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Department: Mathematics and Computing

Course: MA 323 - Monte Carlo Simulation

Lab: 01

Given Expression:

$$
\begin{aligned}
x_{i+1} &= (ax_i + b) \bmod m \\
u_{i+1} &= x_{i+1}/m.
\end{aligned}
$$

Task 1:

In [2]:

```
For a=3 , b=0, m=11
Xo = 0
[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0]
Xo = 1
[1, 3, 9, 5, 4, 1, 3, 9, 5, 4, 1, 3, 9, 5, 4, 1, 3, 9, 5, 4, 1]
Xo = 2
[2, 6, 7, 10, 8, 2, 6, 7, 10, 8, 2, 6, 7, 10, 8, 2, 6, 7, 10, 8, 2]
Xo = 3
[3, 9, 5, 4, 1, 3, 9, 5, 4, 1, 3, 9, 5, 4, 1, 3, 9, 5, 4, 1, 3]
Xo = 4
[4, 1, 3, 9, 5, 4, 1, 3, 9, 5, 4, 1, 3, 9, 5, 4, 1, 3, 9, 5, 4]
Xo = 5
[5, 4, 1, 3, 9, 5, 4, 1, 3, 9, 5, 4, 1, 3, 9, 5, 4, 1, 3, 9, 5]
Xo = 6
[6, 7, 10, 8, 2, 6, 7, 10, 8, 2, 6, 7, 10, 8, 2, 6, 7, 10, 8, 2, 6]
Xo = 7
[7, 10, 8, 2, 6, 7, 10, 8, 2, 6, 7, 10, 8, 2, 6, 7, 10, 8, 2, 6, 7]
Xo = 8
[8, 2, 6, 7, 10, 8, 2, 6, 7, 10, 8, 2, 6, 7, 10, 8, 2, 6, 7, 10, 8]
Xo = 9
[9, 5, 4, 1, 3, 9, 5, 4, 1, 3, 9, 5, 4, 1, 3, 9, 5, 4, 1, 3, 9]
Xo = 10
[10, 8, 2, 6, 7, 10, 8, 2, 6, 7, 10, 8, 2, 6, 7, 10, 8, 2, 6, 7, 10]


For a=6 , b=0, m=11
Xo = 0
[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0]
Xo = 1
[1, 6, 3, 7, 9, 10, 5, 8, 4, 2, 1, 6, 3, 7, 9, 10, 5, 8, 4, 2, 1]
Xo = 2
[2, 1, 6, 3, 7, 9, 10, 5, 8, 4, 2, 1, 6, 3, 7, 9, 10, 5, 8, 4, 2]
Xo = 3
[3, 7, 9, 10, 5, 8, 4, 2, 1, 6, 3, 7, 9, 10, 5, 8, 4, 2, 1, 6, 3]
Xo = 4
[4, 2, 1, 6, 3, 7, 9, 10, 5, 8, 4, 2, 1, 6, 3, 7, 9, 10, 5, 8, 4]
```

```
[4,  2,  1,  6,  3,  7,  9,  10,  5,  8,  4,  2,  1,  6,  3,  7,  9,  10,  5,  8,  4]
Xo = 5
[5,  8,  4,  2,  1,  6,  3,  7,  9,  10,  5,  8,  4,  2,  1,  6,  3,  7,  9,  10,  5]
Xo = 6
[6,  3,  7,  9,  10,  5,  8,  4,  2,  1,  6,  3,  7,  9,  10,  5,  8,  4,  2,  1,  6]
Xo = 7
[7,  9,  10,  5,  8,  4,  2,  1,  6,  3,  7,  9,  10,  5,  8,  4,  2,  1,  6,  3,  7]
Xo = 8
[8,  4,  2,  1,  6,  3,  7,  9,  10,  5,  8,  4,  2,  1,  6,  3,  7,  9,  10,  5,  8]
Xo = 9
[9,  10,  5,  8,  4,  2,  1,  6,  3,  7,  9,  10,  5,  8,  4,  2,  1,  6,  3,  7,  9]
Xo = 10
[10,  5,  8,  4,  2,  1,  6,  3,  7,  9,  10,  5,  8,  4,  2,  1,  6,  3,  7,  9,  10]
```

From the above generated output, we can observe that:\ 1). For Xo=0 and b=0, we were able to generate a single number i.e. 0\ 2). For (a=3, b=0, m=11) and for any 1<=Xo<=10, we were able to generate only 5 distinct values, and then the numbers started repeating\ 3). For (a=6, b=0, m=11) and for any 1<=Xo<=10, we were able to generate all 10 values, except 0, and then the numbers started repeating

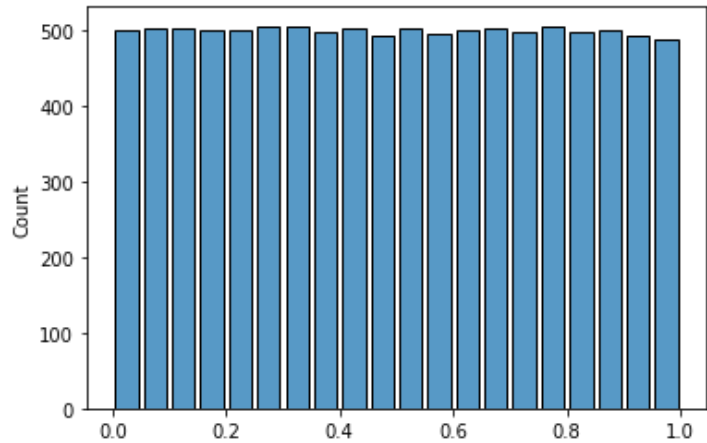**So, we will prefer a=6 over a=3, as it has a larger period**

Task 2:

In [1]:

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Below is the graph for a=1597 and Xo=1
```
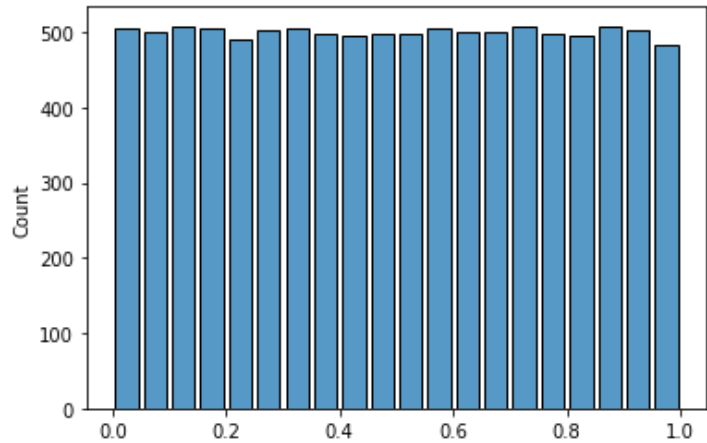


```
Below is the graph for a=1597 and Xo=2
```

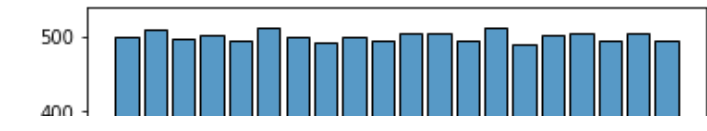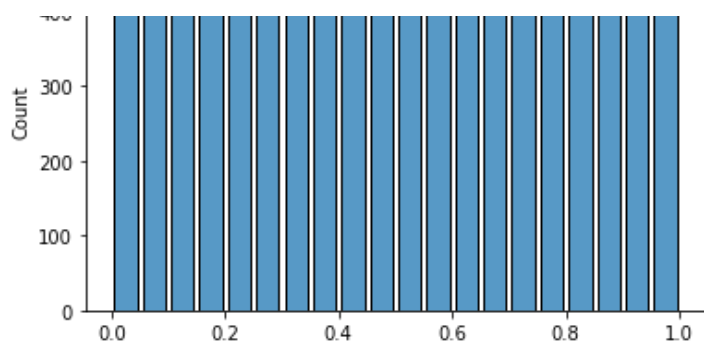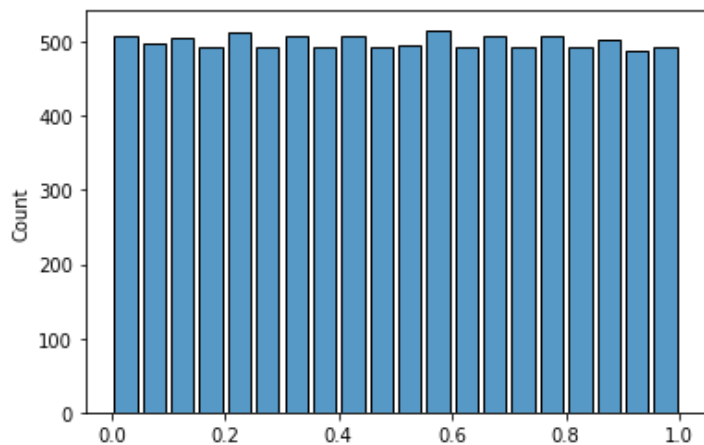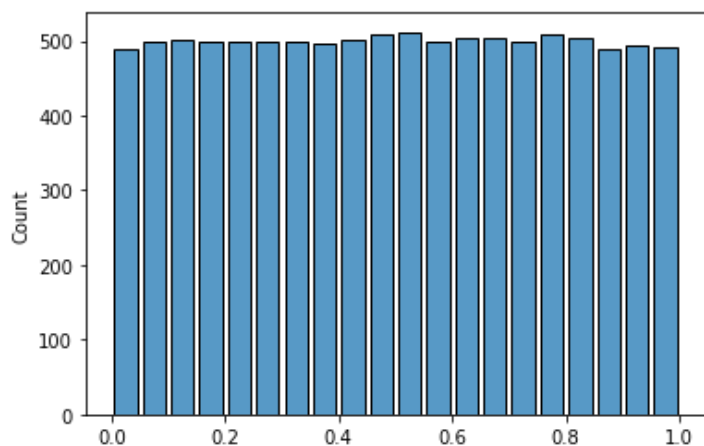

```
Below is the graph for a=1597 and Xo=3
```
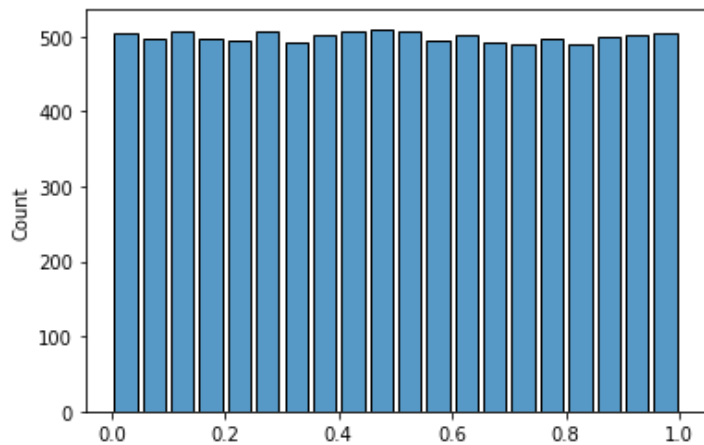
Below is the graph for a=1597 and Xo=4
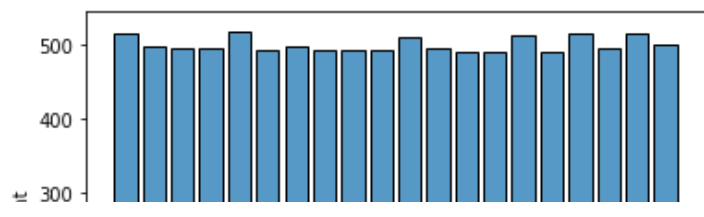

Below is the graph for a=1597 and Xo=5

Below is the graph for a=51749 and Xo=1

Below is the graph for a=51749 and Xo=2

Below is the graph for a=51749 and Xo=3

Below is the graph for a=51749 and Xo=4

Below is the graph for a=51749 and Xo=5

Now, we can see that our distribution is fairly uniform, so our generator works fine.

Task 3:

In [3]:

For a=1229, b=1, m=2048, Xo=5:
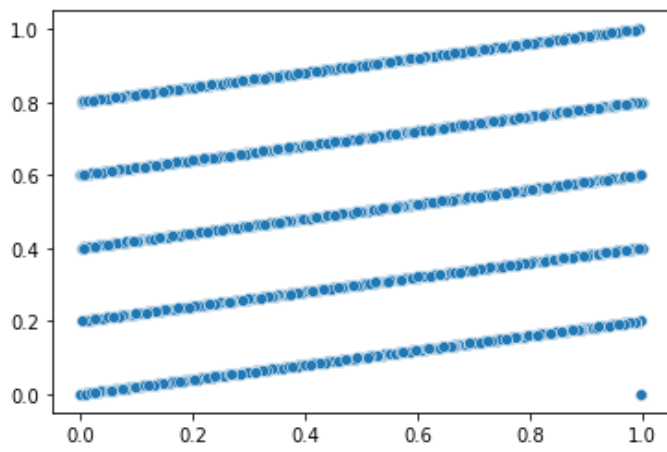
We can see that the scatter plot is of the form y=mx+c, i.e. a straight line