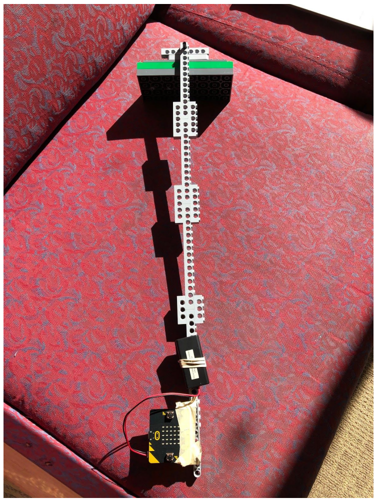
René LaPointe Jameson and Sofia Levy — March 8th 2019
Engineering Science 2 — Dr. Jennifer Cross

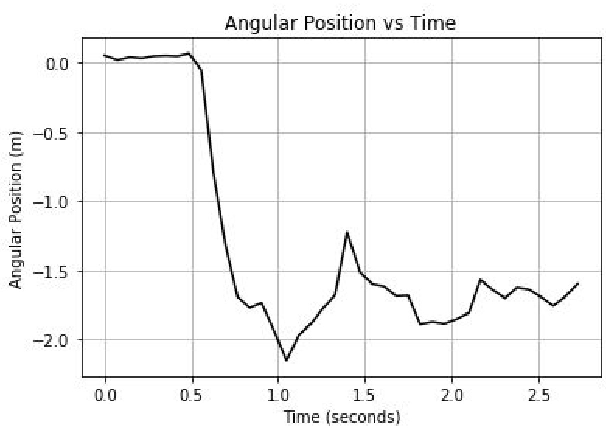
Project 1 Final Report

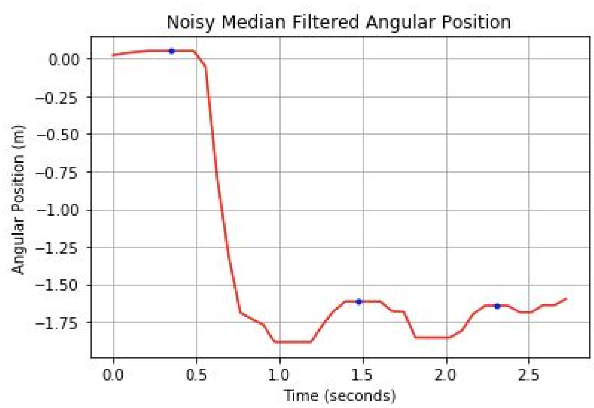
Physical Pendulum Model



Real-World Data

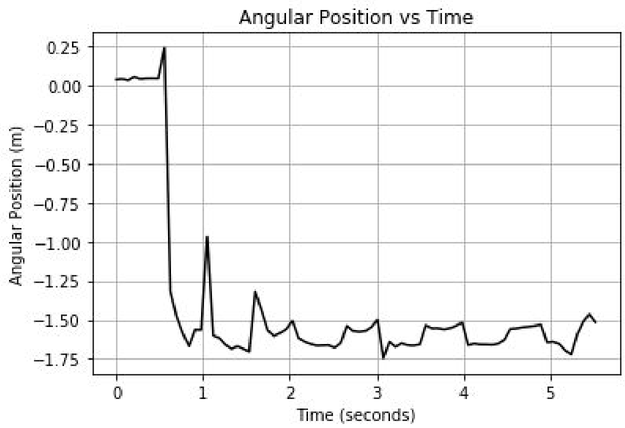
Pendulum Length 1: .17 meters

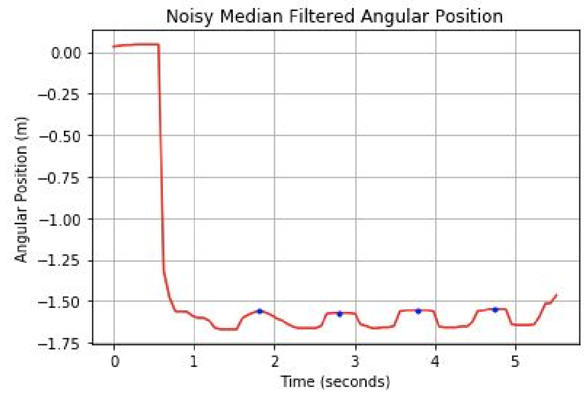




Period: 0.978 seconds

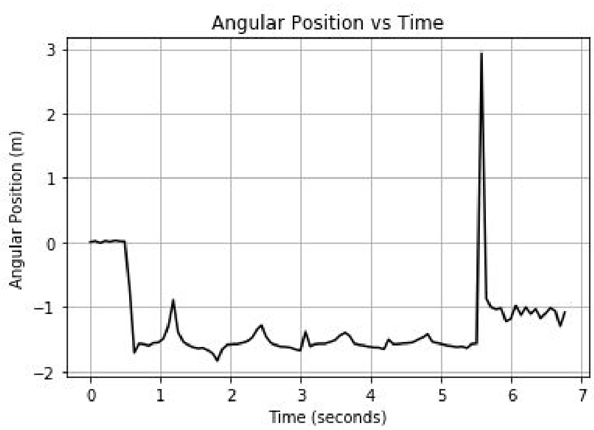
Pendulum Length 2: .28 meters

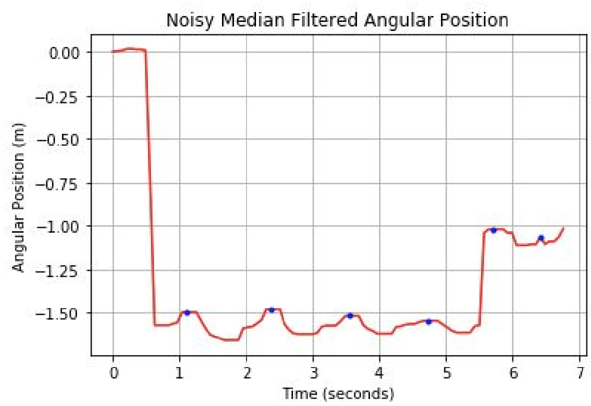




Period: 0.9793333333333333 seconds

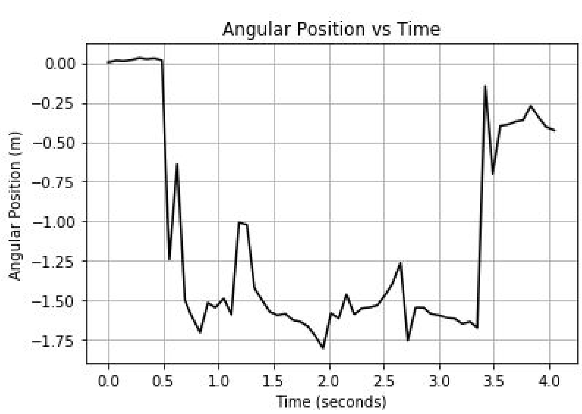
Pendulum Length 3: .42 meters

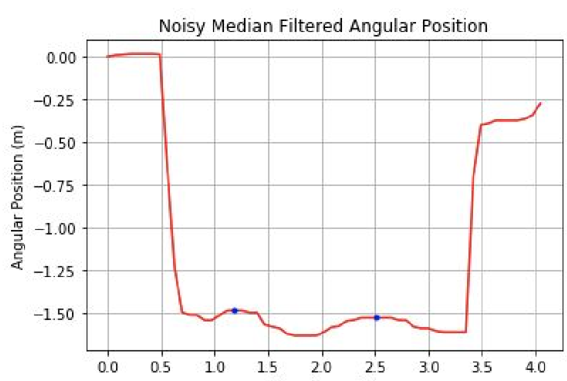




Period: 1.0619999999999998 seconds

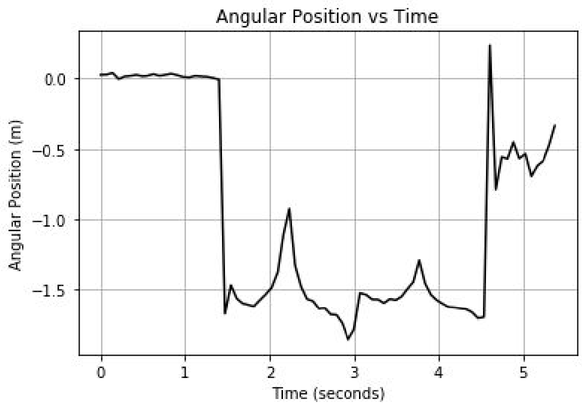
Pendulum Length 4: .48 meters

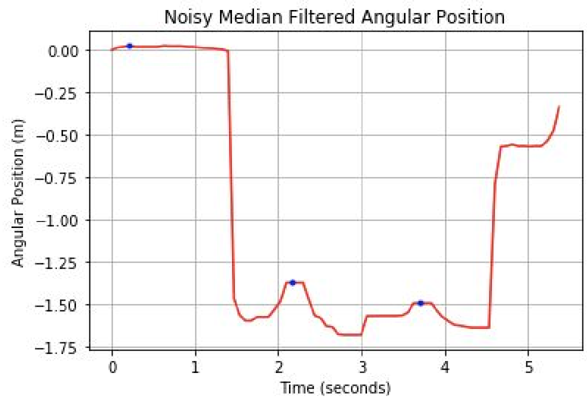




Period: 1.324 seconds

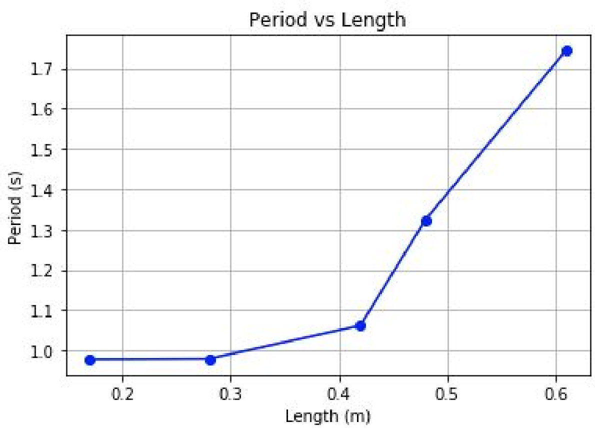
Pendulum Length 5: .61 meters

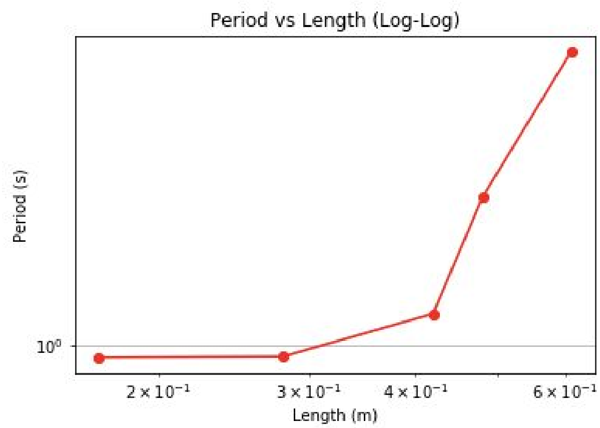




Period: 1.7440000000000002 seconds

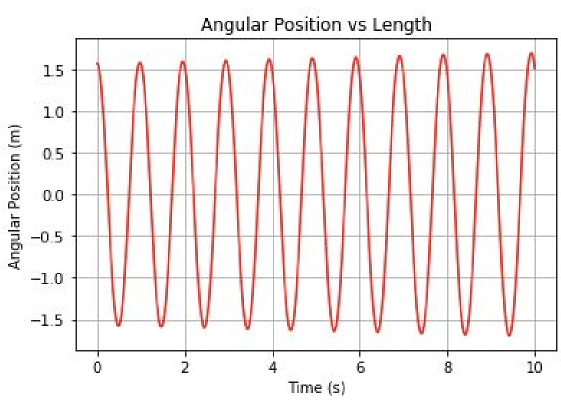
Relationship Between Real-World Pendulum Length and Period





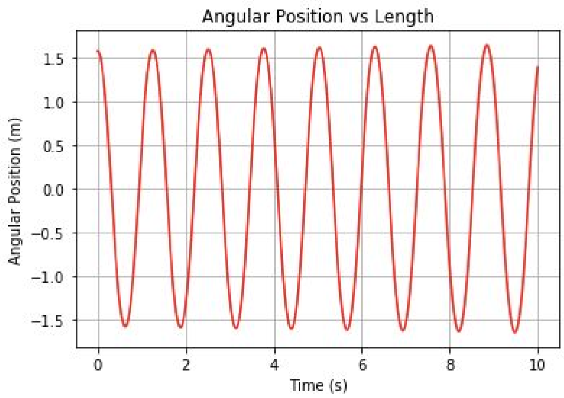
Simulation Data

Pendulum Length 1: .17 meters



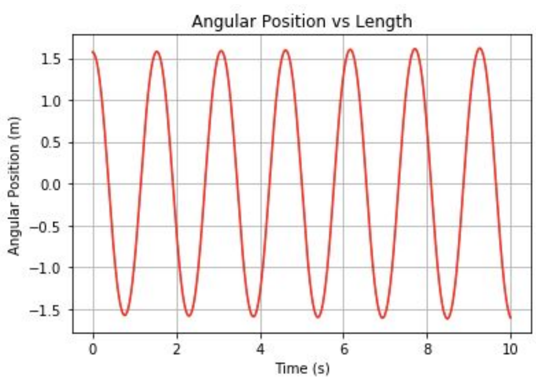
Period: 0.9934034838198309 seconds

Pendulum Length 2: .28 meters



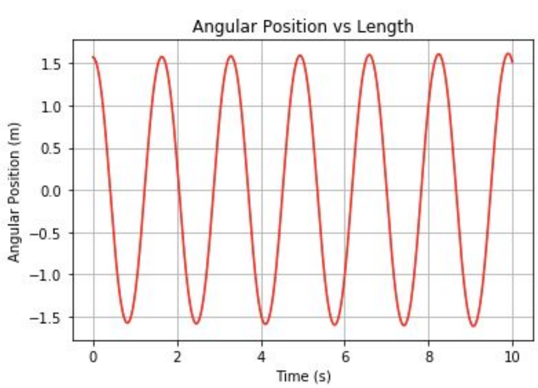
Period: 1.2652643977021456 seconds

Pendulum Length 3: .42 meters



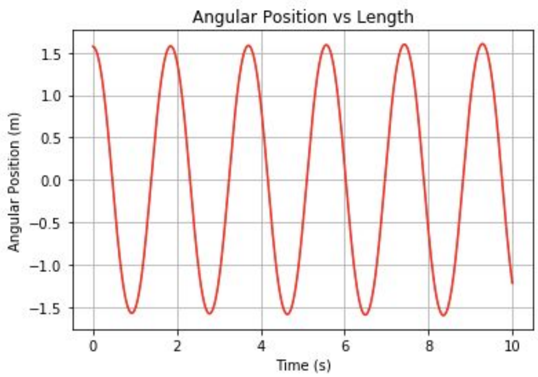
Period: 1.545384846161539

Pendulum Length 4: .48 meters



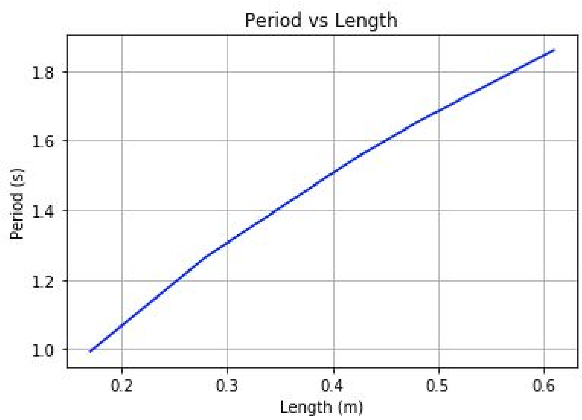
Period: 1.6513217107236908 seconds

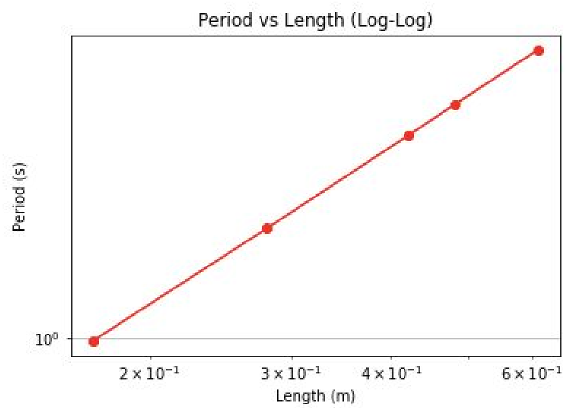
Pendulum Length 5: .61 meters



Period: 1.8588952965098837 seconds

Relationship Between Simulation Pendulum Length and Period





Results and Analysis

The purpose of this project was to determine the relationship between length of a pendulum and period of oscillation by directly comparing simulated data and real world data. Period of oscillation was calculated utilizing the angular position graph for each pendulum and respective length. Using the angular position graph, the peaks of each oscillation were identified and the difference between these peaks, in regards to length, were calculated. This determined difference in spacing of the oscillations' peaks was then divided by the total number of oscillations in the angular position graph that were calculated. This is how the period of the pendulum's oscillations were determined.

When comparing the real-world median filtered angular position graphs to the simulated angular position graphs, the data is very similar and interrelated. For the real-world angular position graph of the pendulum length of .17m, the oscillations are fairly frequent and it has a period of .978 seconds. Similarly, for the simulated angular position graph of the pendulum length of .17m, the oscillations are very frequent and it has a period of .9934 seconds. For the real-world angular position data of the pendulum of .28m, it has a period of .979 seconds and the oscillations are of similar frequency. In slight contrast, the simulated angular position data for the pendulum of .28m has slightly less frequent oscillations and an increased period of 1.26 seconds.

This variance can be accounted for due to uncontrollable errors in the real-world data including air friction, mechanical friction between lego pieces, and delays in micro Bit data collection. For the real-world angular position data of the .42m pendulum, the oscillations on the graph are less frequent or farther apart and the period is 1.0619 seconds. Similarly, the simulated data for the .42m pendulum shows the period is 1.54 seconds and the oscillations continue to get less frequent or wider apart. This trend also occurs for the real-world angular position data of the .48m pendulum whose period is 1.324 seconds while for the simulated data it is 1.6513 seconds. Finally, for the .61m real-world pendulum data, the oscillations are at lowest frequency of all the real-world data and the period is the largest at 1.744 seconds. For the simulated data for the .61m pendulum, the oscillations are also at their widest or least frequent of all the simulated data and the period is largest 1.858 seconds. Similar trends between the real-world pendulum angular position median filtered data and the simulated data includes that amplitude for both data sets is supposed to or did remain fairly constant or similar through all the angular position graphs. This trend does account for the error in the code affecting simulated data which made the amplitude of the angular position graph oscillations become slightly larger as the pendulum length increases, but this is incorrect and negligible. Additionally, as the pendulum length increased, the frequency of the oscillations within the graphs decreased so the oscillations grew further apart. This also relates to how as the length of the pendulums increased and the oscillations decreased in frequency, for both data sets the period increased over time.

Period depends directly on the length of a pendulum; The longer the length of a pendulum, the more time it will require for the pendulum to swing and return to its original position. Period is calculated utilizing time, specifically the time it takes to a complete an oscillation. It takes more time for a pendulum of longer length than a pendulum of shorter length to complete an oscillation, so, the calculated period will be longer. Therefore, period is directly proportional to the pendulum length. Because of this, for our simulated data you would expect to see a linear relationship between period and length. This concept is supported by our simulation graphs of length vs period which are nearly linear; when the length of the pendulum increases, the period of the pendulum also directly increases in a linear fashion. This is further supported in the graphs of the real-world data. Although the real-world data is not linear, it still demonstrates that as length of the pendulum increases, the period increases. It is not perfectly linear because of natural errors in real-world data collection, which is expected, including outliers in data collection as well as air and mechanical friction. Overall, both the real-world and simulated pendulum data validate the concept that as pendulum length increases so does the period length directly.

Discrepancies and errors between the real-world data and the simulated data that caused differences between their results includes how the real-world data is affected by air friction, mechanical friction between the lego pieces, and the micro Bit as a data collector is limited in its efficiency and also picks up noise. The coded simulations for the pendulum does not include these factors which cannot be estimated to an appropriate degree to include in calculations and affect the simulated data. Additionally, there is an error in the code when calculating the angular position where amplitude of the oscillations become slightly larger as the pendulum length increases which is incorrect.