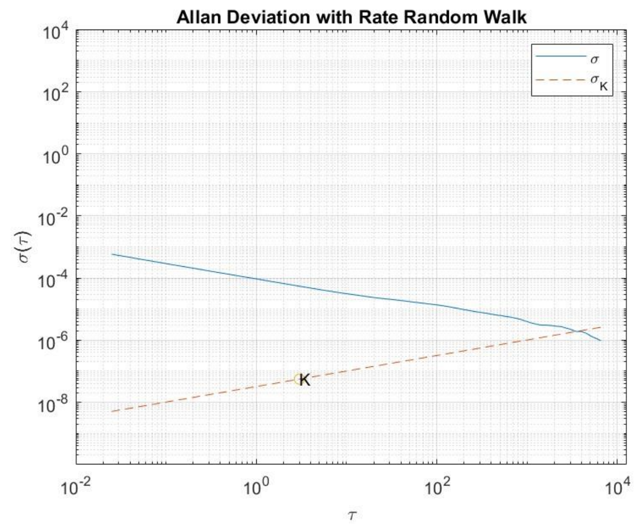
- Bias Instability: A low-frequency drift in the bias (offset) that fluctuates slowly over time. It appears as a flat region in the Allan Variance plot at intermediate time intervals.

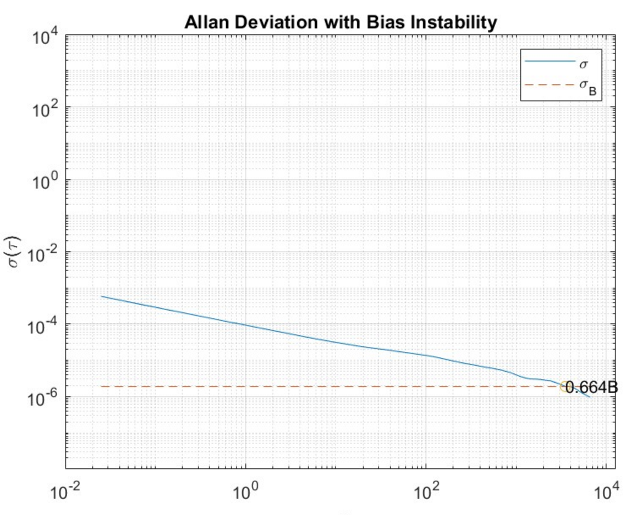
Allan Deviation for Angular Velocity in X:

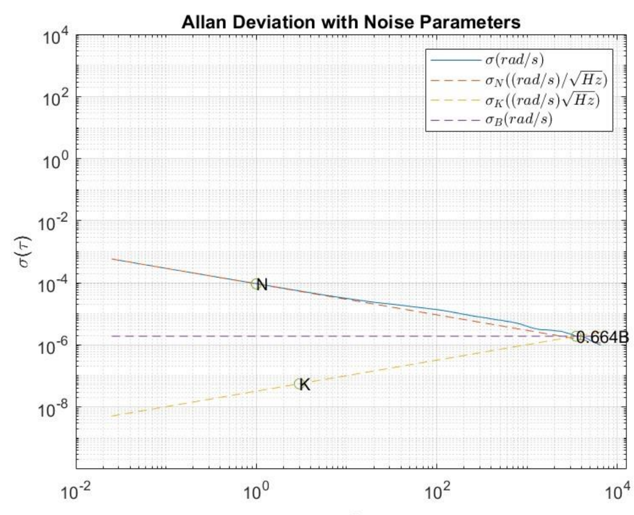




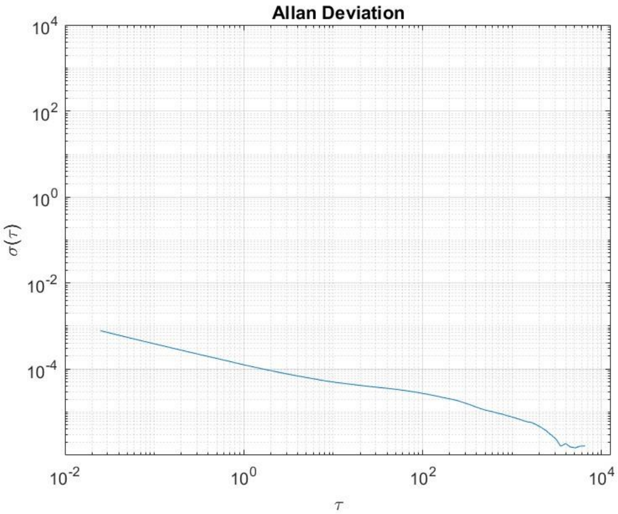


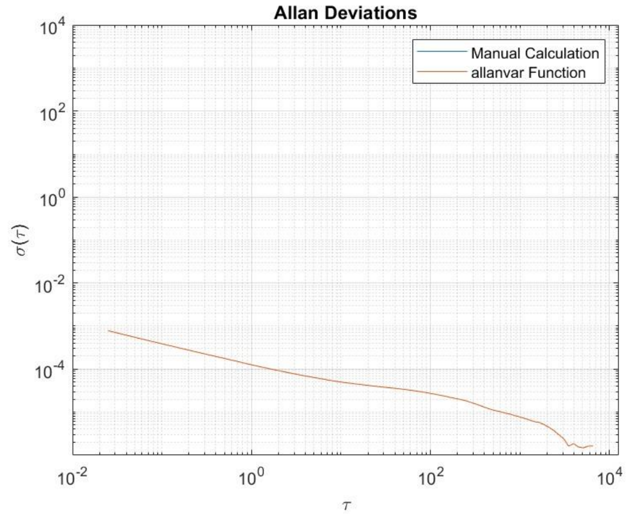


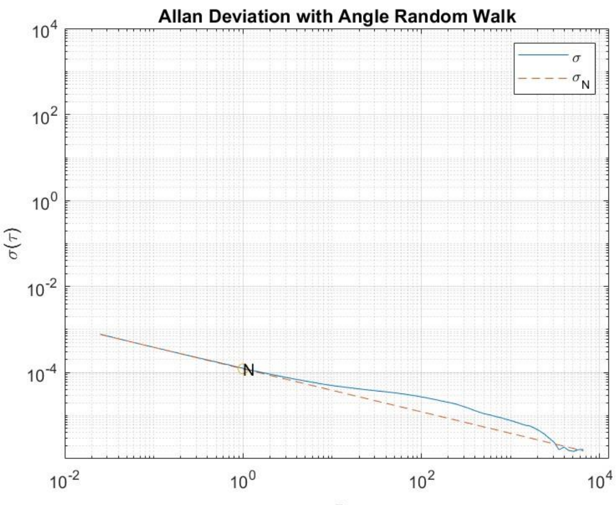


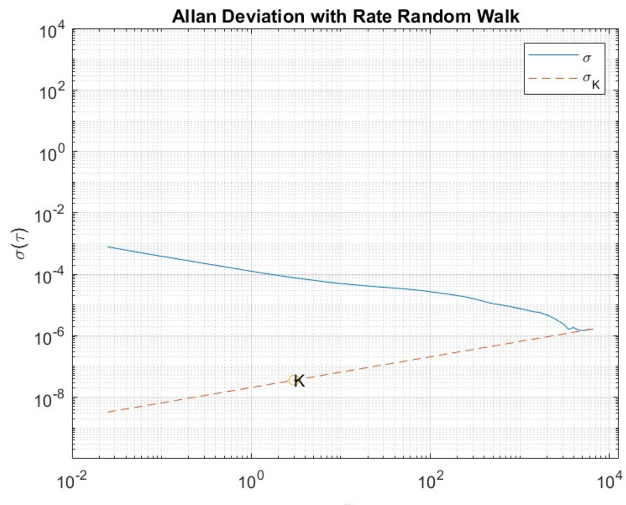


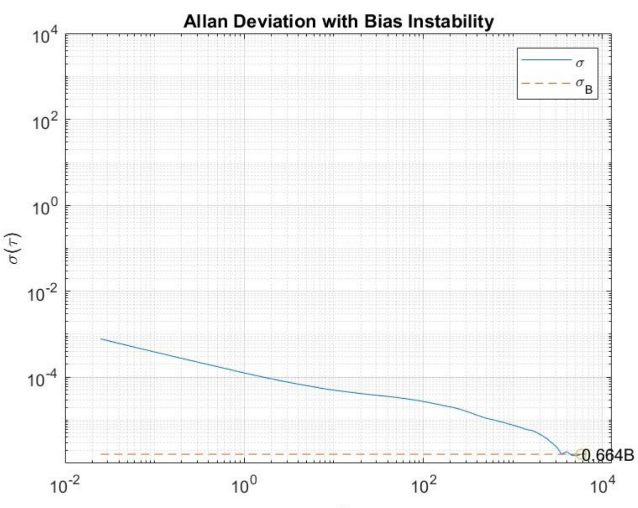
Allan Deviation for Angular Velocity in Y:

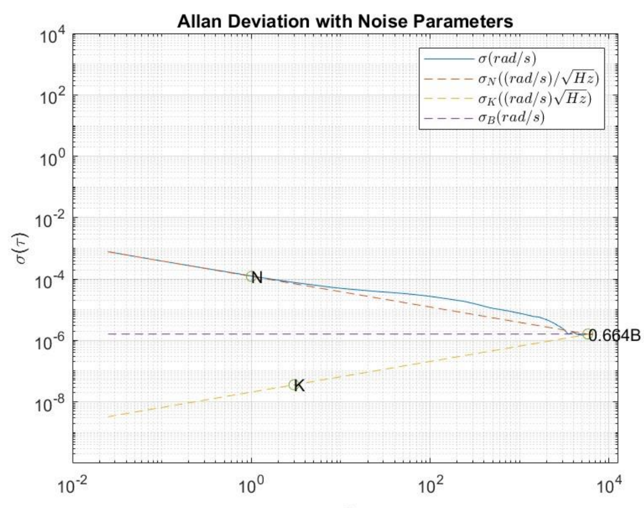




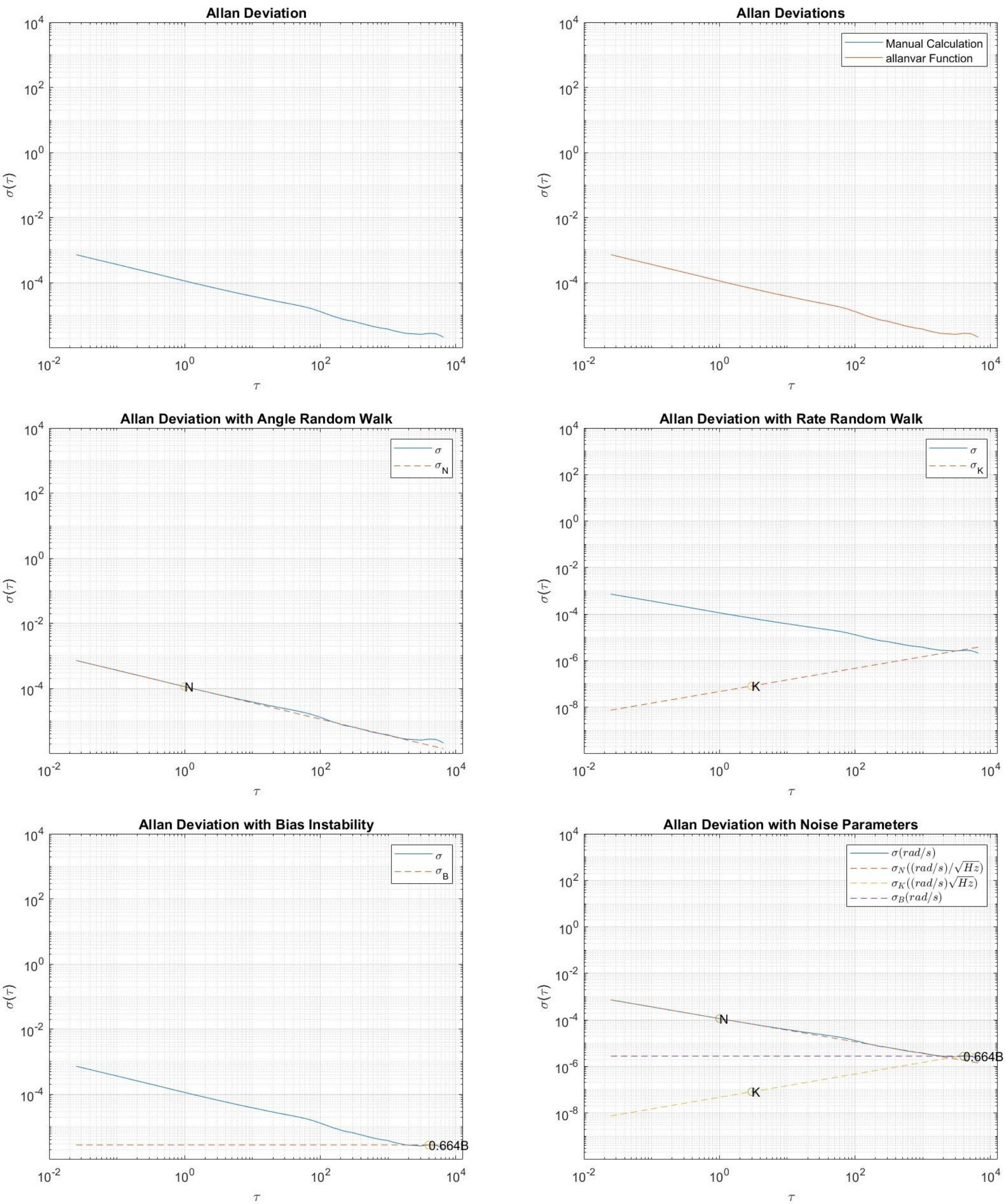




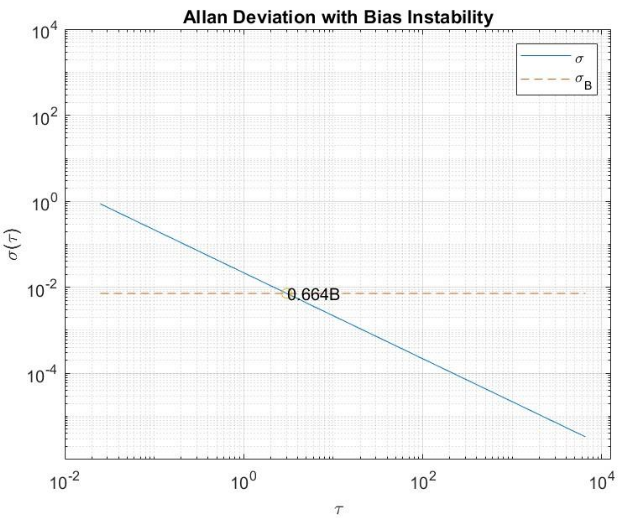


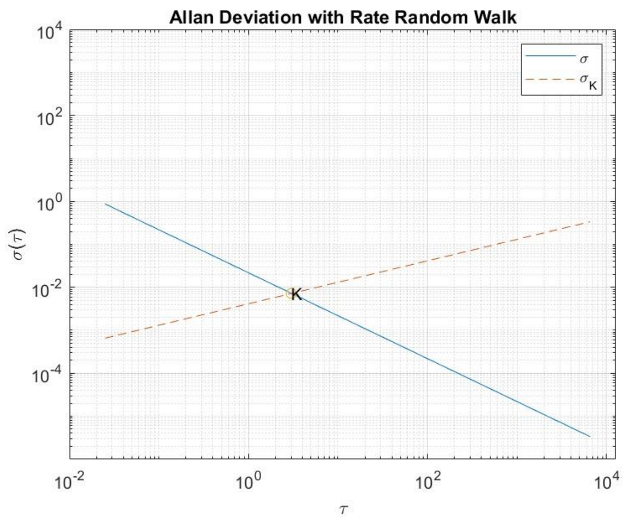


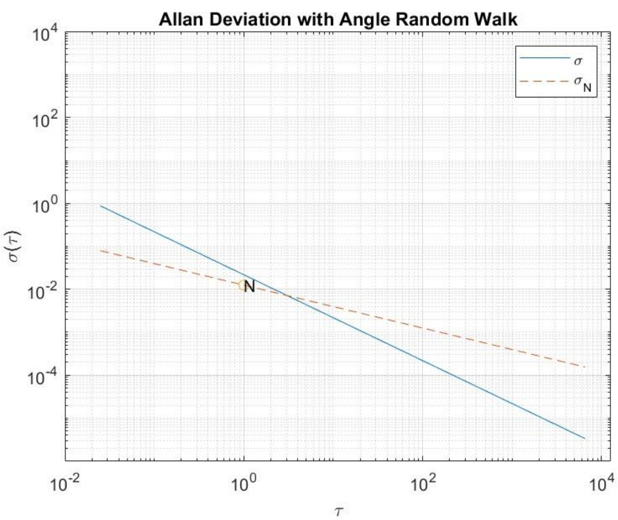
Allan Deviation for Angular Velocity in Z:

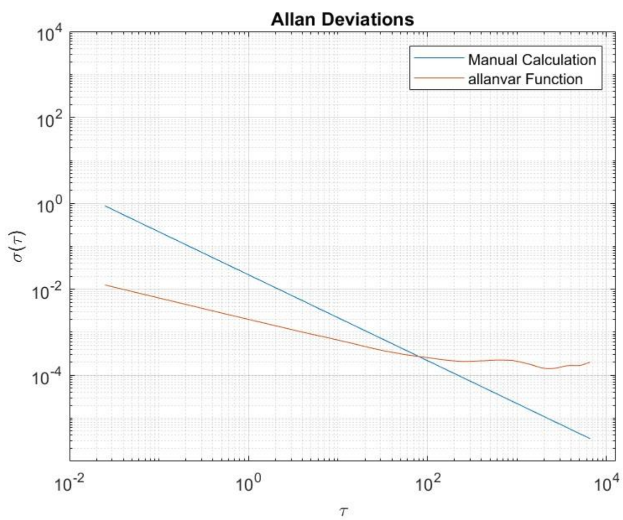


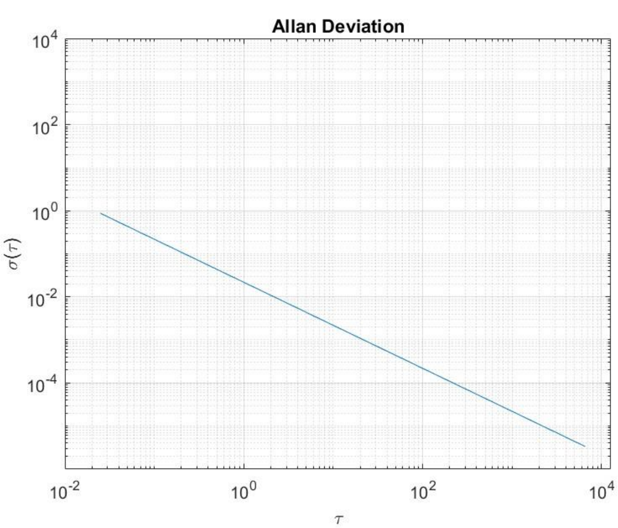
Allan Deviation for Linear Acceleration in X:

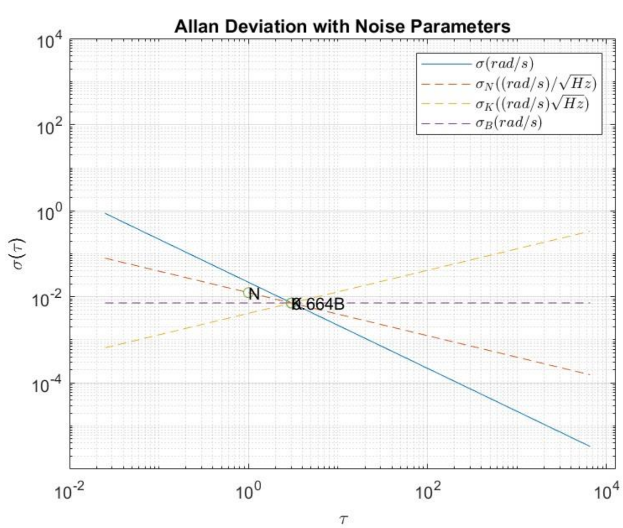




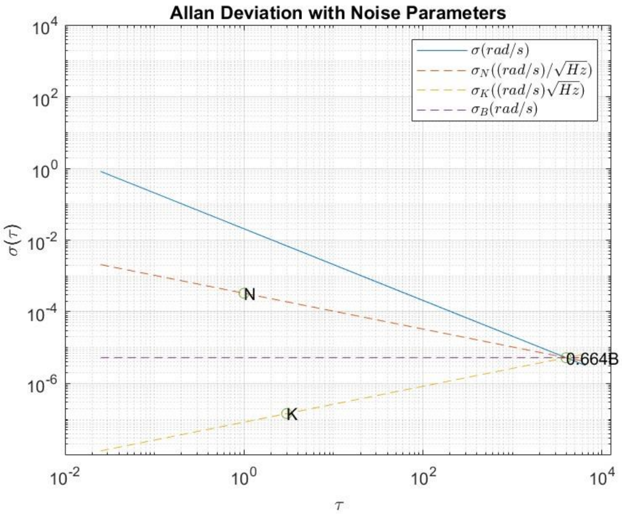


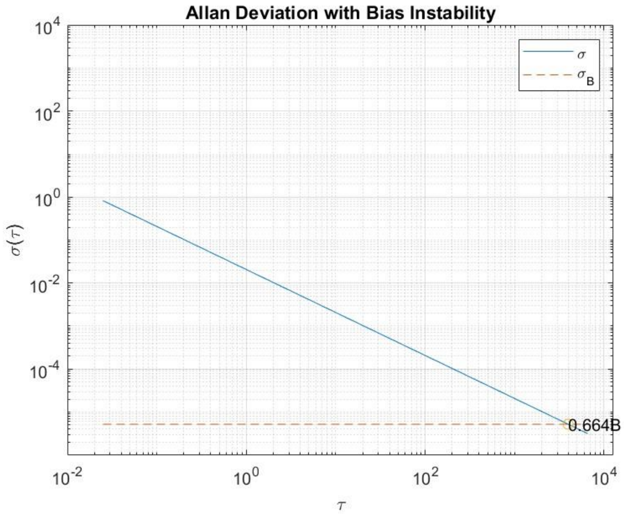


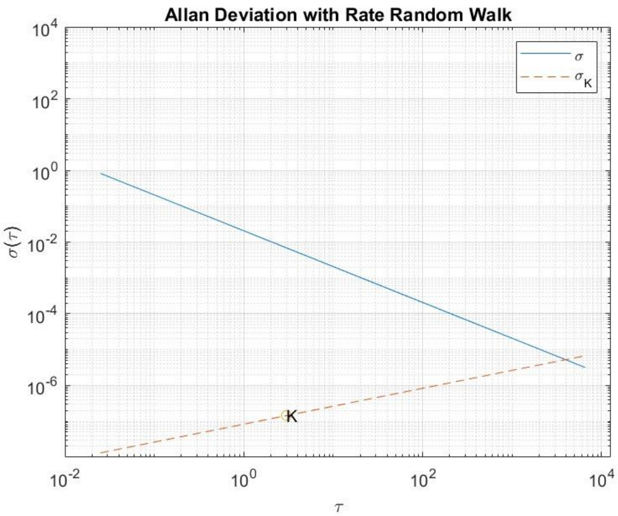


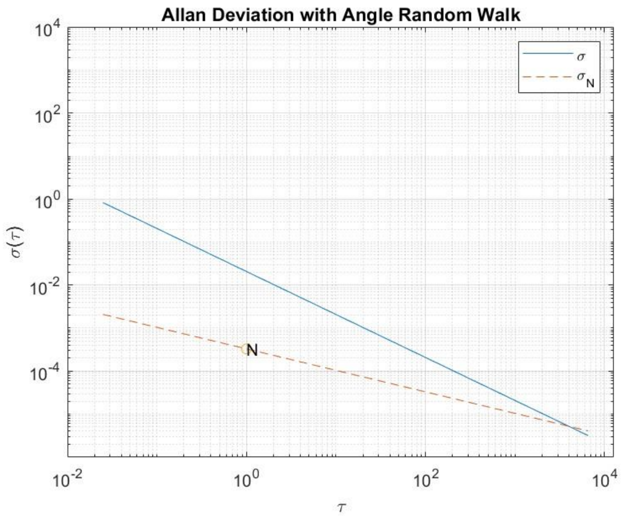


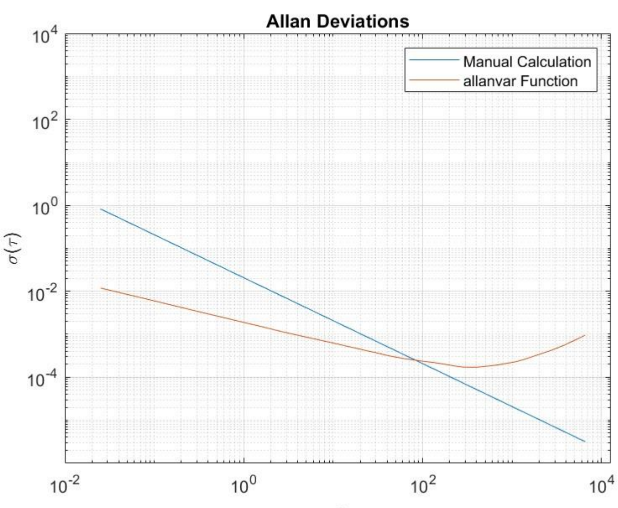
Allan Deviation for Linear Acceleration in Y:

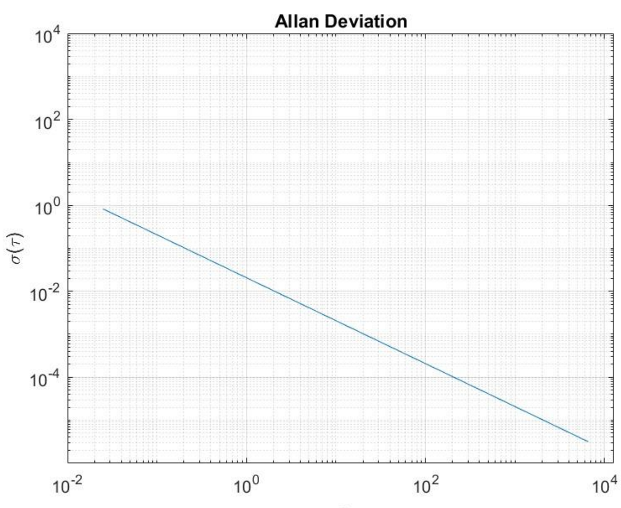












Allan Deviation for Linear Acceleration in Z: