Astron 98 Final Project:

Analyzing the Gravitational Forces of Habitable Planets on the Earth

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Introduction:

In the project proposal, I outlined how I will calculate and analyze gravitational forces of various planets on the Earth. This project includes: data generation, data analysis, fitting data with error, and providing explanations for my results.

Chosen Phenomenon and Data Source:

The phenomenon that I have chosen for this project is the gravitational forces of various planets on the Earth. The data source that I have chosen to examine this phenomenon is the Planetary Habitability Laboratory, whose data on habitable planets can be accessed in the link, Habitable Planets Catalog. In this catalog, there is data listing mass, orbital period, radius, and distance from the Earth. For my data filtration, I am using data from the 11 nearest habitable planets in order to find planets where gravitational forces are relevant.

Equation to Fit the Data:

In order to determine the gravitational force between two planetary masses, only a simple gravity equation is needed. The gravity equation I have chosen is:

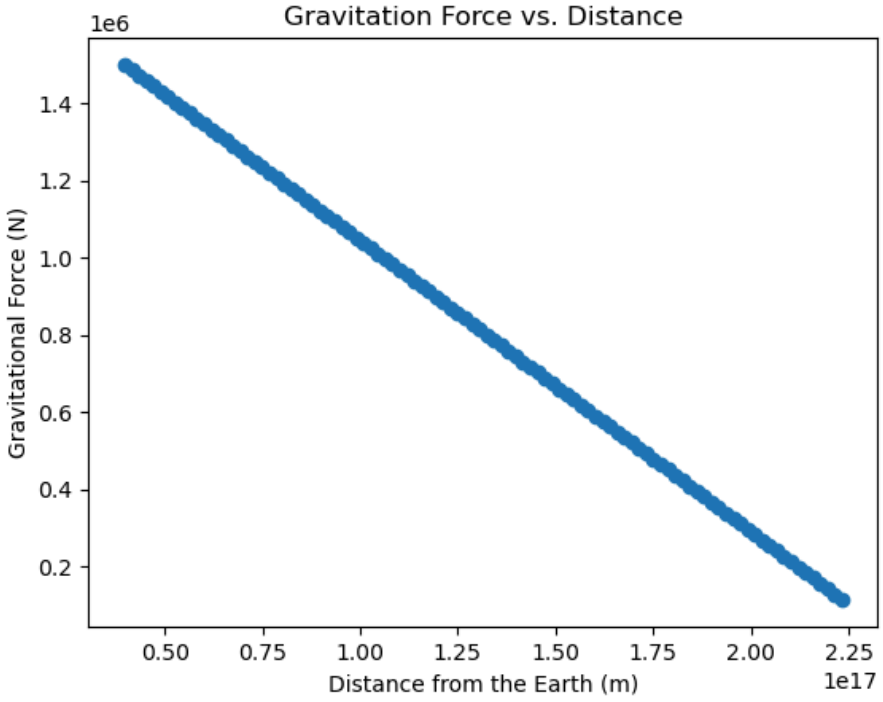
$$F_g = G\frac{mM_e}{r^2}$$

Where:

- F_g is the force of gravity in newtons
- G is the gravitational constant, which has a value of 6.67×10^{-11}
- m and M_e denote the mass of a chosen planet and the mass of the Earth ($5.972 \times 10^{24}\ kg$) respectively.
- r is the distance between the chosen planet and the Earth in meters

Data Generation

For my data generation, I used “back of the envelope” calculations for the gravitational forces using data from my data source and desmos. With that data, I plotted this data, which can be seen here:

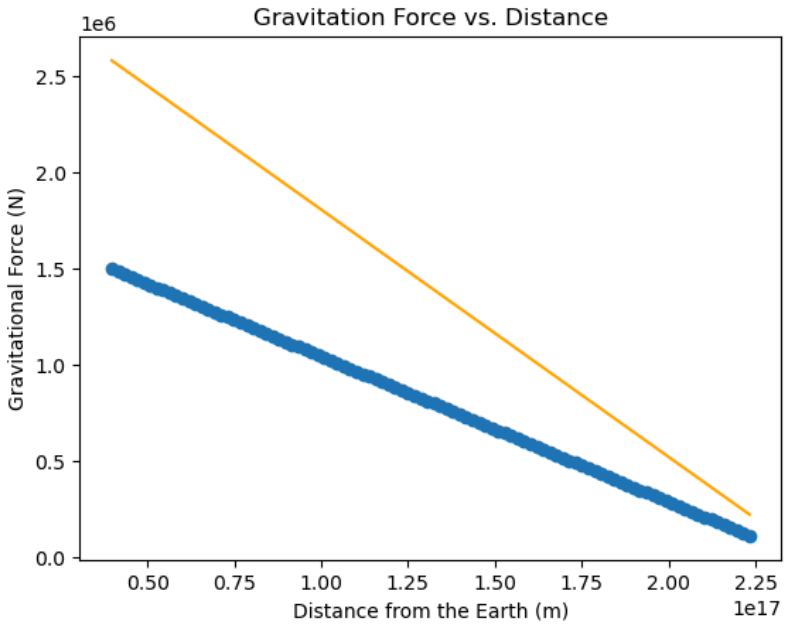


Data Filtering:

For data filtration, I generated 100 values between the minimum and maximum values of my gravitational force and distance. This allowed my fit to be more accurate overall. I have also decided to use the 11 closest planets to the Earth in order for the gravitational force values to be more relevant and reduce outliers.

Data Fitting:

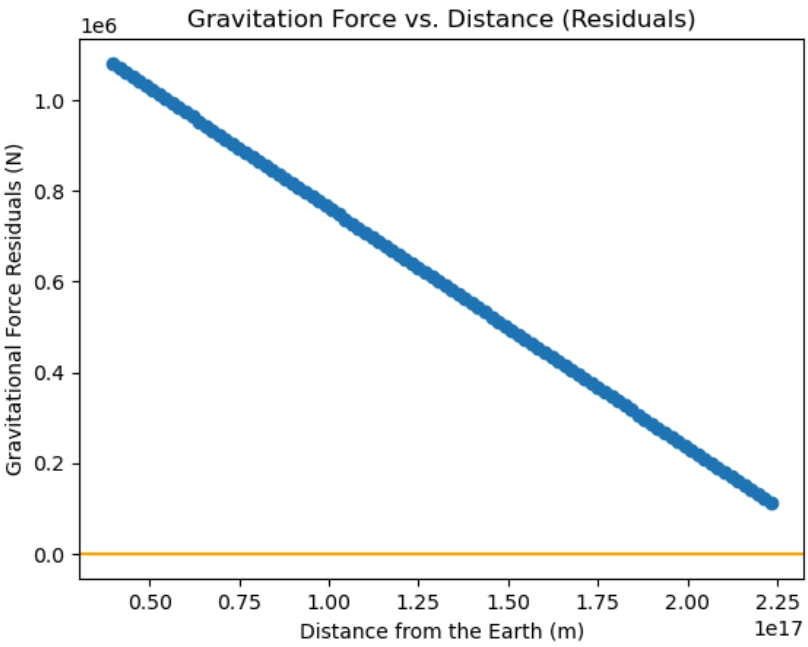
The farther that planets are from the Earth, the lower their gravitational force is on the Earth. To analyze this phenomenon, I fitted the actual values of the gravitational force. The visualization for this is shown below:



Where blue represents the guess values and the orange line represents the fitted values.

From this fit, I obtained a value of $G = 1.09 \times 10^{-10} + / - 4.17 \times 10^{-12}$ which does not agree with the accepted value of the gravitational constant.

Explanation of the Fit:



Reduced Chi-Squared: 435328908782.5982

Although the fit graph and the obtained value for the gravitational constant show that my model is not appropriate. This is further shown by the residuals as there is no random distribution. Since there is recognizable structure in the graph, this must mean that the error is not random and is the result of some coding error. When using the raw data I got a value of $G = 6.31 \times 10^{-11} +/- 7.21 \times 10^{-13}$, which is similar to the well-known value of the gravitational constant. This must mean that all errors with the fit must have been the result of the modified data, not the fit itself. This means that I have (somewhat) provided a working model for gravitation forces.

Conclusion:

This information is useful because it provides us with insight into the effects that these planets have on our Earth and vice versa. This information can therefore help us in future research into these habitable planets.