MA202 LAB2

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1. Write a C-program to find the value of x_M for some value of M, using the following iterative map: $x_{n+1} = a(1 - x_n)x_n$, for integer values of n starting from $n = 0$. Here a is a parameter within the range $0 \leq a \leq 4$, and one needs to consider some value of x_0 $(0 \leq x_0 \leq 1)$ to begin the procedure. The program should also have the following provision: It should save the values of x_n after $n \geq M$, if x_n is different from its previous 20 values.

Solution code:

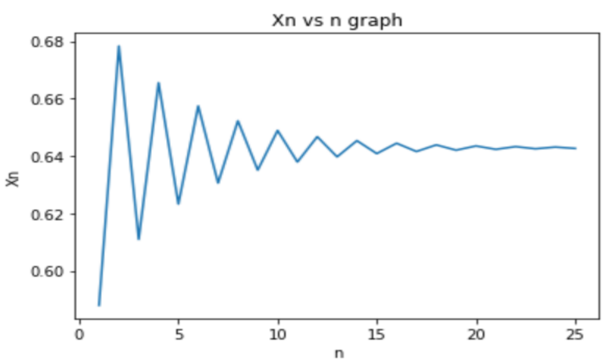
```
#include<stdio.h>
#include<math.h>

int main()
{
    int i, j, m, F;
    double a, Xo, X1, X[100000];

    printf("Enter the value of a (0 <= a <= 4): ");
    scanf("%lf", &a);
    printf("Enter the value of Xo (0 <= Xo <= 1): ");
    scanf("%lf", &Xo);
    printf("Enter the value of m: ");
    scanf("%d", &m);

    X[0] = Xo;
    for(i=1; i<=m; i++)
    {
        X[i] = a * (1 - X[i-1]) * X[i-1];
        F = 0;
        for(j=i-20; j<i; j++)
        {
            if(fabs(X[i] - X[j]) < 0.0001)
            {
                F = 1;
                break;
            }
        }
        if(!F)
        {
            printf(" %lf, ", X[i]);
```

```
        }
    }
    return 0;
}
```

2. Consider $a = 2.8$, and run the program for $M = 50$, for two cases $x_0 = 0.3$ and $x_0 = 0.9$. Plot the the values of x_n obtained in both the cases as a function of n. For $M = 100$, what is the value of x_M that you get in both the cases ?

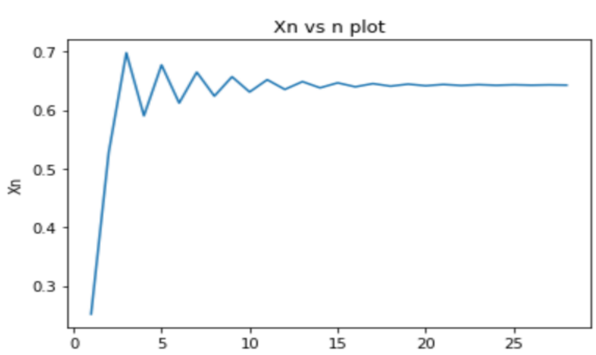
For Xo=0.3

```python
import matplotlib.pyplot as plt
x = [1, 2, 3, 4, 5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25]
y = [ 0.588000,  0.678317,  0.610969,  0.665521,  0.623288,  0.657440,  0.630595,  0.652246,  0.635100,  0.648895,  0.637925,  0.646735,  0.639713,
plt.plot(x, y)
plt.xlabel('X-axis')
plt.ylabel('Y-axis')
plt.title('Line Plot')
plt.show()
```



For Xo=0.9

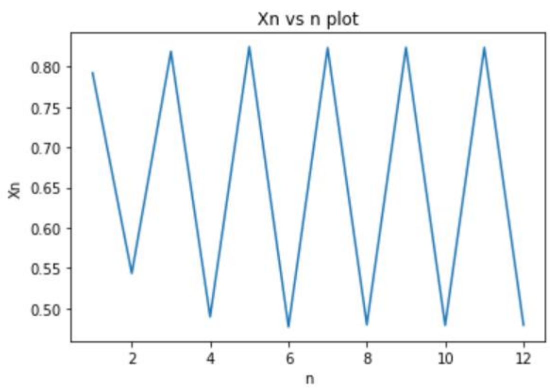
```python
import matplotlib.pyplot as plt

x = [1, 2, 3, 4, 5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28]
y=[ 0.252000,  0.527789,  0.697838,  0.590409,  0.677114,  0.612166,  0.664773,  0.623980,  0.656961,  0.631017,  0.651937,  0.635363,  0.648695,
plt.plot(x, y)
plt.xlabel('n')
plt.ylabel('Xn')
plt.title('Xn vs n plot')
plt.show()
```



3. Now consider $a = 3.3$, and run the program for $M = 50$, for any two different values of x_0. Plot the the values of x_n obtained in both the cases as a function of n.

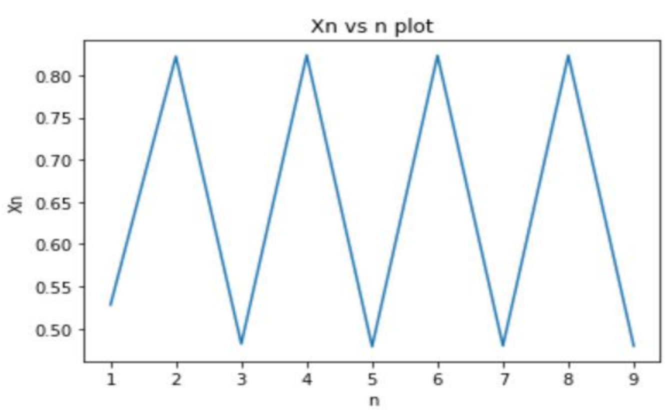
For Xo=0.4

```
import matplotlib.pyplot as plt
x = [1, 2, 3, 4, 5,6,7,8,9,10,11,12]
y=[0.792000,  0.543629,  0.818719,  0.489781,  0.824655,  0.477176,  0.823281,  0.480115,  0.823695,  0.479231,  0.823577,  0.479484]
plt.plot(x, y)
plt.xlabel('n')
plt.ylabel('Xn')
plt.title('Xn vs n plot')
plt.show()
```



For Xo=0.8

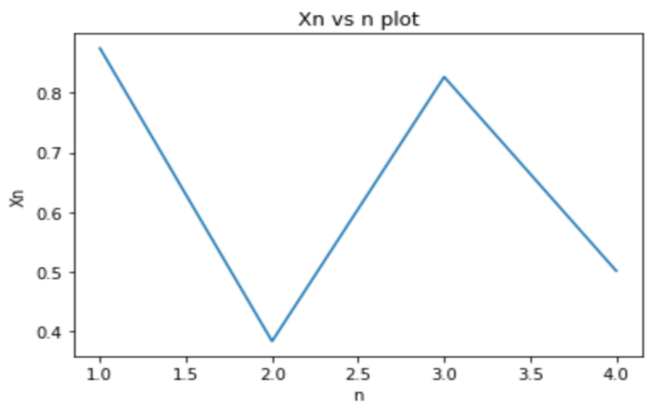
```
import matplotlib.pyplot as plt
x = [1, 2, 3, 4, 5,6,7,8,9]
y=[ 0.528000,  0.822413,  0.481965,  0.823927,  0.478736,  0.823508,  0.479631,  0.823631,  0.479368]
plt.plot(x, y)
plt.xlabel('n')
plt.ylabel('Xn')
plt.title('Xn vs n plot')
plt.show()
```



4. Now consider $a = 3.5$, and run the program for $M = 50$, for any two different values of x_0. Plot the the values of x_n obtained in both the cases as a function of n.

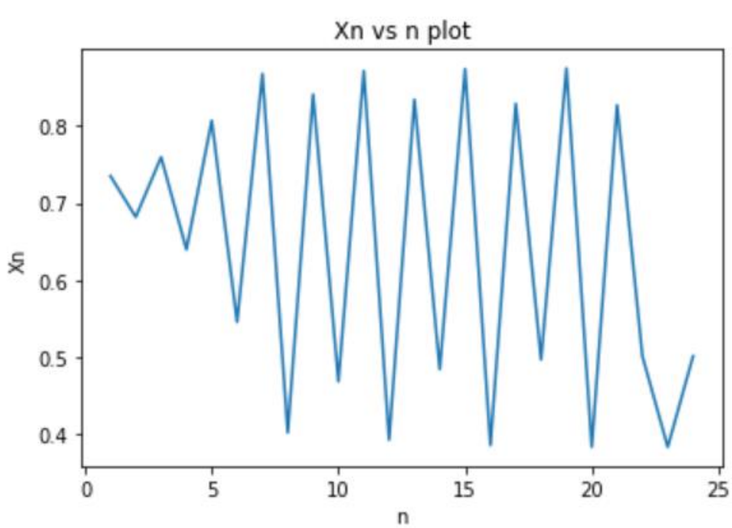
For Xo=0.5

```
D:\Cprogramming>cd "d:\Cprogramming\" && gcc errprop.c -o errprop && "d:\Cprogramming\"errprop
Enter the value of a (0 <= a <= 4): 3.5
Enter the value of Xo (0 <= Xo <= 1): 0.5
Enter the value of m: 50
 0.875000,  0.382813,  0.826935,  0.500898,
```



For Xo=0.7

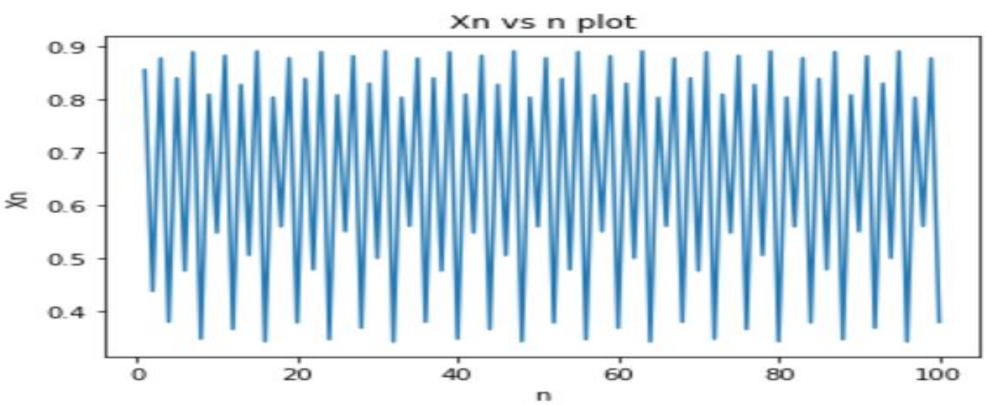
```
D:\Cprogramming>cd "d:\Cprogramming\" && gcc errprop.c -o errprop && "d:\Cprogramming\"errprop
Enter the value of a (0 <= a <= 4): 3.5
Enter the value of Xo (0 <= Xo <= 1): 0.7
Enter the value of m: 50
 0.735000,  0.681712,  0.759432,  0.639433,  0.806955,  0.545225,  0.867841,  0.401425,  0.840990,  0.468040,  0.871425,  0.392152,  0
.834291,  0.483873,  0.874090,  0.385199,  0.828873,  0.496450,  0.874956,  0.382928,  0.827030,  0.500680,  0.382817,  0.500890,
```



5. Now consider $a = 3.5690$, and run the program for $M = 100$, for any two different values of x_0. Plot the the values of x_n obtained in both the cases as a function of n.

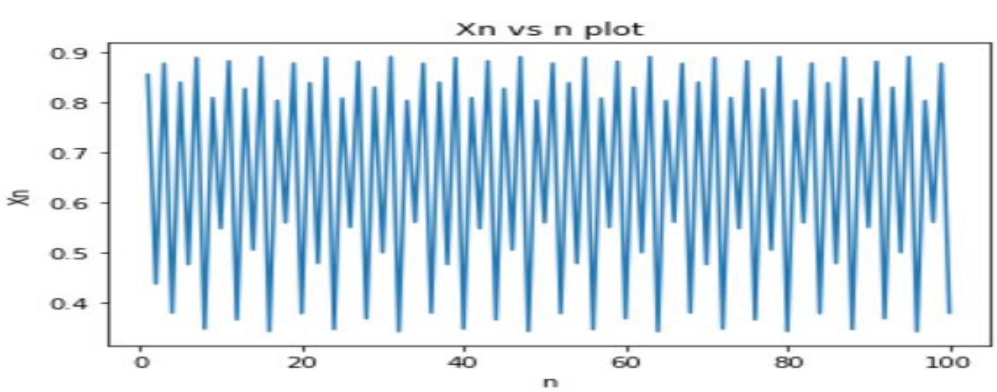
For Xo=0.4,a 3.5690,m=100

```
Enter the value of a (0 <= a <= 4): 3.5690
Enter the value of Xo (0 <= Xo <= 1): 0.4
Enter the value of m: 100
 0.856560,  0.438505,  0.878753,  0.380262,  0.841081,  0.477046,  0.890370,  0.348376,  0.810199,  0.548829,  0.883741,  0.366690,  0
.828824,  0.506352,  0.892106,  0.343527,  0.804867,  0.560534,  0.879172,  0.379130,  0.840108,  0.479411,  0.890737,  0.347351,  0.8
09087,  0.551287,  0.882862,  0.369094,  0.831090,  0.501014,  0.892246,  0.343134,  0.804428,  0.561489,  0.878756,  0.380255,  0.841
075,  0.477061,  0.890372,  0.348369,  0.810192,  0.548845,  0.883735,  0.366706,  0.828838,  0.506318,  0.892108,  0.343522,  0.80486
2,  0.560544,  0.879167,  0.379142,  0.840119,  0.479385,  0.890733,  0.347362,  0.809098,  0.551262,  0.882871,  0.369068,  0.831066,
  0.501070,  0.892246,  0.343135,  0.804429,  0.561486,  0.878757,  0.380252,  0.841072,  0.477068,  0.890373,  0.348366,  0.810188,
0.548853,  0.883732,  0.366713,  0.828845,  0.506301,  0.892108,  0.343520,  0.804860,  0.560549,  0.879165,  0.379148,  0.840124,  0.
479373,  0.890731,  0.347367,  0.809104,  0.551250,  0.882876,  0.369056,  0.831055,  0.501097,  0.892246,  0.343135,  0.804429,  0.56
1485,  0.878758,  0.380250,
```



For Xo=0.6,a=3.5690,m=100

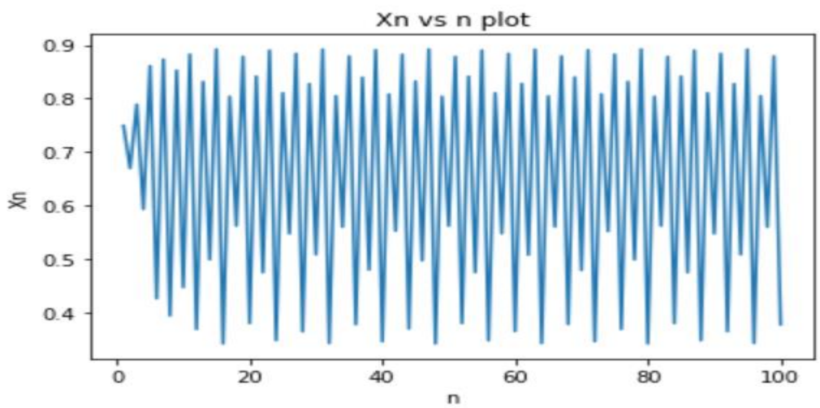
```
Enter the value of a (0 <= a <= 4): 3.5690
Enter the value of Xo (0 <= Xo <= 1): 0.6
Enter the value of m: 100
 0.856560,  0.438505,  0.878753,  0.380262,  0.841081,  0.477046,  0.890370,  0.348376,  0.810199,  0.548829,  0.88374
1,  0.366690,  0.828824,  0.506352,  0.892106,  0.343527,  0.804867,  0.560534,  0.879172,  0.379130,  0.840108,  0.47
9411,  0.890737,  0.347351,  0.809087,  0.551287,  0.882862,  0.369094,  0.831090,  0.501014,  0.892246,  0.343134,  0
.804428,  0.561489,  0.878756,  0.380255,  0.841075,  0.477061,  0.890372,  0.348369,  0.810192,  0.548845,  0.883735,
  0.366706,  0.828838,  0.506318,  0.892108,  0.343522,  0.804862,  0.560544,  0.879167,  0.379142,  0.840119,  0.4793
85,  0.890733,  0.347362,  0.809098,  0.551262,  0.882871,  0.369068,  0.831066,  0.501070,  0.892246,  0.343135,  0.8
04429,  0.561486,  0.878757,  0.380252,  0.841072,  0.477068,  0.890373,  0.348366,  0.810188,  0.548853,  0.883732,
0.366713,  0.828845,  0.506301,  0.892108,  0.343520,  0.804860,  0.560549,  0.879165,  0.379148,  0.840124,  0.479373
,  0.890731,  0.347367,  0.809104,  0.551250,  0.882876,  0.369056,  0.831055,  0.501097,  0.892246,  0.343135,  0.804
429,  0.561485,  0.878758,  0.380250,
```



6. Now consider $a = 3.5697$, and run the program for $M = 100$, for any two different values of x_0. Plot the the values of x_n obtained in both the cases as a function of n.

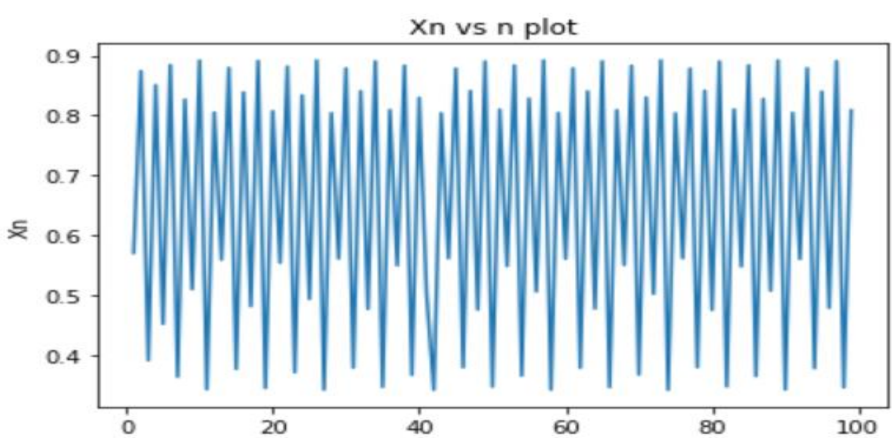
Xo=0.3, a=3.5697, m=100

```
D:\Cprogramming>cd "d:\Cprogramming\" && gcc errprop.c -o errprop && "d:\Cprogramming\"errprop
Enter the value of a (0 <= a <= 4): 3.5697
Enter the value of Xo (0 <= Xo <= 1): 0.3
Enter the value of m: 100
 0.749637,  0.669966,  0.789302,  0.593657,  0.861113,  0.426928,  0.873364,  0.394806,  0.852923,  0.447802,  0.882699,  0.369613,  0
.831737,  0.499581,  0.892424,  0.342702,  0.804101,  0.562307,  0.878567,  0.380842,  0.841740,  0.475534,  0.890288,  0.348671,  0.8
10677,  0.547877,  0.884243,  0.365386,  0.827739,  0.508994,  0.892136,  0.343509,  0.805005,  0.560342,  0.879427,  0.378513,  0.839
740,  0.480400,  0.891054,  0.346536,  0.808354,  0.553009,  0.882394,  0.370444,  0.832509,  0.497751,  0.892407,  0.342751,  0.80415
6,  0.562188,  0.878620,  0.380699,  0.841618,  0.475831,  0.890340,  0.348527,  0.810522,  0.548221,  0.884125,  0.365710,  0.828050,
  0.508266,  0.892181,  0.343384,  0.804865,  0.560647,  0.879295,  0.378871,  0.840049,  0.479648,  0.890946,  0.346835,  0.808682,
0.552288,  0.882665,  0.369704,  0.831822,  0.499379,  0.892424,  0.342704,  0.804104,  0.562302,  0.878569,  0.380835,  0.841735,  0.
475547,  0.890290,  0.348665,  0.810670,  0.547892,  0.884238,  0.365400,  0.827752,  0.508963,  0.892138,  0.343504,  0.804999,  0.56
0356,  0.879421,  0.378529,
```



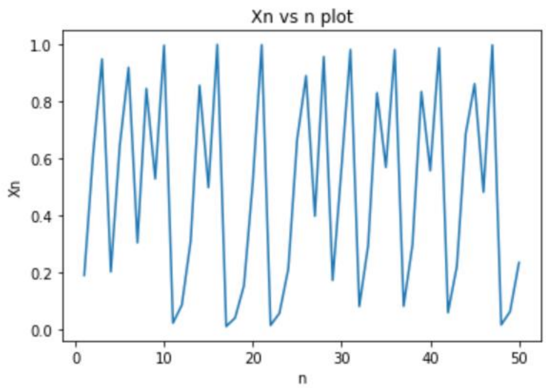
Xo=0.8, a=3.5697, m=100

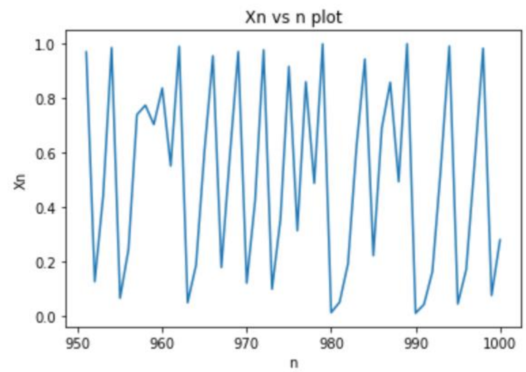
```
D:\Cprogramming>cd "d:\Cprogramming\" && gcc errprop.c -o errprop && "d:\Cprogramming\"errprop
Enter the value of a (0 <= a <= 4): 3.5697
Enter the value of Xo (0 <= Xo <= 1): 0.8
Enter the value of m: 100
 0.571152,  0.874353,  0.392167,  0.850916,  0.452844,  0.884487,  0.364715,  0.827092,  0.510505,  0.892031,  0.343804,  0.8053
.559626,  0.879734,  0.377682,  0.839017,  0.482151,  0.891288,  0.345882,  0.807636,  0.554588,  0.881788,  0.372099,  0.834029
94133,  0.892302,  0.343045,  0.804486,  0.561473,  0.878935,  0.379845,  0.840888,  0.477609,  0.890635,  0.347703,  0.809628,
199,  0.883429,  0.367614,  0.829862,  0.504009,  0.342861,  0.804280,  0.561920,  0.878739,  0.380377,  0.841344,  0.476499,  0
3,  0.348210,  0.810179,  0.548981,  0.883861,  0.366433,  0.828741,  0.506644,  0.892267,  0.343142,  0.804595,  0.561236,  0.8
  0.379564,  0.840647,  0.478196,  0.890728,  0.347445,  0.809347,  0.550820,  0.883206,  0.368227,  0.830440,  0.502647,  0.892
0.342771,  0.804178,  0.562141,  0.878641,  0.380642,  0.841569,  0.475949,  0.890360,  0.348470,  0.810460,  0.548357,  0.88407
365839,  0.828173,  0.507977,  0.892198,  0.343337,  0.804813,  0.560762,  0.879246,  0.379005,  0.840165,  0.479367,  0.890905,
6950,  0.808807,
```



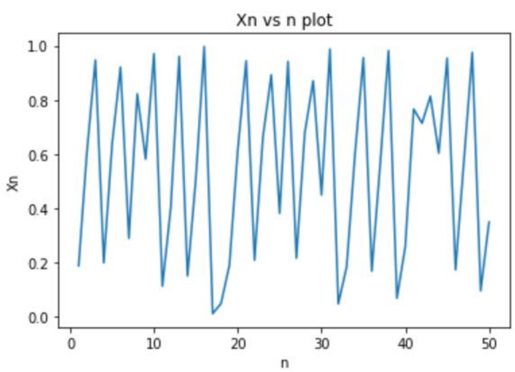
7. Take the value of $a = 3.99$, and run the program for $M = 1000$, for any two different values of $x_0 = 0.95$ and $x_0 = 0.95005$. Plot the first 50 and last 50 values of x_n obtained in both the cases as a function of n.

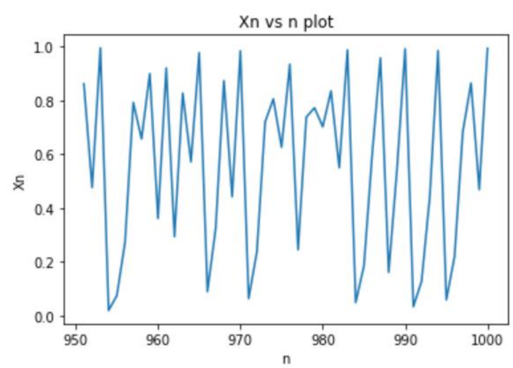
For a=3.99, Xo=0.95, m=1000, first 50 on left and last 50 on right





For a=3.99, Xo=0.95005, m=1000, first 50 on left and last 50 on right





8. Now using provision of the program create a plot of the saved values of x_n (as discussed in 1) as a function of a starting from $a = 0.7$ untill $a = 3.99$.

```
import numpy as np
import matplotlib.pyplot as plt
import matplotlib.cm as cm
%matplotlib inline

last = round(0.8*iters)
n_pixels = 3000
Zx = np.linspace(x_min, x_max, n_pixels)
y = np.repeat(y_ini, n_pixels)
for i in range(iters):
```

```
    y = Zx*y*(1-y)
    if i >= (iters-last):
        if i == (iters-last):
            D = np.array([Zx, y]).T
        else: D = np.concatenate([D,np.array([Zx, y]).T], axis = 0)
X = D[:,0]
Y = D[:,1]

fig, ax = plt.subplots(figsize=(10, 10),
                dpi=300,
                facecolor='steelblue',
                edgecolor='none'
               )
plt.axis('off')
ax.set_xlim(x_min, x_max)
ax.set_ylim(y_min, y_max)
plt.gca().set_axis_off()
plt.subplots_adjust(top = 1, bottom = 0, right = 1, left = 0, hspace = 0, wspace = 0)
plt.margins(0,0)
plt.gca().xaxis.set_major_locator(plt.NullLocator())
plt.gca().yaxis.set_major_locator(plt.NullLocator())

plt.scatter(X,Y
        ,s = (3*72/n_pixels)**2
        ,alpha = 0.8
        ,c = 'darkred'
        ,marker = '.'
       )
```