PHYS2502 Mathematical Physics Lab #13 18 Apr 2022

This lab assignment is at 8am, the morning after the date shown, although you should able to complete it easily before the end of the lab period. When you're done, upload your executed MATHEMATICA *notebook to the Canvas page for the course.*

Please ignore the due date above. This lab must be turned in by 5pm on Friday 22 April 2022. It covers material from that last week of the course.

Your task is to generate a set of values that follow the Gaussian probability distribution

$$\mathcal{P}(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-(x-\mu)^2/2\sigma^2} \qquad \text{with} \qquad \int_{-\infty}^{\infty} \mathcal{P}(x)\, dx = 1$$

and then fit a binning of this data to check that you get the same values for μ and σ, and normalization, that you used to generate it.

Choose some number of values n to generate, and also your input values for the mean μ and standard deviation σ. Use RandomReal to generate n random numbers between -1 and $+1$. (I suggest you use SeedRandom to set a specific seed so your results are reproducible.) Then use InverseErf to turn this list into a list that is distributed according to the Gaussian e^{-t^2}, and finally use the appropriate linear transformation to turn this list into a list that has your selected mean and standard deviation.

Check that the distribution looks right by making a simple Histogram of them.

Now extract the numbers that make up the histogram frequencies, along with the centers of the bins. An easy way to do this is to define values of xlo, xhi, and dx that should span your range of values, given your choices for μ and σ. Then use these values twice, once with Range to create an array of x-values corresponding to the bin centers, and again with BinCounts to extracted the binned values corresponding to those bin centers and width. Then use ListPlot to plot the frequencies versus the bin centers, and check that it looks like the histogram.

It is a little tricky to get the bin centers correctly, because Range *will give you one more value than you need, so you have to lop off the end before you add half a bin width to get the centers. Also, you'll need to* Transpose *your x- and y-value arrays to use* ListPlot.

Now enter the formula above. Integrate it to make sure you get unity. Then use FindFit to fit $\mathcal{P}(x)$, times some normalization factor, to your data. The normalization factor should be close to the number of data values you originally generated. The fit should also give you values close to your input values for μ and σ. (Beware of factors of $\sqrt{2}$ if you don't get the right answer.)

Finally, take the plot of the data points of frequencies versus bin centers, and superimpose a plot of your fit function, using the best fit parameters. The curve should go neatly through the points, with about as many of them above the curve as below.