Computational Physics
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Lecture - 10
Numerical Integration Part 05

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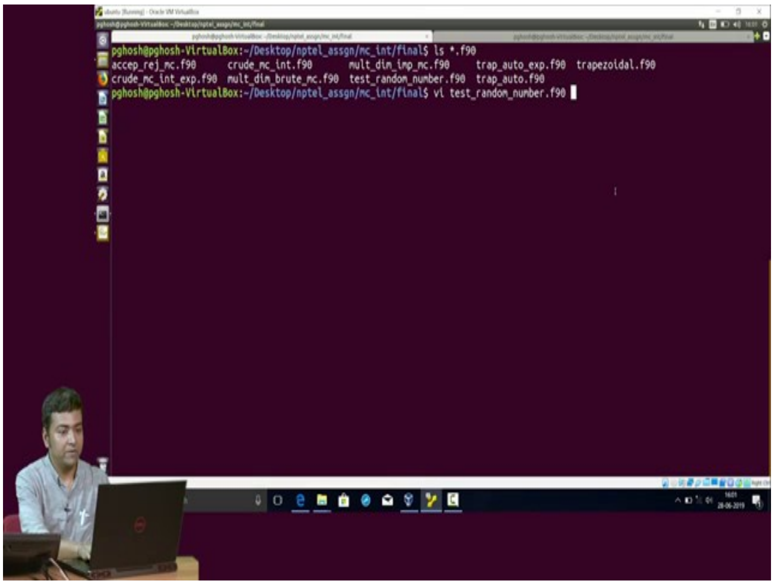

So, we will see how to test random number with so, what I will take you through a code which has been written by me which what it does is, it does the different steps of the random number. So, in the lectures what I have told is; so, we have to check whether one gets the expected value of average value, the expected value of sigma then the correlation plot one should do, one should do the scatter plot, one should do the histogram.

So, these are the five tests one needs to do. So, I will not go into the histogram, I will not show you how to do the histogram, but I will show a code which does the other stuff. For, so, example this is my code test random number dot f 90.

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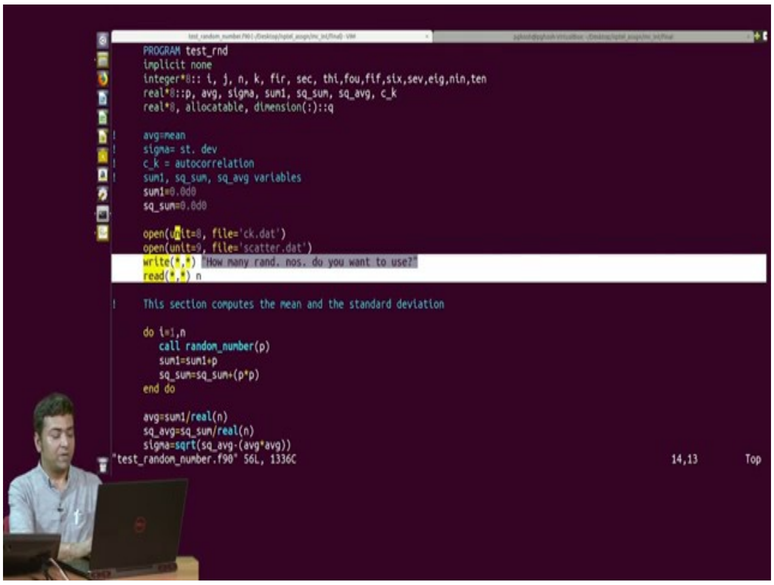

So, I start with the Fortran keyword program and then I have the program name and then I have a set of variables, it is a long list of variables; some of them are temporary variables which are used in the code and others are others the significant ones I have within comments I have kept here what it means. For example, average a v g the variable stores the mean of my distribution, sigma variable stores, the standard deviation, c underscore k stores the autocorrelation and these are some again dummy variables. So, to begin with I make it 0, I set the sum 1 and square of sum to be 0.

So, what I will do is? So, I need to have two files; one file will store my correlation coefficient which we have defined already in the lecture as a function of k and in the other one I will store x 1 and x 2 that I mean basically what I am going to do is I am going to store the data for the scatter plot. Then in this part what I am doing is I am asking the user to give me to tell me how many random numbers I want to use and then I read that number.

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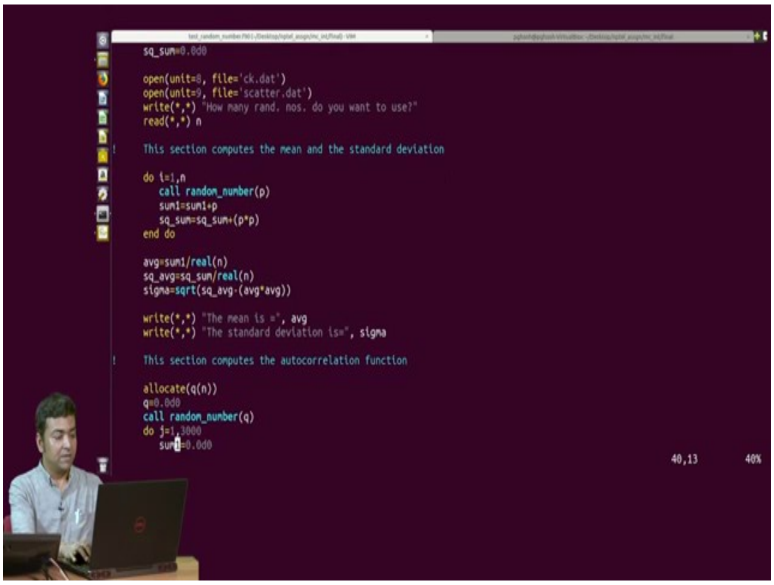

So, this particular section what it does is it will compute for me the average and the standard deviation. So, what it does is, it will first do loop what it will do is it will call the random numbers n random numbers that depends on the value of n. And these random numbers I sum them up and store in this variable; and then I also take the square of the random numbers and sum them up and stored in this variable. Once that is done what I do is; the average is computed by dividing the sum the number stored in sum 1 by the number of times or the number of random numbers are used that is n.

And then similarly I compute the I take I compute the average of the square sum that is given by square underscore sum divided by real n and once that is done I get the sigma using this formula and then it prints out the average value and then the sigma. So, once that is done in the next part I compute the correlation function.

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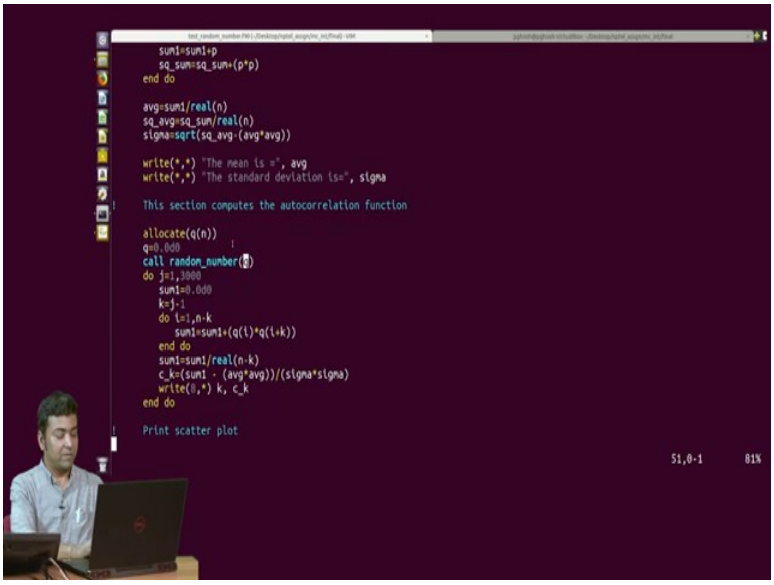

So, if you refer to the lecture notes the correlation function is given by it again involves a sum over n and that is what I am doing here. And this part of the code computes this correlation function and this now I am using q number of using a different set of random numbers to do that. And then again I use the same set and to write the data in such a way; I write I plot i versus i plus 1th random numbers how the plot looks like. So that is what is my scatter plot.

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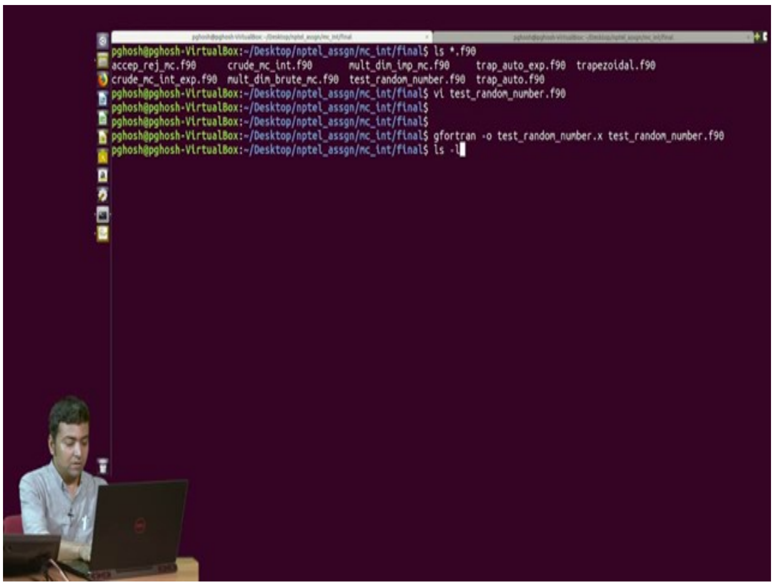

So, let us compile this, it is done.

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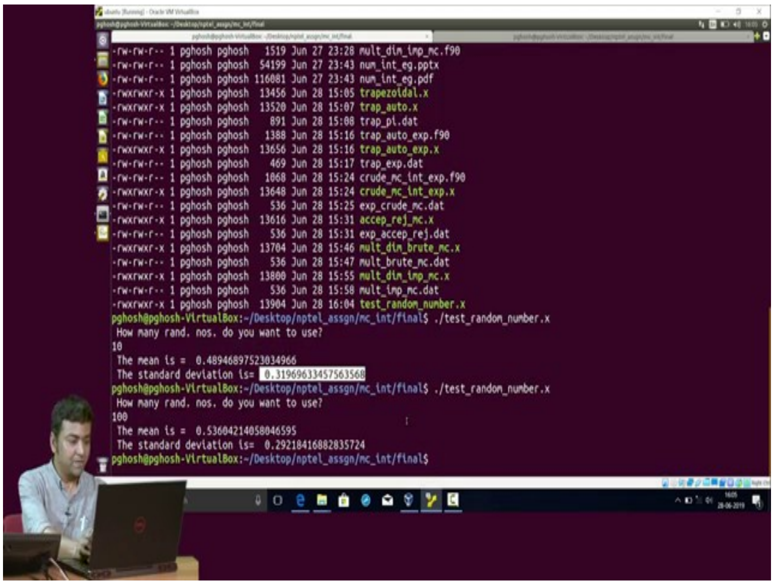

And then if you see do l s minus l t r; we have this execute to run it. So, we run this. So, let us start with a very small set of random numbers, so, say 10. So, we know that the average value of a uniform distribution is 0.5 and the standard deviation sigma is 2.2886. So, let us see what values we have got? So, you see with 10 random numbers here; the value of the mean is quite far away from 0.5 similarly the standard deviation is also quite far away from 0.2886.

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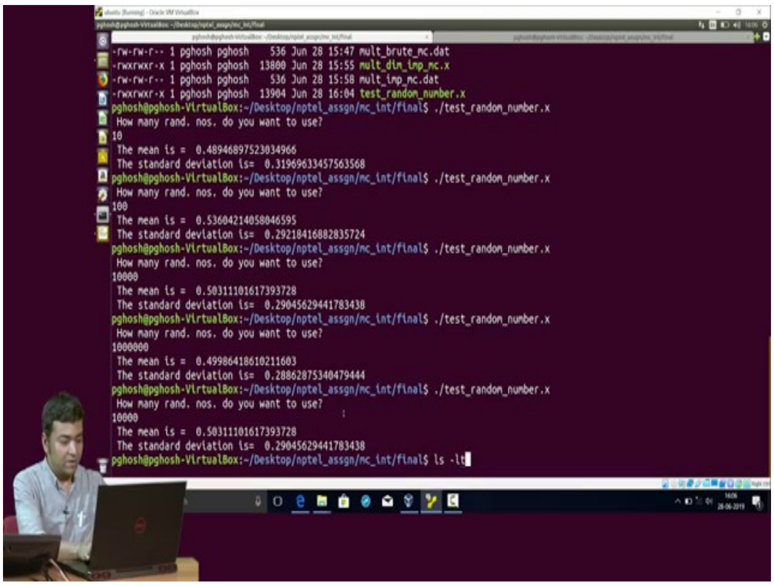

Now, if I increase the number of random numbers says from 10 I go to 100. So, you see it has still away from both the values are still away from the exact value. Now we make it say 10000; now you see it is slowly gradually going towards 0.5 and this is gradually going towards 0.2886. Now if I increase it further. So, then you see it is much closer to that well. So, it is taking time because it is computing the correlation function also. Now let us look at what happens to the correlation plot. So, let us do it with first say 10000.

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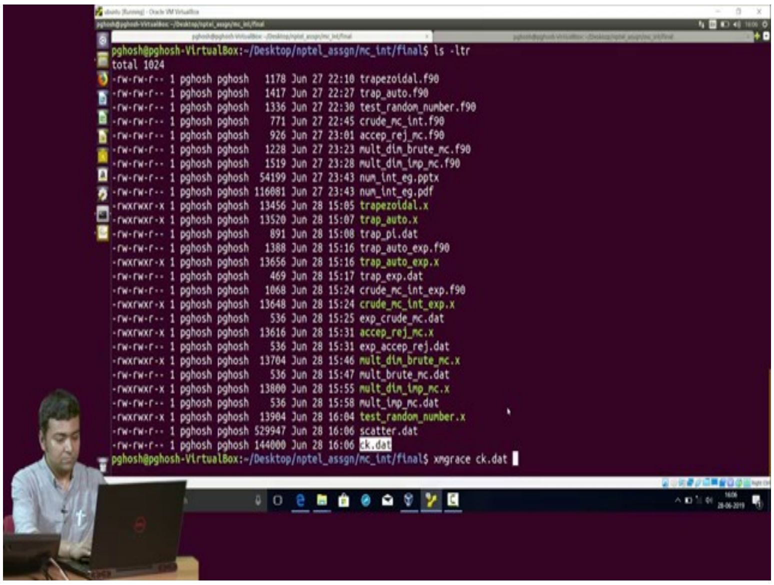

So, if I run it then this is the data is stored here. So, you can use any plotting software you want. So, in my machine I have x m grace. So, I will use x m grace to plot it.

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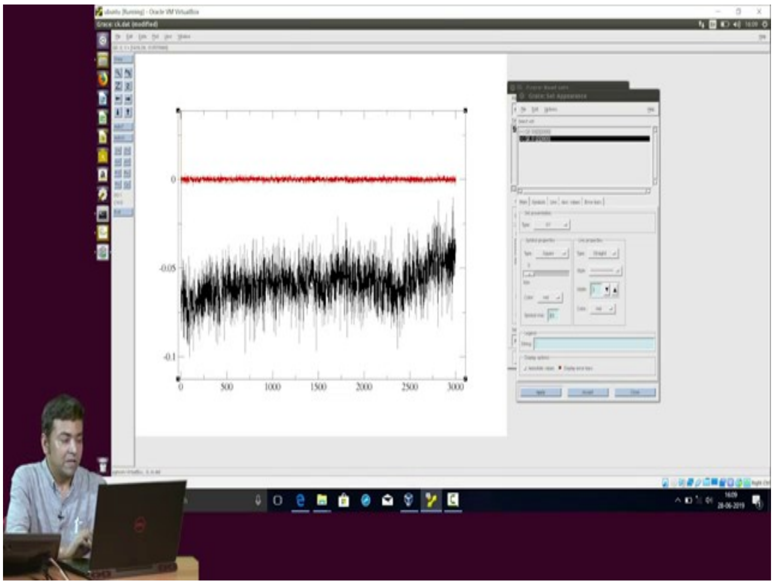

So, this is what my data will look like. So, if I instead of, if I put the just the symbols here along with the lines, so at k; so in the x axis I have k and in the y axis I have c k. So, for k equals to 0 it is nothing, but autocorrelation and it should be 1. So, you should expect a point here and it is somewhere which is close to 1. The reason it is not going to 1 is because the number of points are very few.

Now, let us try to run it again with a few more points and see how the things are changing. So, what we do here is? So instead of 10000, so rather than that, so I put 1000000 point and let it run.

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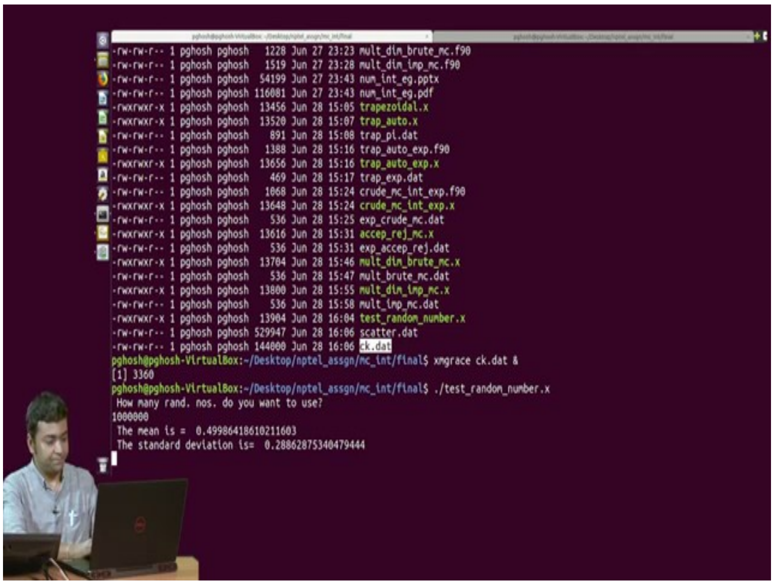

So, once it is done what I will do is I will plot it in this one only. Let me try to plot it in this graph, see it is done. So, let me just try to reload the data ok. So, the two things to notice here ok, let me just put some make this 25 not; so the two things to notice here. So if, so ideally if the numbers are completely random you expect the correlation to be 0.

So, what you would expect is that these numbers this plots will hover around 0; but when we have used fewer numbers for the correlation plot what we see is that it is having a certain nonzero value. And the moment you increase the number of random numbers that goes into the evaluation of the correlation plot; you see that it starts hovering around 0 nicely. So, this also tells you another thing that in addition to that in these type of methods; so what is also very important is the average.

So, one needs to do a very good average, by a very good average I mean average over a sufficient till large number of points to get into some meaningful and realistic number. Now, we will also look at the scatter plot. So, for the scatter plot what we will do is we will use fewer random numbers so that, you can see.

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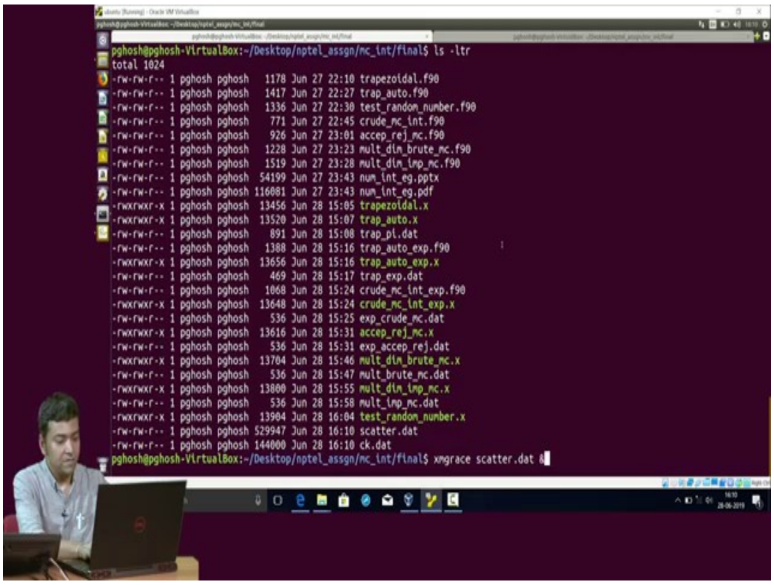

So, let us put say 10000 random numbers and do the evaluation. So, let us open it in x m grace.

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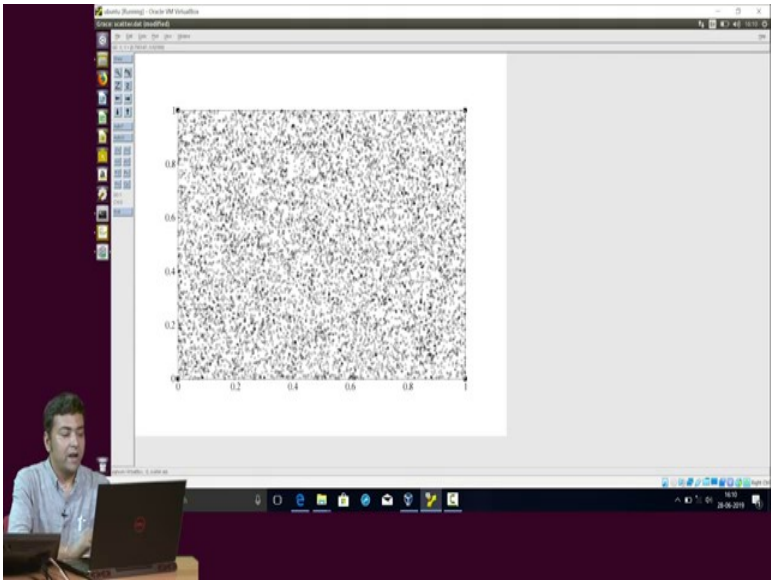

So, if your numbers are correlated then what your scatter plot would have looked like? Let me just first make this plot proper. So, circle let me reduce it slightly straight line I do not want I just want to see that dots here. So, this is how it, you see it is I mean the points are spread all over this area from the x axis is from 0 to 1 and y axis again is from 0 to 1. Had there been correlations then what we would have seen is that certain parts of this area is covered while the other parts are empty or it would have been something like a diagonal one.

So, this says since in all the points are scattered all over the space all over the extent of my plot; this tells that the numbers are not correlated and it is genuinely a good random number. There is one more test which I am not going to show it to you and I leave it to you as exercise; that is you what you can do is? You can generate say a million random numbers divide them into small bins and once you have them in small bins you can plot a histogram, that is in each bin how many random numbers are there.

So, and what you would see is that the height of the histogram and of all of them are same that is what it tells you, that it is a uniform distribution. Because each random number has an equal probability of, if there is an equal probability of finding each random number in a uniform distribution.

So, if you use very few random numbers in plotting the histogram then you will find that some bin heights are larger, some bin heights are smaller. But then gradually as you increase the number more and more as you increase the more and more random numbers that is as you enhance or better the sampling; what you will find is that the heights of all the bins are same.