Getting your toolbox ready for modeling

Due date: 1/24/2024, 9am

This is an ungraded assignment!

Assembling your computational toolbox is arguably the most important first step in modeling. Obviously, modeling can hardly be done without a computer, but a computer by itself is of no use if you don't know how to wield it. Hopefully your programming and computational physics classes taught you the basics; in Principles of Scientific Modeling, we will kick it up a notch and use computers as tools to solve real-world physics problems. Here are a few small steps to get you in gear.

1. Generate a white noise timeseries of length 1 million with mean 1 and standard deviation 0.1.

2. Overplot histograms with 10, 20, 50, 100 and 1000 bins. Label everything appropriately and make the plot visually appealing and legible.

3. How many 1-, 2-, 3-, 4- and 5-σ outliers do you expect? How many are there in the timeseries? Re-generate the timeseries several times and re-evaluate these numbers. Which ones change more and why?

4. Plot a cumulative function for the timeseries and fit a line to it using least squares. What is the significance of the slope and of the intercept?

5. Run autocorrelation on the timeseries and figure out if there are any interesting peaks. Why would you ever expect any interesting peaks? How would you modify the timeseries to get a strong autocorrelation signal?

6. Study the similarities and the differences between the consecutively generated timeseries of length 1000. What are some of the useful estimators for similarity? Look up the χ^2 test, the Student t-test, and the Kolmogorov-Smirnov test. Which may be applicable for this comparison?

7. Think of something fun to do with the generated timeseries and then do it.