Monte Carlo Simulation - MA 323

Lab 01 - Report - Lakshya Kohli - 210123077

Answer 1:

Sequence of x_i for a = 6, b = 0, m = 11:

Seeds(x0)	0th Value	1st Value	2nd Value	3rd Value	4th Value	5th Value	6th Value	7th Value	8th Value	9th Value	10th Value
0	0	0	0	0	0	0	0	0	0	0	0
1	1	6	3	7	9	10	5	8	4	2	1
2	2	1	6	3	7	9	10	5	8	4	2
3	3	7	9	10	5	8	4	2	1	6	3
4	4	2	1	6	3	7	9	10	5	8	4
5	5	8	4	2	1	6	3	7	9	10	5
6	6	3	7	9	10	5	8	4	2	1	6
7	7	9	10	5	8	4	2	1	6	3	7
8	8	4	2	1	6	3	7	9	10	5	8
9	9	10	5	8	4	2	1	6	3	7	9
10	10	5	8	4	2	1	6	3	7	9	10

Observations:

1. When **seed (x_0) = 0**, only **1 distinct value** appears that is 0.
2. For other **seeds (x_0) = 1 to 10**, **10 distinct values** (all in the range 1 to 10, both inclusive) are generated.

Sequence of x_i for a = 3, b = 0, m = 11:

Seeds(x0)	0th Value	1st Value	2nd Value	3rd Value	4th Value	5th Value
0	0	0	0	0	0	0
1	1	3	9	5	4	1
2	2	6	7	10	8	2
3	3	9	5	4	1	3
4	4	1	3	9	5	4
5	5	4	1	3	9	5
6	6	7	10	8	2	6
7	7	10	8	2	6	7
8	8	8	2	6	7	8
9	9	5	4	1	3	9
10	10	8	2	6	7	10

Observations:

1.When **seed (x_0) = 0**, only **1 distinct value** appears that is 0.

2.For other **seeds (x_0) = 1 to 10**, **5 distinct values** (all in the range 1 to 10, both inclusive) are generated.

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PS E:\SEM 5\MA323 MonteCarlo\Lab01> python -u "e:\SEM 5\MA323 MonteCarlo\Lab01\q1.py"
for a = 6, b = 0, m = 11:
x0 = 0 & Sequence =  [0]
x0 = 1 & Sequence =  [1, 6, 3, 7, 9, 10, 5, 8, 4, 2]
x0 = 2 & Sequence =  [2, 1, 6, 3, 7, 9, 10, 5, 8, 4]
x0 = 3 & Sequence =  [3, 7, 9, 10, 5, 8, 4, 2, 1, 6]
x0 = 4 & Sequence =  [4, 2, 1, 6, 3, 7, 9, 10, 5, 8]
x0 = 5 & Sequence =  [5, 8, 4, 2, 1, 6, 3, 7, 9, 10]
x0 = 6 & Sequence =  [6, 3, 7, 9, 10, 5, 8, 4, 2, 1]
x0 = 7 & Sequence =  [7, 9, 10, 5, 8, 4, 2, 1, 6, 3]
x0 = 8 & Sequence =  [8, 4, 2, 1, 6, 3, 7, 9, 10, 5]
x0 = 9 & Sequence =  [9, 10, 5, 8, 4, 2, 1, 6, 3, 7]
x0 = 10 & Sequence =  [10, 5, 8, 4, 2, 1, 6, 3, 7, 9]

for a = 3, b = 0, m = 11:
x0 =  0  & Sequence =  [0]
x0 =  1  & Sequence =  [1, 3, 9, 5, 4]
x0 =  2  & Sequence =  [2, 6, 7, 10, 8]
x0 =  3  & Sequence =  [3, 9, 5, 4, 1]
x0 =  4  & Sequence =  [4, 1, 3, 9, 5]
x0 =  5  & Sequence =  [5, 4, 1, 3, 9]
x0 =  6  & Sequence =  [6, 7, 10, 8, 2]
x0 =  7  & Sequence =  [7, 10, 8, 2, 6]
x0 =  8  & Sequence =  [8, 2, 6, 7, 10]
x0 =  9  & Sequence =  [9, 5, 4, 1, 3]
x0 =  10  & Sequence =  [10, 8, 2, 6, 7]
PS E:\SEM 5\MA323 MonteCarlo\Lab01>
```

Best Choice:

The linear congruence generator with **a = 6 is preferred over a = 3** as it has higher period length (10,5 respectively). The reason behind this choice is that there will be more randomness in the generated numbers as there are more numbers in the sequence generated by a = 6. Also, seed(x_0) should not be equal to zero, as $x_0 = 0$ has zero randomness (as only 1 distinct number is generated that too 0).

Answer 2:

Tabulated Data of Frequencies of numbers (u_i) in different intervals:

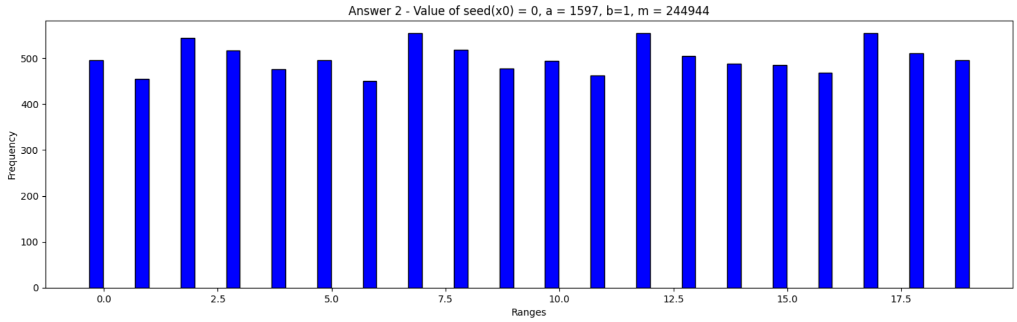
	b = 1, m = 244944									
	a = 1597					a = 51479				
Seeds	**x0 = 0**	**x0 = 2**	**x0 = 5**	**x0 = 7**	**x0 = 10**	**x0 = 0**	**x0 = 2**	**x0 = 5**	**x0 = 7**	**x0 = 10**
0.00 - 0.05	496	467	478	555	509	507	508	417	496	496
0.05 - 0.10	455	554	495	509	459	497	491	556	515	506
0.01 - 0.15	544	500	468	486	487	499	491	416	503	505
0.15 - 0.20	516	452	561	495	492	504	505	556	499	493
0.20 - 0.25	476	511	501	455	556	498	503	554	493	494
0.25 - 0.30	496	469	475	549	508	503	507	417	494	508
0.30 - 0.35	451	575	505	507	453	503	498	555	507	512
0.35 - 0.40	554	492	450	476	507	490	496	417	491	485
0.40 - 0.45	518	459	575	500	463	500	504	556	505	495
0.45 - 0.50	477	506	520	445	567	507	500	555	504	500
0.50 - 0.55	494	472	465	562	497	492	512	416	492	511

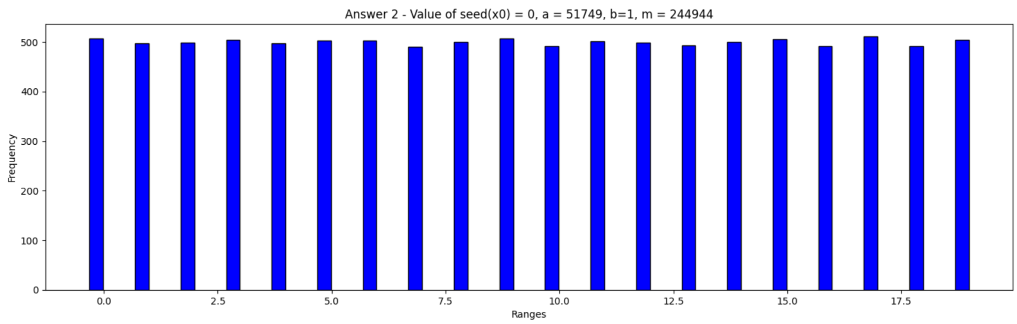
	b = 1, m = 244944									
0.55 - 0.60	462	581	511	526	459	502	492	555	507	495
0.60 - 0.65	554	509	461	468	488	499	495	417	500	489
0.65 - 0.70	505	461	559	512	477	494	503	555	509	506
0.70 - 0.75	488	505	500	452	574	500	500	557	492	512
0.75 - 0.80	485	461	462	562	514	506	507	416	495	493
0.80 - 0.85	468	566	507	503	460	492	491	556	507	491
0.85 - 0.90	554	500	455	470	496	511	494	417	488	502
0.90 - 0.95	511	450	559	497	490	492	500	555	507	509
0.95 - 1.00	496	510	493	471	544	504	503	557	496	498

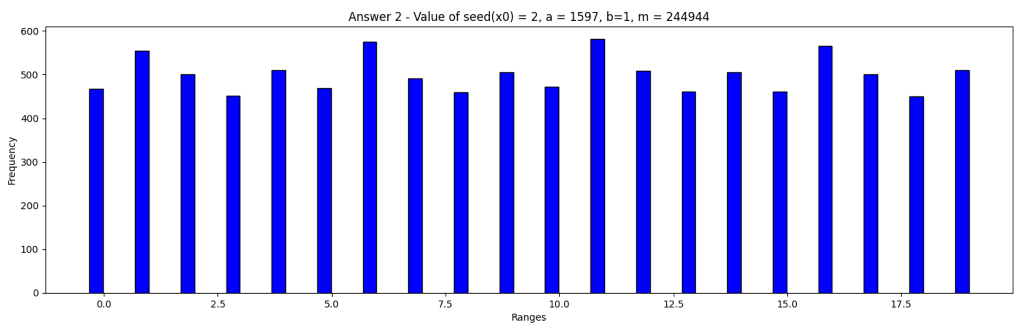
Observations:

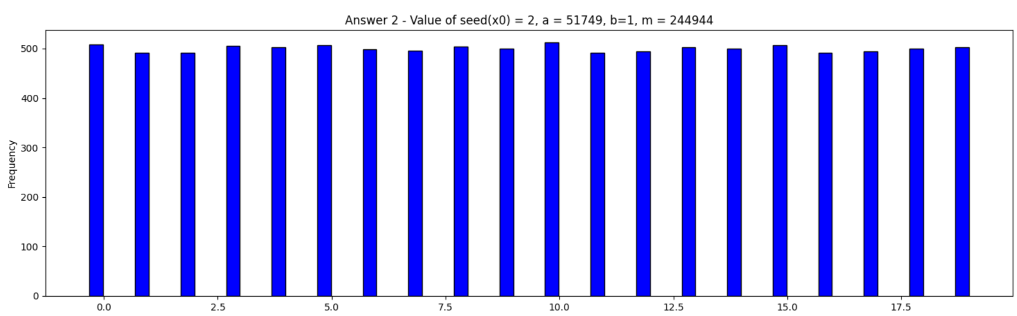
1. For different values of seed (x0), the frequencies are almost identical, and so the nature of bar graphs is the same.

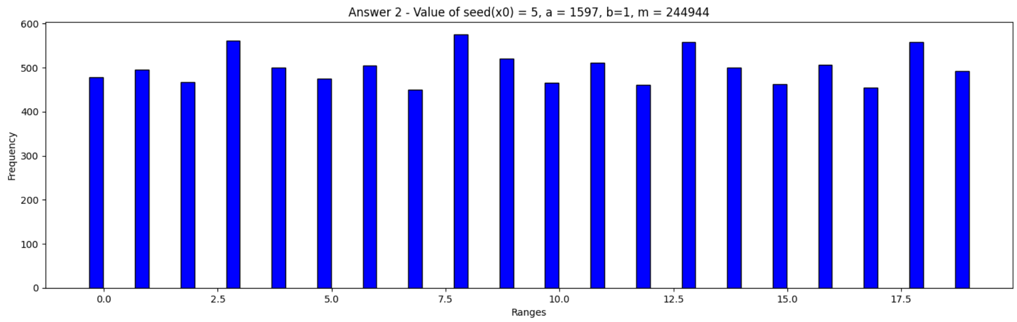
2.The numbers are generated consistently between 0 and 1. The frequency of various integers falling within intervals of the same length is nearly identical. As a result, the random number generator adheres to the principle of uniform number generation.

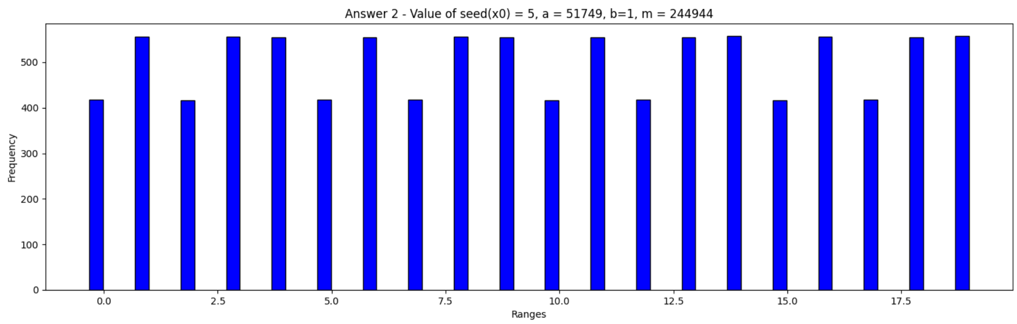

Answer 2 - Value of seed(x0) = 0, a = 1597, b=1, m = 244944
Frequency
Ranges
0
100
200
300
400
500
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5

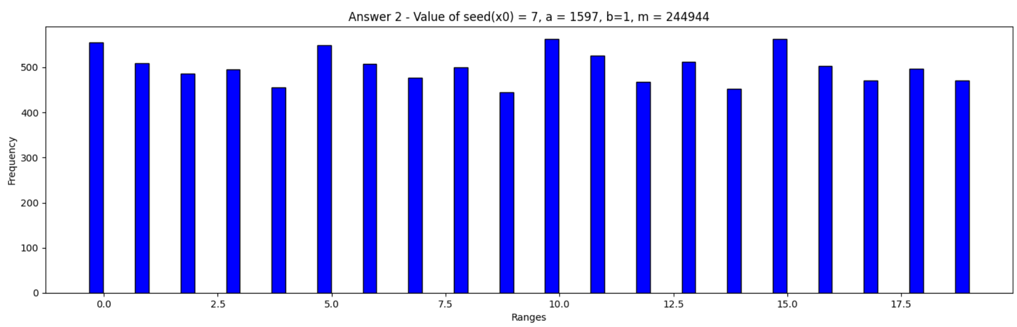

Answer 2 - Value of seed(x0) = 0, a = 51749, b=1, m = 244944
Frequency
Ranges
0
100
200
300
400
500
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5

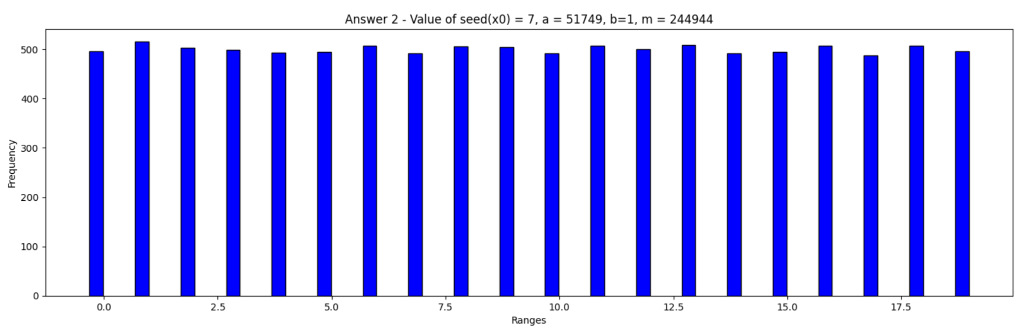

Answer 2 - Value of seed(x0) = 2, a = 1597, b=1, m = 244944
Frequency
Ranges
0
100
200
300
400
500
600
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5

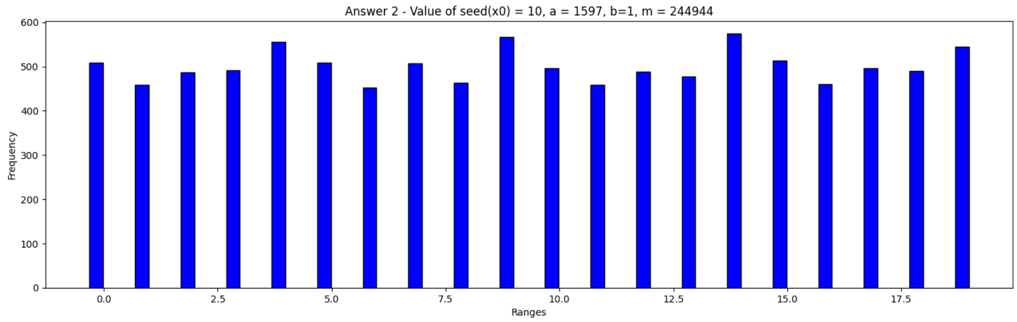

Answer 2 - Value of seed(x0) = 2, a = 51749, b=1, m = 244944
Frequency
Ranges
0
100
200
300
400
500
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5

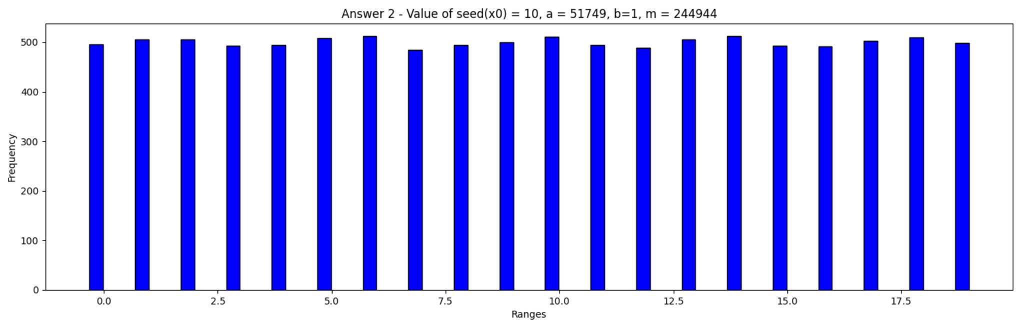

Answer 2 - Value of seed(x0) = 5, a = 1597, b=1, m = 244944
Frequency
Ranges


Answer 2 - Value of seed(x0) = 5, a = 51749, b=1, m = 244944
Frequency
Ranges


Answer 2 - Value of seed(x0) = 7, a = 1597, b=1, m = 244944
Frequency
Ranges


Answer 2 - Value of seed(x0) = 7, a = 51749, b=1, m = 244944
Frequency
Ranges


Answer 2 - Value of seed(x0) = 10, a = 1597, b=1, m = 244944
Frequency
Ranges
0
100
200
300
400
500
600
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5


Answer 2 - Value of seed(x0) = 10, a = 51749, b=1, m = 244944
Frequency
Ranges
0
100
200
300
400
500
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5

Answer 3:

Two Dimensional plot for coordinates (u_{i-1}, u_i) with a = 1229, b = 1, m = 2048 and seed(x0) = 1 :