CS302-Modulation and Simulation

Lab 5

Undertaken By

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Submitted To - Prof. Mukesh Tiwari

Contents

1 Radioactive Decay

Radioactive decay is a continuous process and is determined by a standard equation which is :

$N = N_0 e^{-\lambda(t-t_0)}$

Now using Monte Carlo simulation we are trying to determine the same process by applying the Monte Carlo model which uses the probability for the decay process. Here, we generate a random number between 0 and 1 and if the number is less than λ the atom won't decay else it would decay.

We try the procedure for different values of n which is the number of times a random number is being generated and we check for which how many steps do we get a similar curve to the actual exponential function that we calculated.

1.1 Computational Analysis

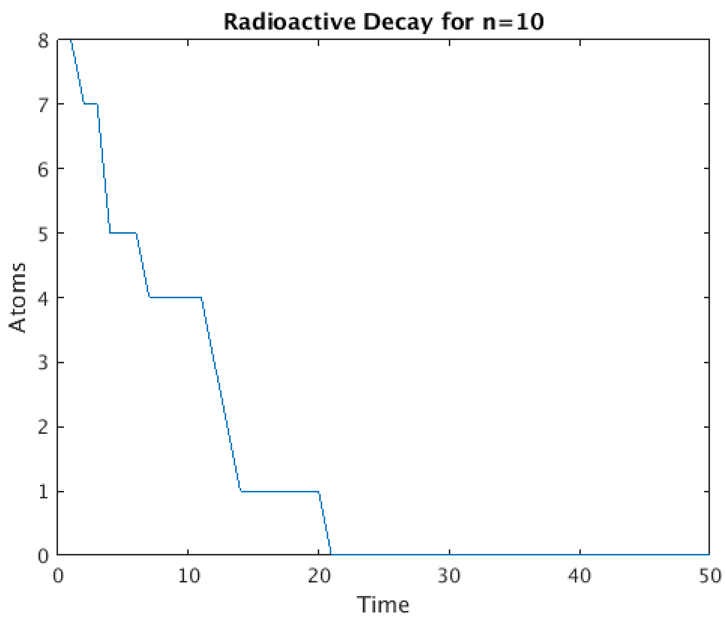

Figure 1: The radioactive decay for $\lambda = 0.1$ and n=10

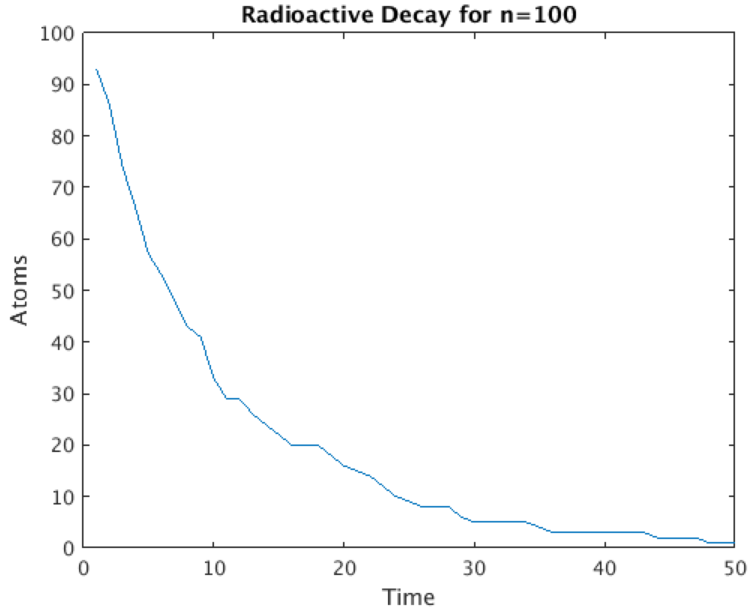

Figure 2: The radioactive decay for $\lambda = 0.1$ and n=100

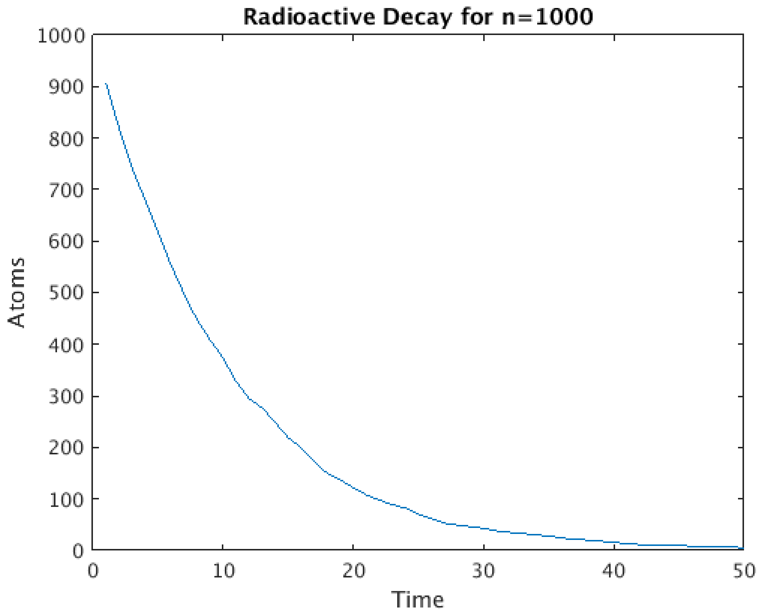

Figure 3: The radioactive decay for $\lambda = 0.1$ and n=1000

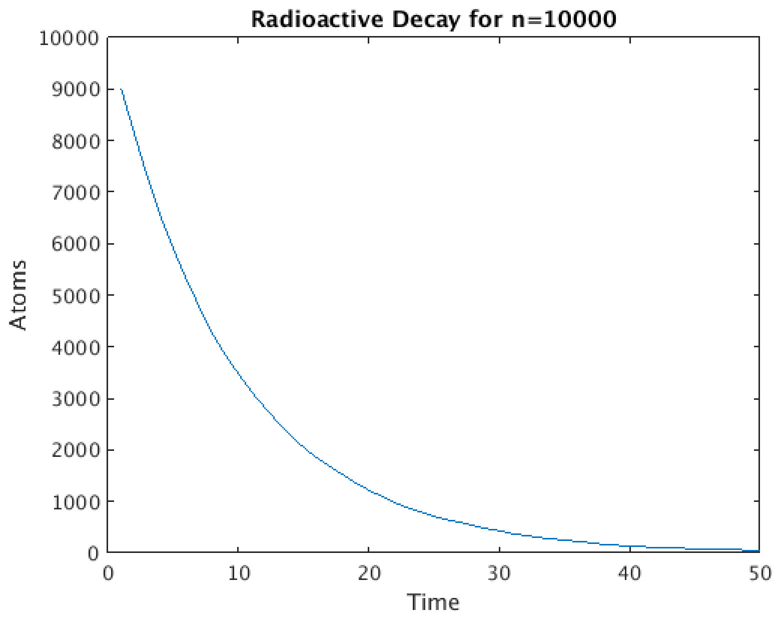

Figure 4: The radioactive decay for $\lambda = 0.1$ and n=10000

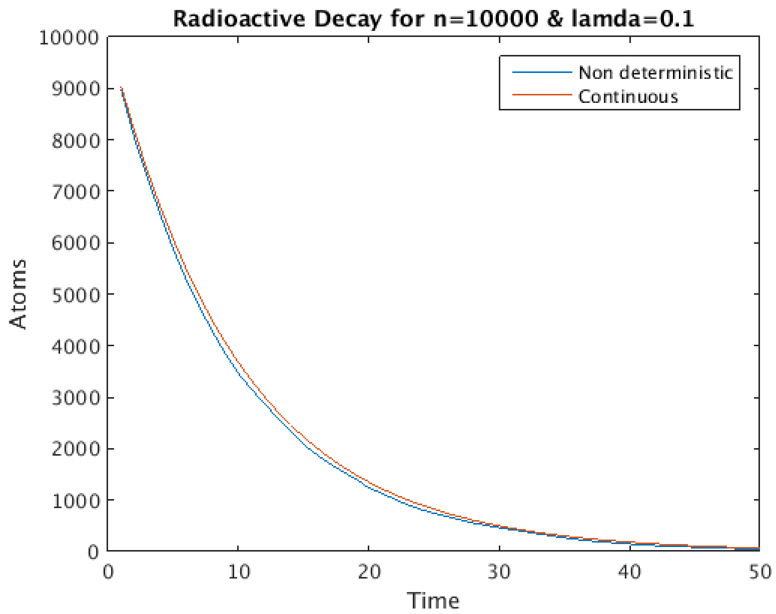

Figure 5: The radioactive decay of non-deterministic model with $\lambda = 0.1$ and n=10000 and a continuous model with the same λ

1.1.1 Observations

For smaller step size, the differential model is smoother as compared to the probabilistic model. The reason for the same being that the probabilistic model introduces bias for smaller step size which doesn't give the perfect estimate.

Here, we see that for a sufficient large number of steps, in this case 10000 we get a behaviour similar to the actual function that we expected. As we increase n we increase the number of times we are checking the probability of the atom to decay. As this number increases, we are increasing the step sizes and for higher value of n the step size decreases and hence we get a smoother curve which assumes the shape of the actual function.

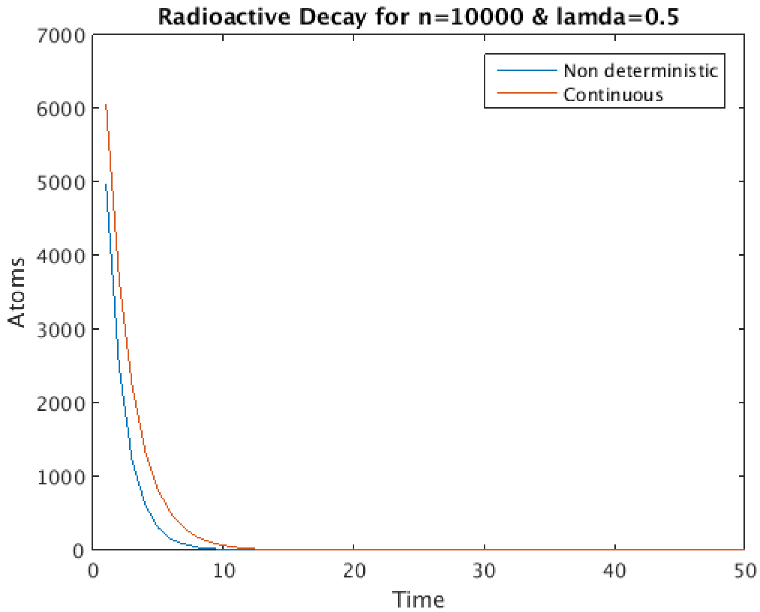

Figure 6: The radioactive decay for $\lambda = 0.5$ and n=10000

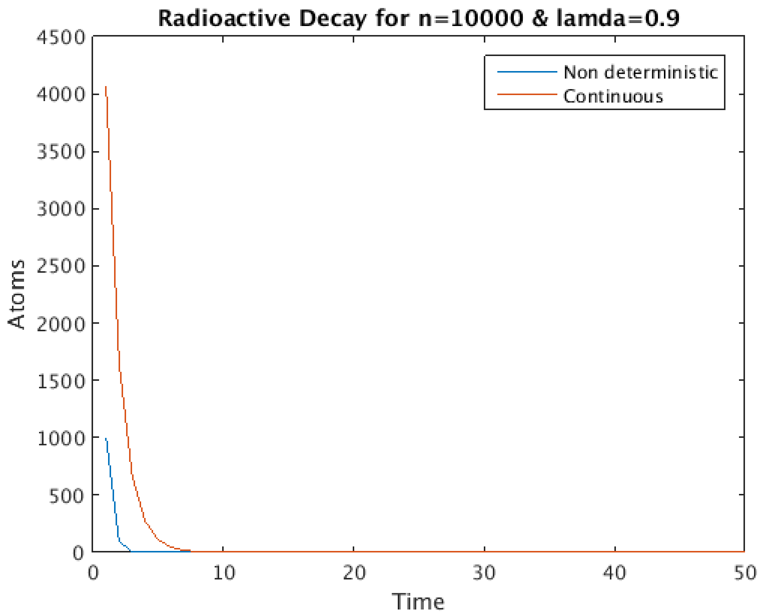

Figure 7: The radioactive decay for $\lambda = 0.9$ and n=10000

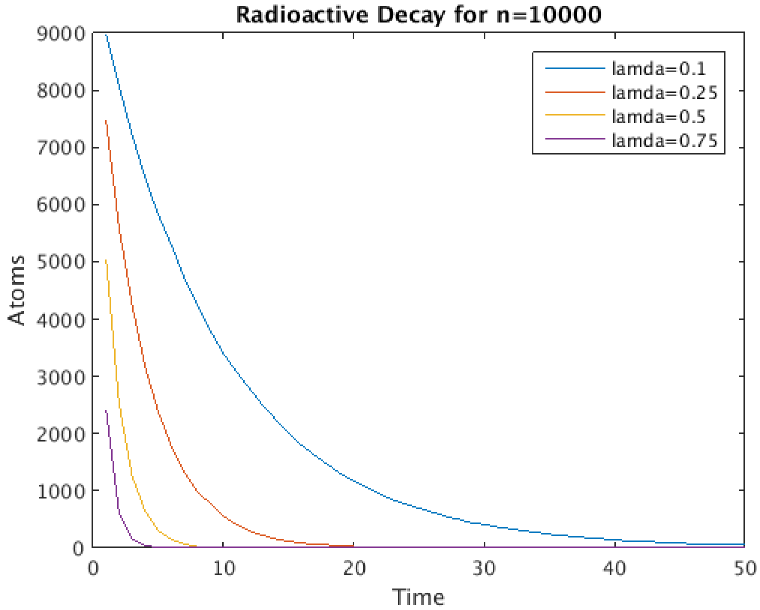

Figure 8: The radioactive decay for n=10000 and different values of λ

As we increase the value of λ the atoms would decay at a faster rate. Because of this, the graph will try to reach the 0 level faster for a higher value of λ.

2 1D Random Walk

2.1 Symmetric Random Walk

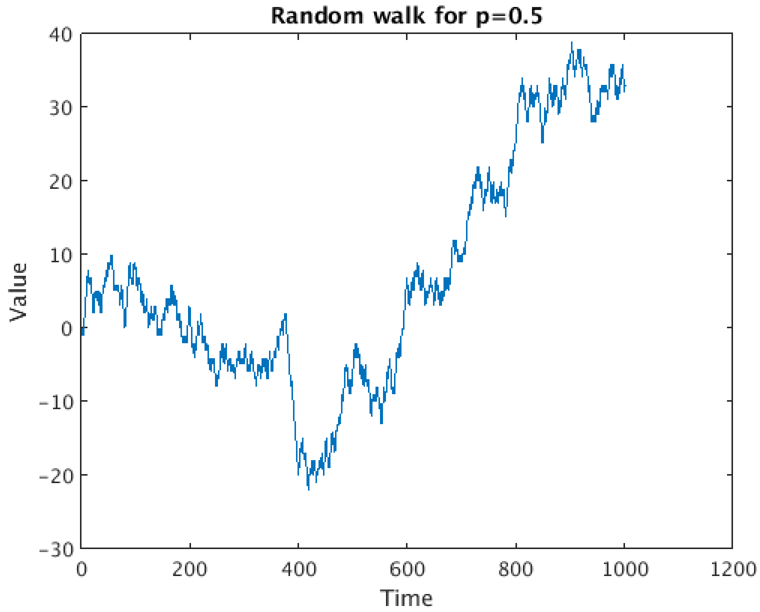

Figure 9: Position of the random walker with equal probabilities to go on both sides

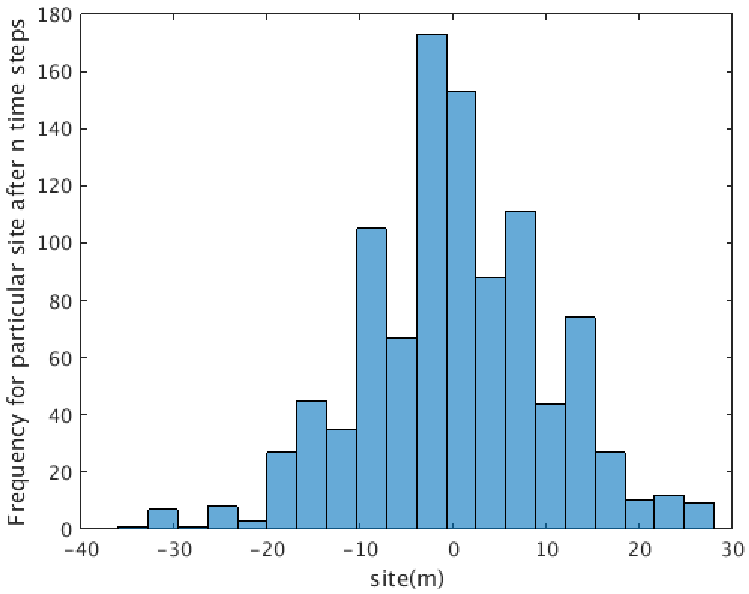

Figure 10: Histogram showing the frequency of the position of the random walker at different points

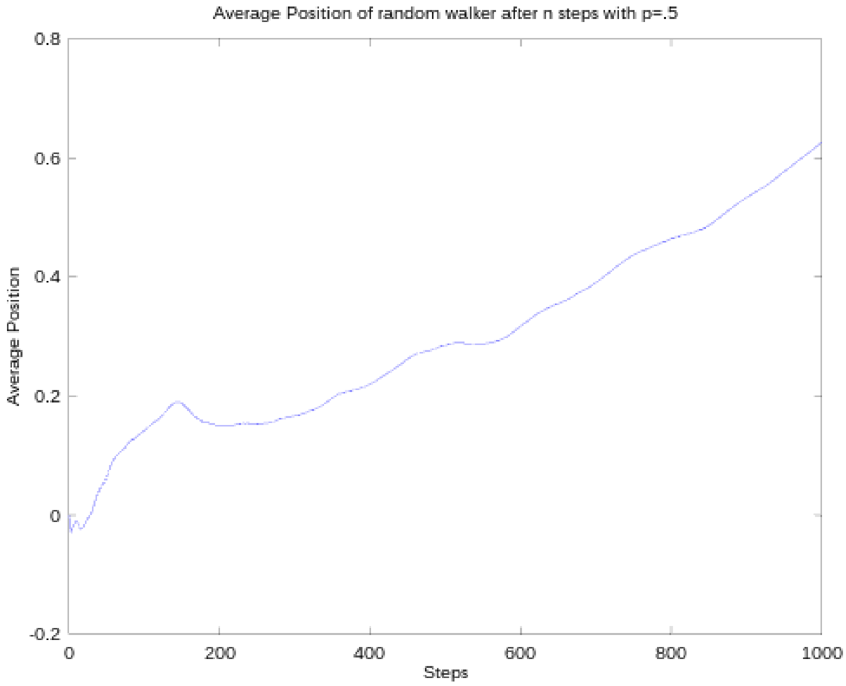

Figure 11: Average Position of the random walker with equal probabilities to go on both sides

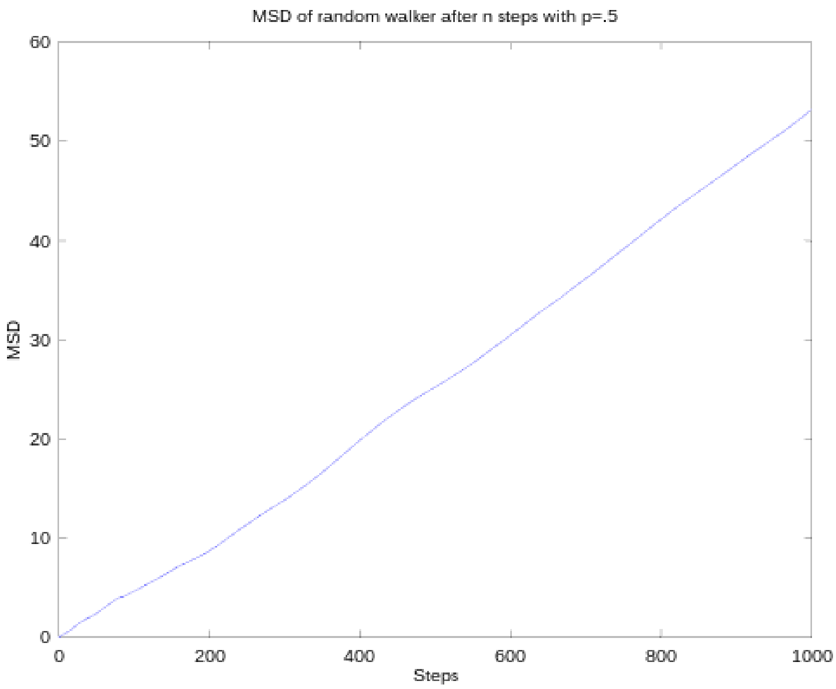

Figure 12: MSD of the random walker

2.1.1 Observations

1. The average position for a symmetric random walk for large number of steps will be nearly equal to 0. It means that after large number of time steps the random walker will be likely near to 0. This is also near to the theoretical value of average position which is 0.

2. The mean square displacement of the random walker for large number of steps increases as the steps increases. So that satisfies Einstein's equation which is - Variance is linearly dependant on time.

3. Here, since the mean is 0, the MSD is nearly equal to the variance.

2.2 Asymmetric Random Walk

Here we consider the case of unequal probabilities of going left or right. Such a situation arises quite often when we force the random walker to prefer one of the directions. p is the probability of going right and q = 1p is the probability of going left. Assuming that the random walker takes unit steps at each step.

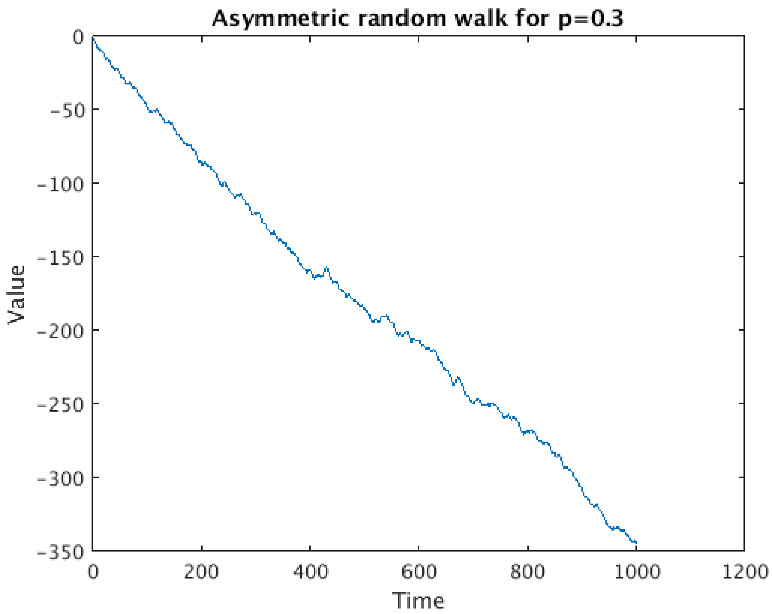

Figure 13: Mean position of the random walker for walks of different lengths

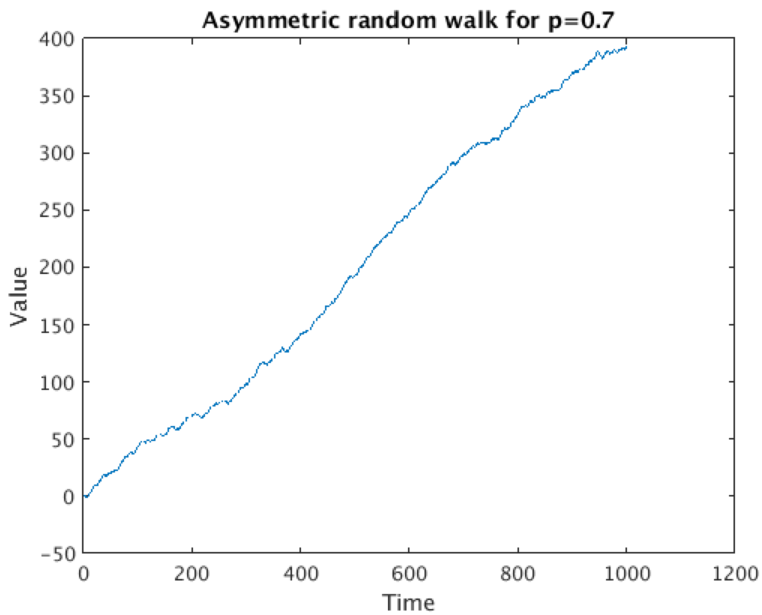

Figure 14: Mean position of the random walker for walks of different lengths

2.2.1 Observations

In this case the mean position of the random walker is not nearly equal to 0 as in the previous case. Also the value of mean square distance is also high as compared to the first case. The reason being, once we force the random walker to go in one direction then the model has some deterministic properties and the walker travels further in that particular direction and so his displacement from the starting point increases.

2.3 Walk of Varying Lengths

Here the random walker does not have to necessarily take unit step in each step. The number of steps that he takes is also randomly decided.

In this case we generate a random number every time to determine the step length. We will check how does the random walk vary when we introduce this difference.

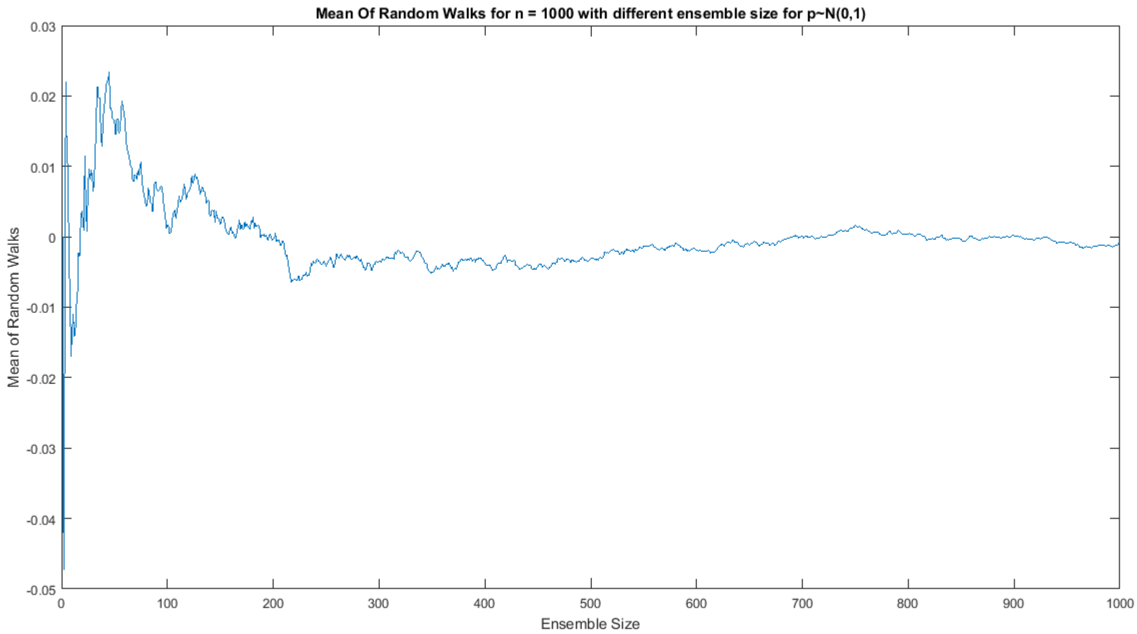

Figure 15: Mean position of the random walker for walks of different lengths with p N(0,1)

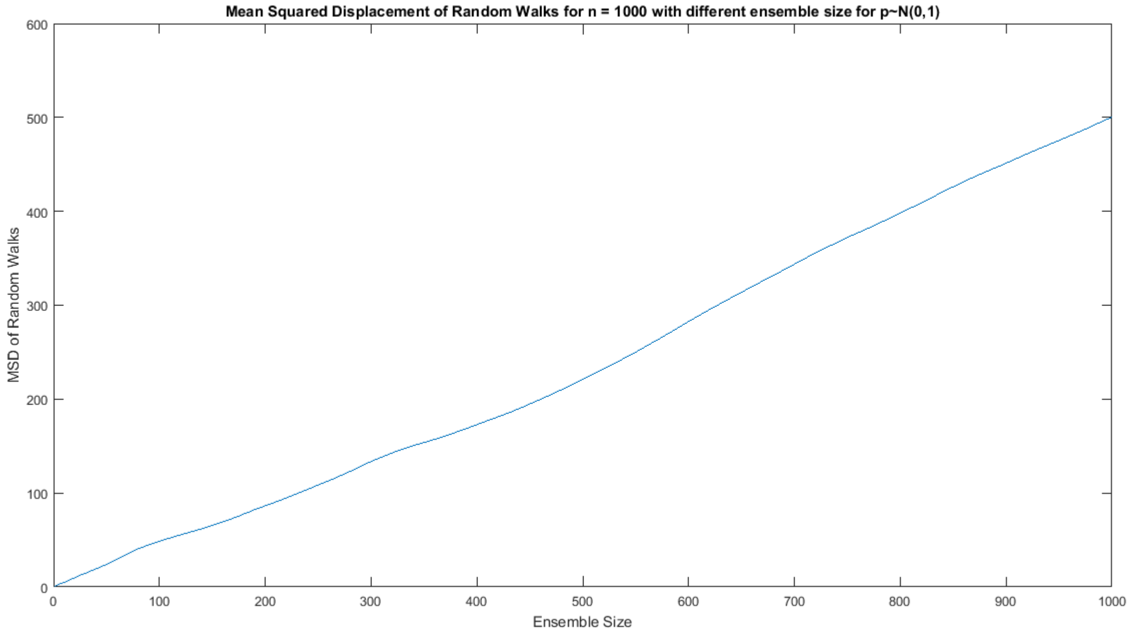

Figure 16: MSD of the random walker for walks of different lengths with p N(0,1)

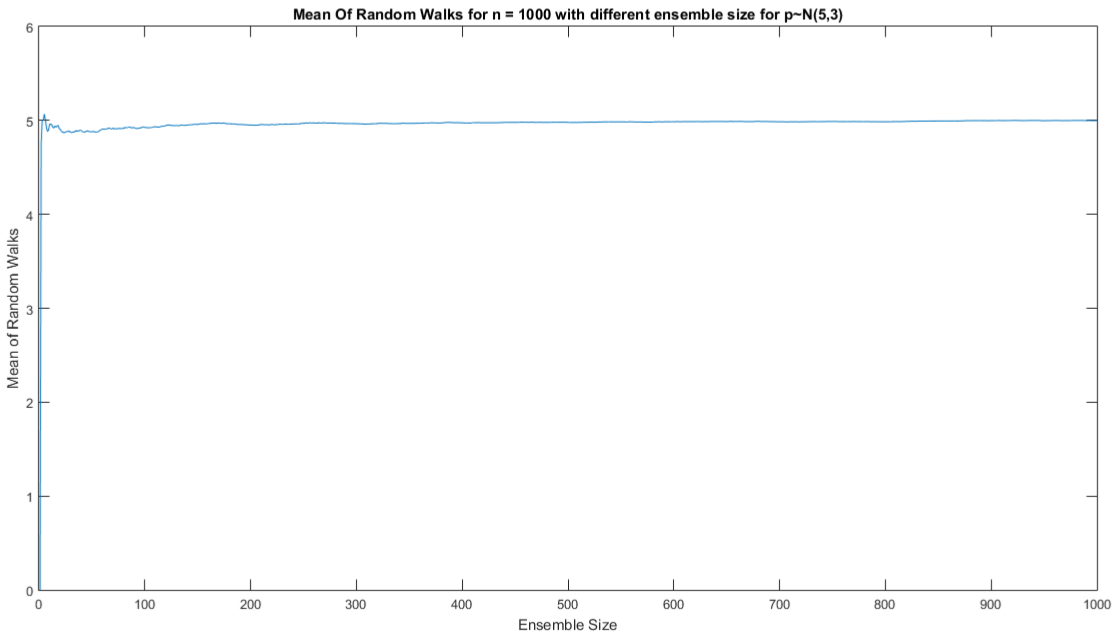

Figure 17: Mean position of the random walker for walks of different lengths with p N(5,3)

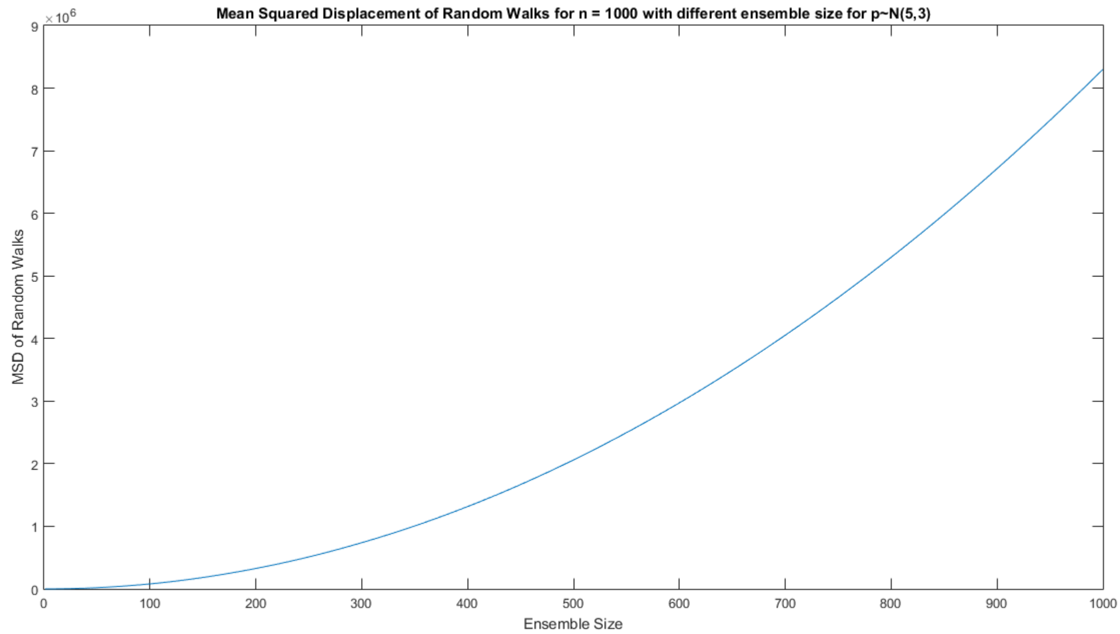

Figure 18: MSD of the random walker for walks of different lengths with p N(5,3)

2.3.1 Observations

1. We see that when the number of random steps is decided by a normal random variable with mean 0 and variance 1, then the average position of the random walker is nearly equal to 1 and his mean squared distance is also a smaller value.

2. Now compared to this when the step size is decided by a random variable with mean 5 and variance 3 then the average position of the walker is equal to 5 and at the same time due to the change in variance the mean squared distance increases exponentially to bery large values.