Durkin
Phys 416

LAB 2

1) In this exercise we will determine a value for π, one of the most fundamental constants in all of science.

a) Determine π by throwing a dart 100 or more times. To do this first make a dart board target from an 8x11 inch sheet of paper. On this piece of paper inscribe (using pen or pencil) a circle inside of a square. How is the value of π related to the ratio of the circle's area to the square's area? Unless you are really an expert dart thrower, your dart tosses should be uniformly distributed throughout the square. Thus π can be determined from the *probability* of a dart falling within the circle. Calculate the value of your π and its uncertainty. What is the % deviation of your value of π with the true value of π?

$$\%\ deviation = \frac{(your\ value\ of\ \pi) - (true\ value\ of\ \pi)}{true\ value\ of\ \pi} \times 100$$

b) Determine π by writing a FORTRAN program. One method of determining π using the random number generator is as follows:

> Generate 2 random numbers each between [0,1]. Call one random number x, the other y.
>
> Assume that (x,y) represents the coordinates of a point inside a square with sides = 1. Note: the units used to measure the size of the sides of the square are arbitrary.
>
> Assume that there is a circle inscribed in this square with radius = 1/2 and calculate if (x,y) falls inside the circle.
>
> Repeat the above procedure keeping track of the number of (x,y) points generated (= dart tosses) and the number of times the point lies within the circle.
>
> Once all the points have been generated calculate π.

Determine π using runs of 10^3, 10^4, 10^5 and 10^6 points. For each case, calculate the % difference between the true value of π and your calculated value. Plot the absolute value of your % differences vs. the number of points (use semilog scales). How does the accuracy in your value of π increase with the number of points (e.g. does the accuracy increase linearly with the number of points?).

Determine π using 25 trials of 100 points. For each trial calculate π and make a histogram of your 25 trials. Calculate the average value of π and its standard deviation using your 25 trials. Where does the result you obtained from tossing the darts fall on the histogram? Using the histogram as a probability distribution for obtaining π from 100 dart tosses, comment on your expertise as a dart player.

2) *Binomial distribution*

Take a dozen six sided dice and toss them 50 times. For each toss record the number of times (e.g.) a two comes up.

Make a histogram (frequency distribution) of your results (i.e. the number of times there were no two's in a toss, one two, etc.).

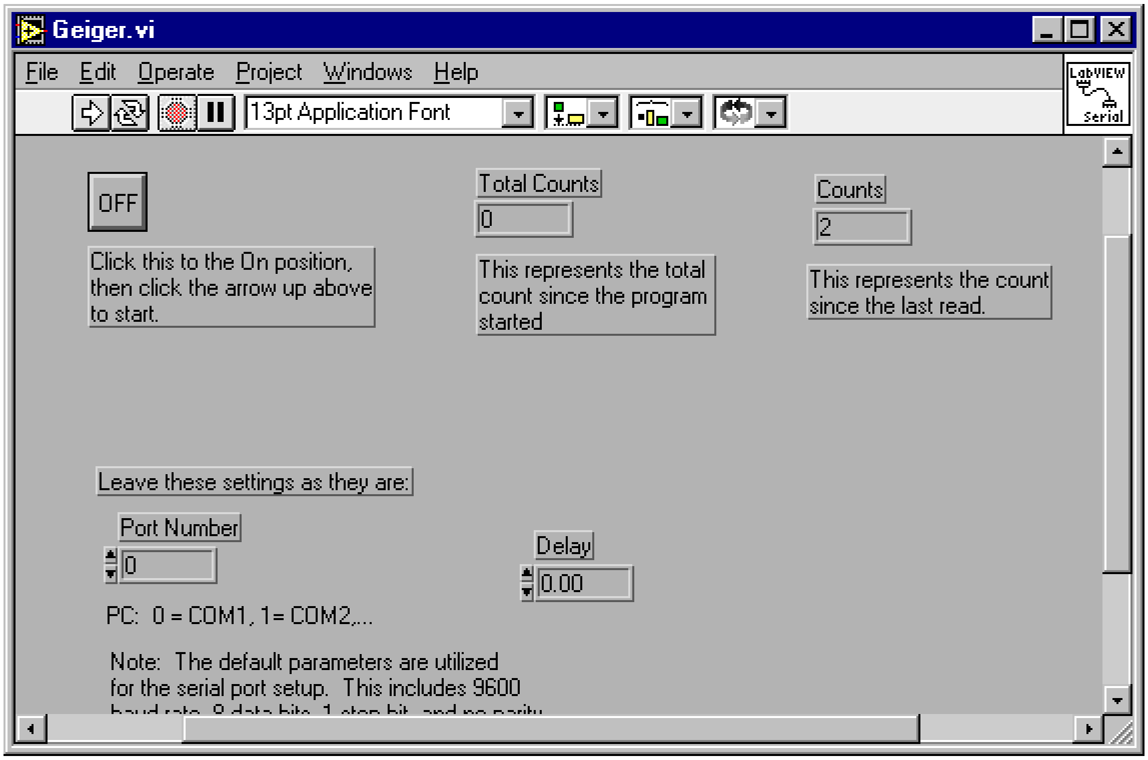
Compare your results with that expected from a binomial distribution. Plot the theoretical expectations along with your experimental results. How does your average (i.e. average number of two's in a toss) and variance compare with theoretical expectations?

Compare your results from above with a Poisson distribution assuming the same average number of two's as above. Plot the Poisson distribution along with the binomial expectations. How would you change the dice and the experiment if you wanted to generate a Poisson distribution from the toss of dice?

3) *Poisson distribution*

The rate of cosmic-ray particles passing through a Geiger counter is governed by Poisson statistics. The counter has a wire strung inside a chamber filled with gas. The wire (anode) is held at high voltage (~kV) with respect to the chamber (cathode). A traversing particle knocks electrons off the gas molecules. The electrons accelerate toward the wire under the strong electric field, resulting in an avalanche of electrons. The electronic signal produces the well-known "click". The signal is also being sent to an electronic device which use the LabView program to count the number of particles traversing the chamber. Turn the switch on the Geiger counter to the "Audio" position. You should hear occasional "click", indicating that the counter is working.

Double click the Geiger icon to start the LabVIEW program and you will see the following window:



Click the "OFF" button to turn on the program and then click the "➔" button at the top of the window to start the counting. Record the number of counts in the "Total Counts" window every 15 seconds for duration of 20 minutes. Use the clock on the wall as a timer. Stop the counting by clicking on the icon that looks like a stop sign.

Histogram the number of counts per 15 seconds interval. Calculate the mean of the distribution and use it to calculate the Poisson expectation. Superimpose the result on the histogram. Is your distribution consistent with the Poisson statistics? How many data points have zero counts and how many have 10 or more counts? What are the Poisson predictions? Is your observation consistent with the predictions?

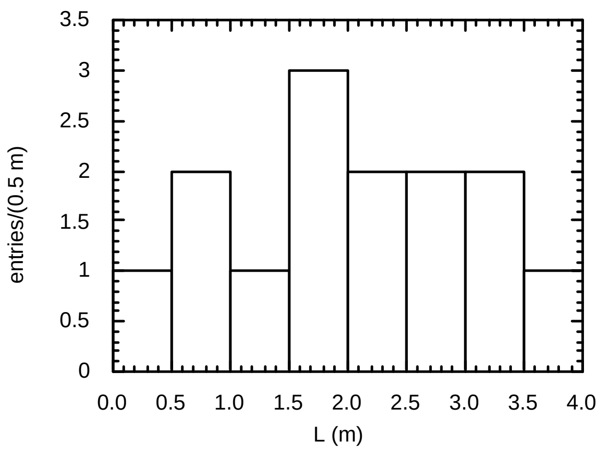
Note on Histogram:

A Histogram is a very useful and convenient way of presenting data. To make a histogram, you first divide the variable you measured into some number of equal interval (bin) and then count the number of entries in each interval. You then plot the number of entries vs. the central value of each bin.

For example, suppose we measured the length of 14 snakes (in meters): 0.7, 1.3, 1.5, 0.3, 2.4, 3.1, 2.6, 1.6, 3.3, 2.2, 2.7, 3.5, 0.6, 1.7. Let's choose a bin width of 0.5 m, then you have the following number of snakes in each bin:

Length (m)	#snakes
0.0 - 0.5	1
0.5 - 1.0	2
1.0 - 1.5	1
1.5 - 2.0	3
2.0 - 2.5	2
2.5 - 3.0	2
3.0 - 3.5	2
3.5 - 4.0	1

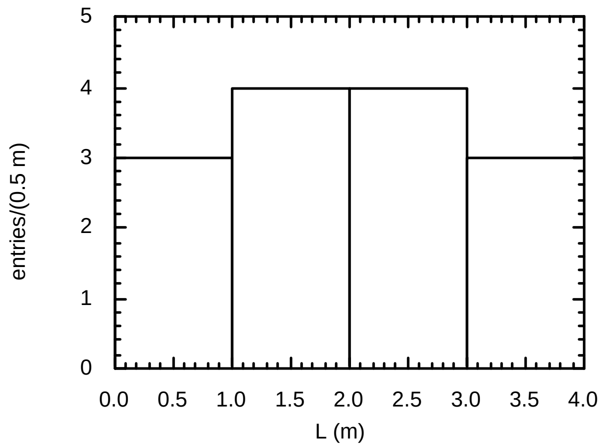
The histogram of the data looks like:



The bin width is somewhat arbitrary. For example, I could also use a bin width of 1 m:

length (m)	#snakes
0.0 - 1.0	3
1.0 - 2.0	4
2.0 - 3.0	4
3.0 - 4.0	3

Then the histogram looks like:



In general, we try to choose the bin width such that if possible each bin contains several entries. So, for this example, a bin width of 0.05m would be too small and a bin width of 5 m too large! To make histogram under the “Gallery” menu, use the more versatile “Scatter” option under “Linear” instead of the “Histogram” option.