NE 334 Assignment 1
Due October 8, 2024

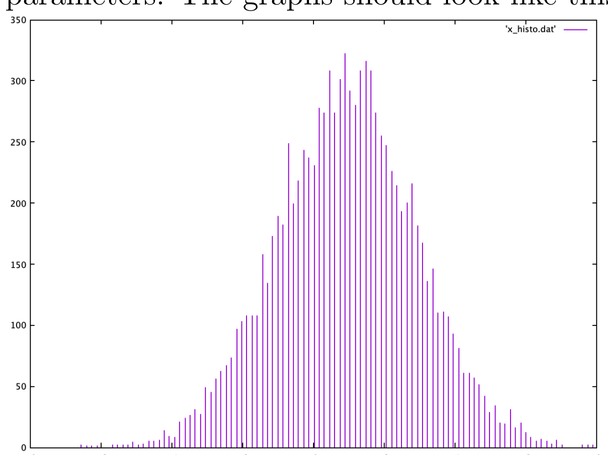
The purpose of this assignment is to gain experience with numerical simulations and data analysis. The required Python scripts are available on the UW Learn page, in the same content section this Assignment PDF file was found. You can run the calculations on your own computer. You will need to have Python installed in your computer. Upload a *single* PDF file to the learn dropbox for Assignment 1.

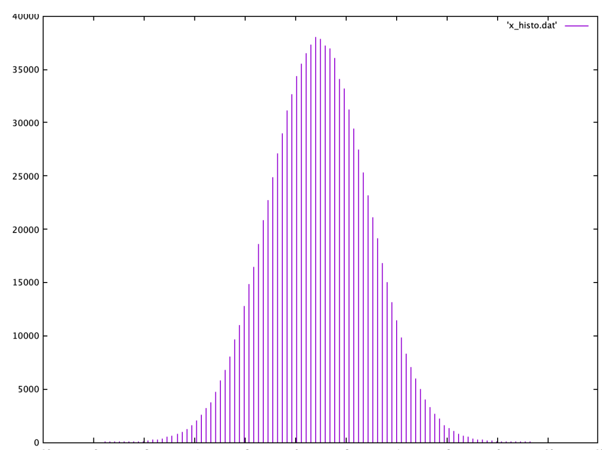
1. **Normal distribution**. The python script `normal.py` samples the normal distribution for a random variable x. Open the script in a text editor to modify calculation parameters. After running the script, a file named `x_normal.dat` is created and contains the sampled data. The input parameters are `x_mean`, `standard_deviation`, and `sample_size`.

   (a) Modify the input parameters in `normal.py` and calculate the average value of x: $\langle x \rangle$. This can be done by either modifying the python script to compute and print the average value, or by importing the `x_normal.dat` datafile using tools such as MS Excel. Increase the value of `sample_size` and recompute $\langle x \rangle$. What happens to $|\langle x \rangle - \texttt{x\_mean}|^2$ as you increase `sample_size`? Report all your input parameters. Be careful as not to increase `sample_size` too much as each real number stored in computer RAM occupies 8 bytes and each character saved in the `x_normal.dat` files requires 1 byte of disk storage.

   (b) Choose input parameters and compute the variance of x, σ_x^2, based on the sampled data. This can be done by modifying the python script or by analyzing the data in a program such as MS Excel. Also calculate the standard deviation and compare your result to the input parameter `standard_deviation`. Report all your input parameters.

   (c) The file `x_histo.dat` contains the histogram of x sampled from the normal distribution. Plot the histogram of x for different values of `sample_size` and your choice of input parameters. The graphs should look like this:





   The script parameters `nbins` can be adjusted to generate as smoother graph. When `sample_size` is smaller, `nbins` should also be smaller. Report all your input parameters.

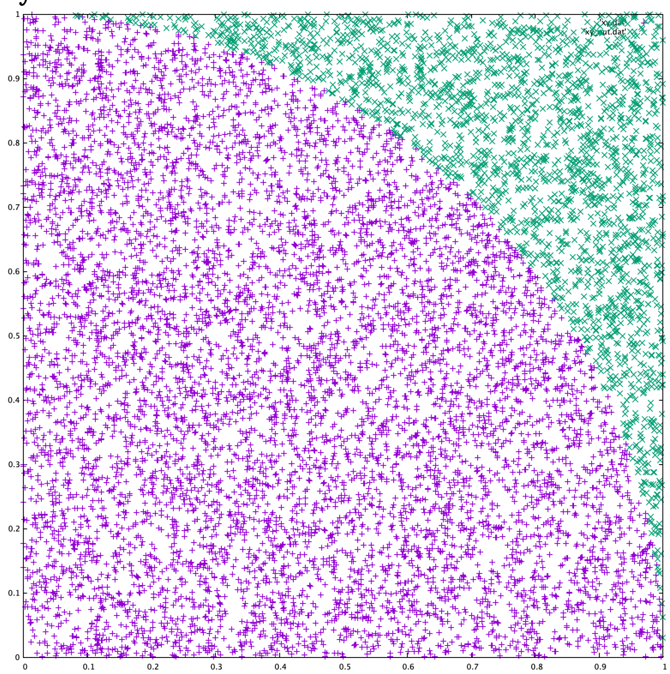
2. **Uniform distribution**. The python script `uniform.py` samples a uniform distribution of random numbers in the range $0 \leq x \leq 1$. A file named `x_uniform.dat` is created and contains the sample data.

   (a) What do you expect $\langle x \rangle$ to be?

   (b) Use a text editor to modify the input parameters in `uniform.py` and calculate $\langle x \rangle$. How does $\langle x \rangle$ change when `sample_size` increases?

   (c) Modify the script to generate random numbers between -1 and 3. Include your script with your submission.

3. **Can you calculate π ?** The python script `pi.py` samples uniform distributions for two sets of random numbers, $0 \leq x \leq 1$ and $0 \leq y \leq 1$. The total number of samples is `sample_size`. The code also reports the number of data points, `count_circle`, for which $x^2 + y^2 \leq 1$ and those data points are stored in `xy.dat`. Below is a graph of the sample points in the (x, y) plane. The purple points are those for which $x^2 + y^2 \leq 1$ holds true. The points in green are those for which the $x^2 + y^2 \leq 1$ condition is NOT met. Those points are stored in the file `xy_out.dat`.



   (a) Devise an approach to estimate the value of π based on the data generated by running `pi.py`. Describe your procedure.

   (b) Report your estimate of π for a series of `sample_size` values.

   (c) Estimate the standard error of your computed π value.
   Hint: for N independent samples, the standard error of the mean of property A, $\langle A \rangle$, is defined as $\sigma_A / \sqrt{N}$.

NOTE: You can use matplotlib to make your plots if you wish. This requires modifying the python scripts.