

SCIENCE II

ASSIGNMENT - 2

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Q1) Generate random numbers using the formula **(10 marks)**:

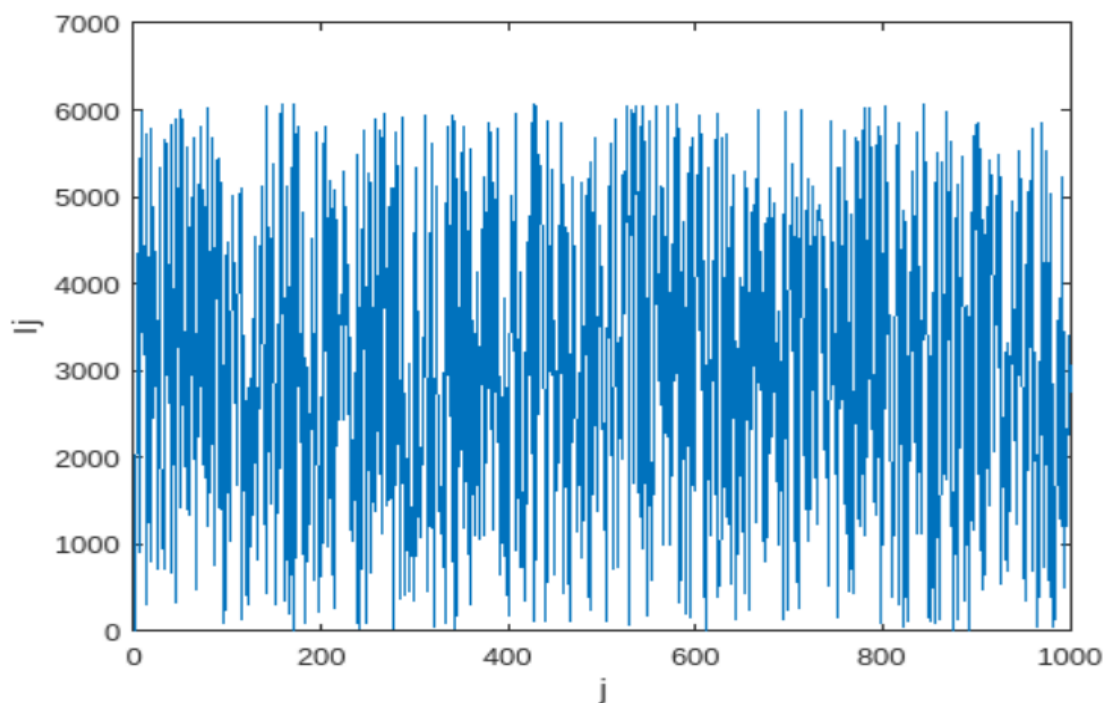
$$I_{j+1} = (AI_j + C) \bmod M$$

where $A = 106$, $C = 1283$, $M = 6075$ and $I_1 = 1$

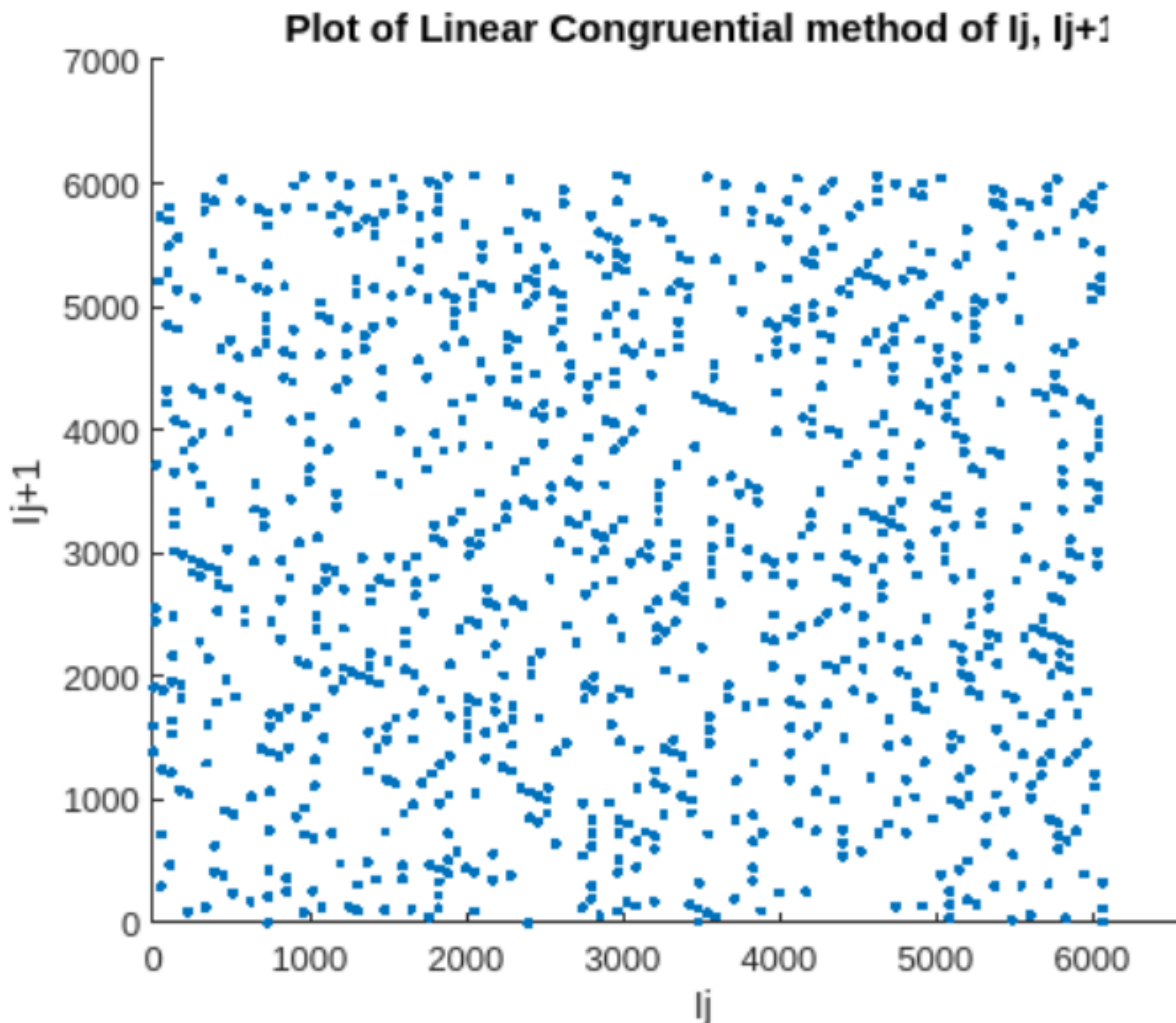
You can use this random number generator to get N random numbers (I_1, I_2, \dots, I_N)

- a) Plot I_j vs j for $N = 1000$ **(2 marks)**
- b) Plot I_{j+1} vs I_j for $N = 1000$. What can you deduce from the plot? **(3 marks)**
- c) Plot the expectation value $E(I_j)$ as a function of N . $N = [1, 10, 50, 100, 200, 300, \dots, 1800, 1900, 2000]$. **(5 marks)**

Solution : A):



B):

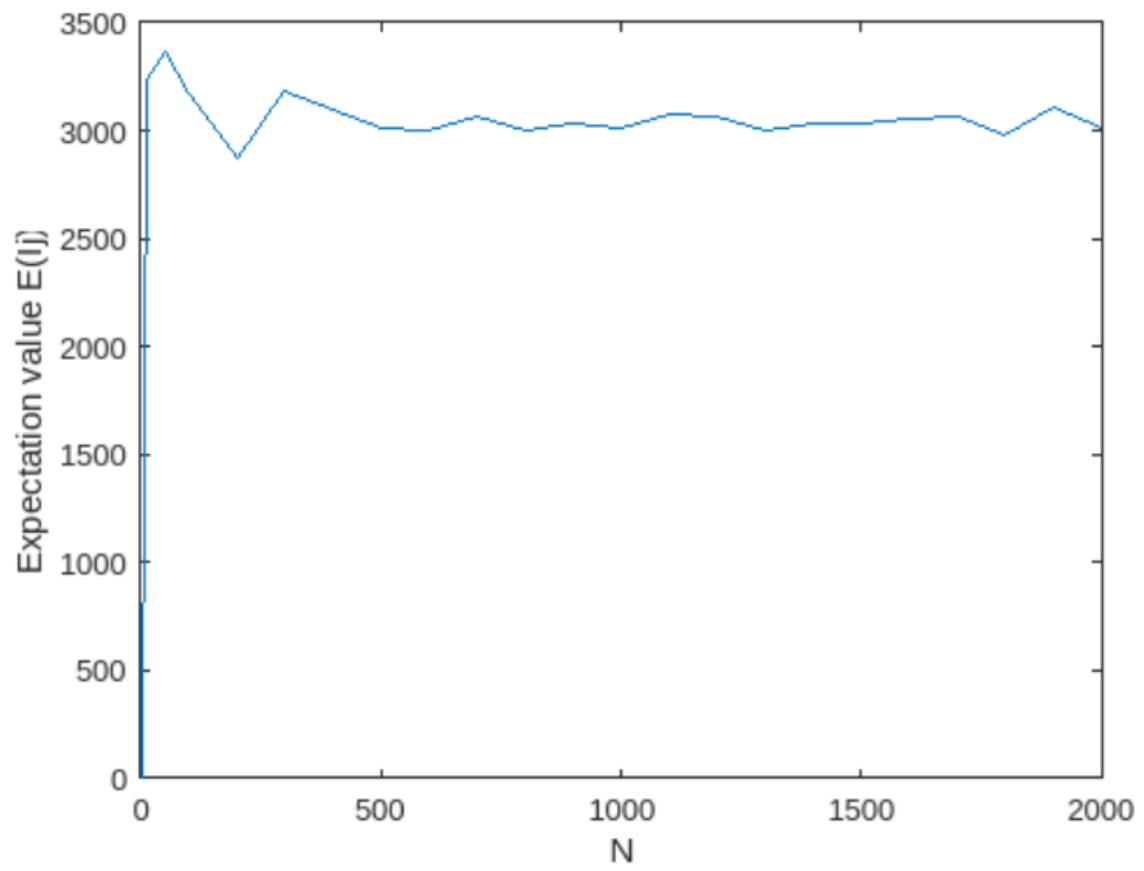


OBSERVATIONS FROM ABOVE PLOT

From the scatter plot of I_{j+1} vs I_j , we can see that the generated random numbers exhibit a clear pattern. Specifically, we can observe that the points in the scatter plot form several diagonal lines, which indicates that there is a significant correlation between adjacent random numbers. This is not desirable because it means that the generated numbers are not truly random and can be predicted or influenced by their predecessors.

The presence of this pattern in the scatter plot suggests that the linear congruential method with the given parameters ($A = 106$, $C = 1283$, $M = 6075$) is not a good choice for generating high-quality random numbers. In general, the quality of random numbers generated by the linear congruential method depends on the choice of parameters A , C , and M . If the parameters are not chosen carefully, the generated random numbers may exhibit some patterns or correlation, which can lead to problems in applications where high-quality random numbers are required.

c)

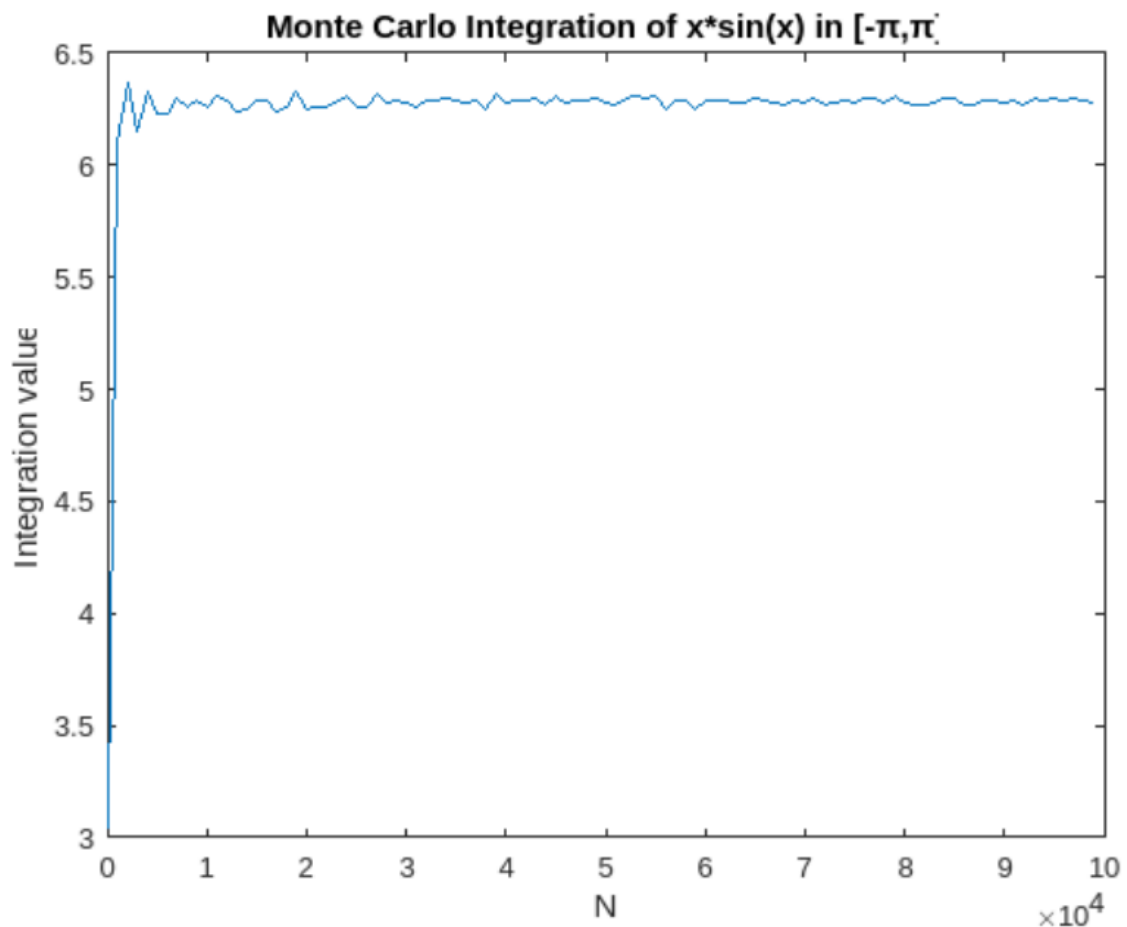


Q2) Perform integration using the Monte Carlo method for the function applicable to you. The function you need to use is your Roll Number % 5 + 1. Therefore if your Roll Number is 2021101110, take option 1. Similarly for 2021101113, take option 4. **(10 marks)**

1. $x \sin x$ in the range $[-\pi, \pi]$
 2. $x^2 \cos x$ in the range $[-\pi/2, \pi/2]$
 3. $e^{\cos x}$ in the range $[-3, 3]$
 4. $e^x \cos x$ in the range $[-\pi/2, \pi/2]$
 5. $\cos x - \cos^2 x$ in the range $[-\pi/2, \pi/2]$
- a. Find the integration value using $N = 100000$. **(4 marks)**
 - b. Plot the integration value as a function of N in the range $[1, 100000]$ with a gap of 1000, i.e, $N = 1, 1000, 2000, \dots 100000$. **(6 marks)**

Q2 a : Answer obtained ~ 6.278

Q2 b :



Q3

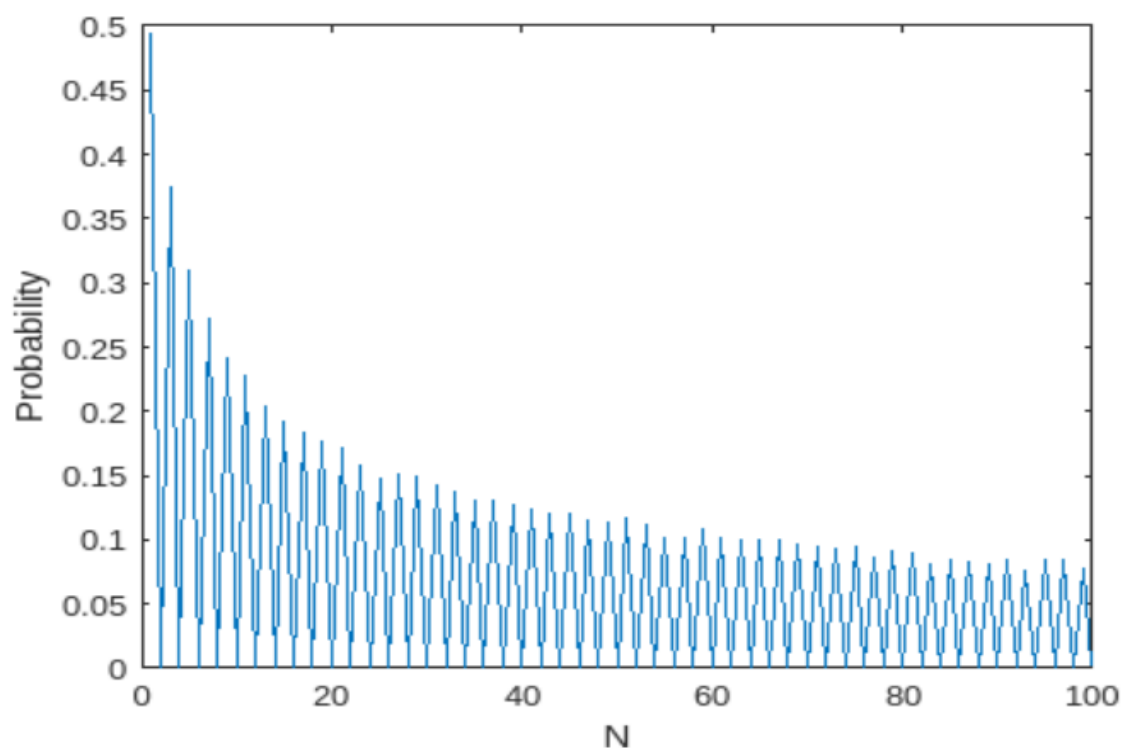
- a) A drunk person starts out at initial position “a”. Plot the probability that the person returns back to the origin after N timesteps for different values of N in the range of 1 to 100. **(3 marks)**
- b) Now assume, two drunk people start out at initial positions “a” and “b” respectively and take their steps simultaneously. Plot the probability that they meet again after N timesteps for different values of N in the range of 1 to 100. **(4 marks)**
- a) Plot the mean displacement for a drunk person after N steps for different values of N in the range of 1 to 100. You can assume that the person starts out at the origin. **(3 marks)**

To compute probabilities (in subparts a and b) and mean (in subpart c) simulate the experiments appropriate number of times (atleast 10000).

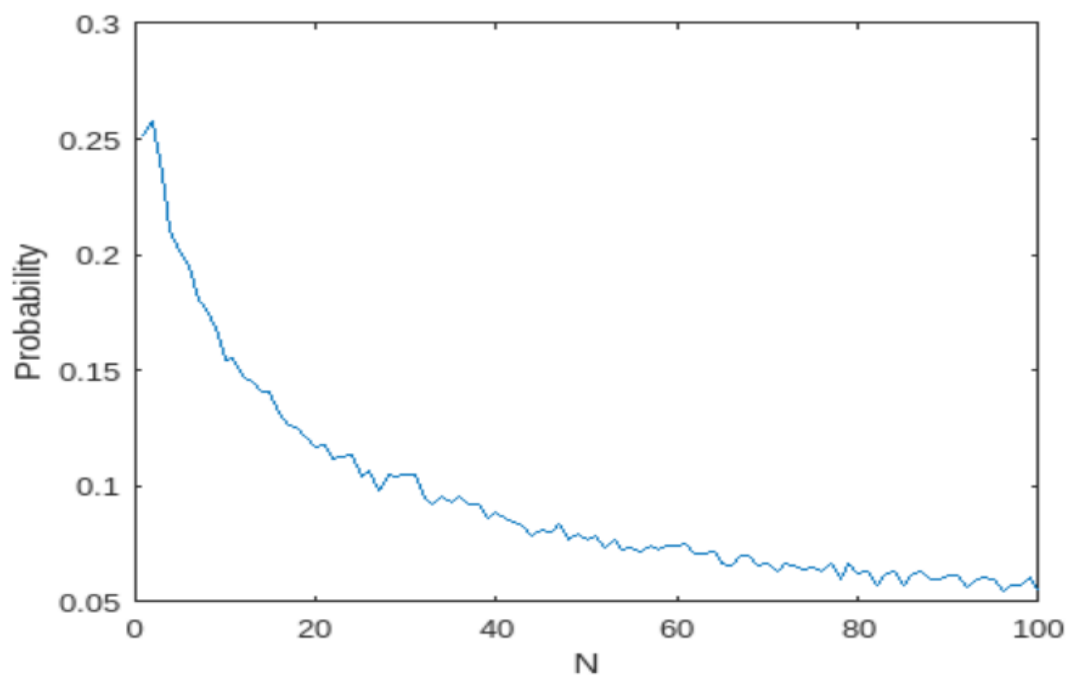
$$a = -(\text{Roll Number} \% 5 + 1); \quad b = \text{Roll Number} \% 5 + 1$$

Therefore, if your Roll Number is 2021101132, then $a = -3$, $b = 3$.

Q3 a :



B:



C:

