**Exercise 11. Answer Sheet**

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***Problem 1.***  (40 points) Consider constructing a random number generator for integers from 1 to 6 using the simplest linear congruential method.

a) What is the equation of this generator? x­i+1 = (A \* xi) mod 7

b) Which values of the parameter A ∈ [1, 6] give the longest sequence?

**3** and **5** gives the longest sequence.

The sequence of 3 is “3, 2, 6, 4, 5, 1”

The sequence of 5 is “5, 4, 6, 2, 3 ,1”

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First, x0 = 1

When A = 1:

x1 = (1 \* 1) mod 7 = 1 mod 7 = 1

x2 = (1 \* 1) mod 7 = 1 mod 7 = 1

x3 = (1 \* 1) mod 7 = 1 mod 7 = 1

x4 = (1 \* 1) mod 7 = 1 mod 7 = 1

x5 = (1 \* 1) mod 7 = 1 mod 7 = 1

x6 = (1 \* 1) mod 7 = 1 mod 7 = 1

When A = 2:

x1 = (2 \* 1) mod 7 = 2 mod 7 = 2

x2 = (2 \* 2) mod 7 = 4 mod 7 = 4

x3 = (2 \* 4) mod 7 = 8 mod 7 = 1

x4 = (2 \* 1) mod 7 = 2 mod 7 = 2

x5 = (2 \* 2) mod 7 = 4 mod 7 = 4

x6 = (2 \* 4) mod 7 = 8 mod 7 = 1

When A = 3:

x1 = (3 \* 1) mod 7 = 3 mod 7 = 3

x2 = (3 \* 3) mod 7 = 9 mod 7 = 2

x3 = (3 \* 2) mod 7 = 6 mod 7 = 6

x4 = (3 \* 6) mod 7 = 18 mod 7 = 4

x5 = (3 \* 4) mod 7 = 12 mod 7 = 5

x6 = (3 \* 5) mod 7 = 15 mod 7 = 1

When A = 4:

x1 = (4 \* 1) mod 7 = 4 mod 7 = 4

x2 = (4 \* 4) mod 7 = 16 mod 7 = 2

x3 = (4 \* 2) mod 7 = 8 mod 7 = 1

x4 = (4 \* 1) mod 7 = 4 mod 7 = 4

x5 = (4 \* 4) mod 7 = 16 mod 7 = 2

x6 = (4 \* 2) mod 7 = 8 mod 7 = 1

When A = 5:

x1 = (5 \* 1) mod 7 = 5 mod 7 = 5

x2 = (5 \* 5) mod 7 = 25 mod 7 = 4

x3 = (5 \* 4) mod 7 = 20 mod 7 = 6

x4 = (5 \* 6) mod 7 = 30 mod 7 = 2

x5 = (5 \* 2) mod 7 = 10 mod 7 = 3

x6 = (5 \* 3) mod 7 = 15 mod 7 = 1

When A = 6:

x1 = (6 \* 1) mod 7 = 6 mod 7 = 6

x2 = (6 \* 6) mod 7 = 36 mod 7 = 1

x3 = (6 \* 1) mod 7 = 6 mod 7 = 6

x4 = (6 \* 6) mod 7 = 36 mod 7 = 1

x5 = (6 \* 1) mod 7 = 6 mod 7 = 6

x6 = (6 \* 6) mod 7 = 36 mod 7 = 1

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***Problem 2.*** (60 points)Write a program implementing the 3 algorithms from the lecture. Upload your code.

a) (20 points) Fill the following table with the first 5 random numbers generated by each of the algorithms?

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 |
| Rand1 | 1688960045 | 707878749 | 1576208621 | 583533981 | 1844902829 |
| Rand2 | 48271 | 182605794 | 1291394886 | 1914720637 | 2078669041 |
| Rand2 | 890394181 | 479799993 | 1961812856 | 1081941947 | 1764863974 |

b) (40 points) Generate N = {10, 1000, 1000000} real random numbers in the interval (0.0, 1.0) using each algorithm. Calculate the histogram of the number distribution (**in %**) for 10 intervals and fill the table:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| N | 0.0-0.1 | 0.1-0.2 | 0.2-0.3 | 0.3-0.4 | 0.4-0.5 | 0.5-0.6 | 0.6-0.7 | 0.7-0.8 | 0.8-0.9 | 0.9-1.0 |
| Rand1 | | | | | | | | | | |
| 10 | 0 | 10 | 10 | 30 | 0 | 10 | 10 | 20 | 10 | 0 |
| 1000 | 8.8 | 8.4 | 11.1 | 10.4 | 11.9 | 11.0 | 9.1 | 11.0 | 9.8 | 8.5 |
| 1000000 | 10.01 | 9.97 | 10.03 | 9.95 | 9.96 | 10.08 | 10.03 | 10.01 | 9.98 | 9.98 |
| Rand2 | | | | | | | | | | |
| 10 | 20 | 10 | 10 | 10 | 0 | 10 | 10 | 10 | 10 | 10 |
| 1000 | 9.9 | 10.7 | 9.4 | 10.0 | 9.4 | 9.8 | 10.6 | 10.9 | 9.0 | 10.3 |
| 1000000 | 10.00 | 10.02 | 10.00 | 9.98 | 10.04 | 10.04 | 9.96 | 10.01 | 9.98 | 9.98 |
| Rand3 | | | | | | | | | | |
| 10 | 10 | 10 | 10 | 0 | 20 | 10 | 0 | 0 | 30 | 10 |
| 1000 | 11.7 | 9.6 | 9.6 | 11.0 | 10.8 | 9.6 | 10.4 | 8.2 | 9.4 | 9.7 |
| 1000000 | 9.96 | 10.00 | 9.98 | 10.02 | 10.04 | 10.02 | 9.93 | 9.98 | 10.02 | 10.04 |

<How to compile/run>

Command:

javac LinearCongruentialGenerator.java

java LinearCongruentialGenerator

Then it automatically output the answer of this problem 2.

