

# 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?

The equation of this generator is:

$$x_{i+1} = (A * x_i) \bmod M$$

For  $M = 7$

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

The value of parameter  $A$  give the longest sequence is  $A = 5$

**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
Rand3	890394181	479799993	1961812856	1081941947	1764863974

The implementation of the program is on the file randCount.cpp (remember to modify the main() to satisfy the requests of problem a)

To compile and run the program, run the following command lines:

```
g++ -std=c++11 -o randCount randCount.cpp
./rand
```

The output will be:

```
week11 — -bash — 80x9
[(base) wlan-napt-003:week11 thoatran$ g++ -std=c++11 -o randCount randCount.cpp ]
[(base) wlan-napt-003:week11 thoatran$ ./randCount ]
Rand1 algorithm:
1688960045    707878749    1576208621    583533981    1844902829
Rand2 algorithm:
48271        182605794    1291394886    1914720637    2078669041
Rand3 algorithm:
890394181    479799993    1961812856    1081941947    1764863974
(base) wlan-napt-003:week11 thoatran$
```

b) (40 points) Generate  $N = \{10, 1000, 1000000\}$  real random numbers in the interval (0.0, 1.0) using each algorithm. Make a program to calculate a histogram of the number distribution (in %) for 10 intervals and fill the table (upload your code):

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	0.1	0.1	0.3	0	0.1	0.1	0.2	0.1	0
1000										
1000000										
Rand2										
10	0.2	0.1	0.1	0.1	0	0.1	0.1	0.1	0.1	0.1
1000	0.099	0.107	0.094	0.1	0.094	0.098	0.106	0.109	0.09	0.103
1000000	0.0998653	0.100075	0.0999122	0.997315	0.100249	0.100279	0.0994809	0.0999861	0.0997085	0.0996457
Rand3										
10	0.1	0.1	0.1	0	0.2	0.1	0	0	0.3	0.1
1000	0.118	0.099	0.094	0.116	0.102	0.098	0.1	0.086	0.094	0.093
1000000	0.0995548	0.100202	0.100085	0.0998553	0.0997235	0.0994989	0.09941	0.100248	0.0998094	0.100546

The implementation of the program is on the file randCount.cpp (remember to modify the main() to satisfy the requests of problem b and change the value of n equals to 10, 1000, 1000000 respectively before running)

To compile and run the program, run the following command lines:

```
g++ -std=c++11 -o randCount randCount.cpp
./randCount
```

For N = 10, we have the output:

```

week11 — -bash — 80x40
(base) Thoas-MacBook-Pro:week11 thoatran$ g++ -std=c++11 -o randCount randCount.
cpp
(base) Thoas-MacBook-Pro:week11 thoatran$ ./randCount
Rand1:
The appearance frequency:
0.0 - 0.1: 0
0.1 - 0.2: 0.1
0.2 - 0.3: 0.1
0.3 - 0.4: 0.3
0.4 - 0.5: 0
0.5 - 0.6: 0.1
0.6 - 0.7: 0.1
0.7 - 0.8: 0.2
0.8 - 0.9: 0.1
0.9 - 1.0: 0
Rand2:
The appearance frequency:
0.0 - 0.1: 0.2
0.1 - 0.2: 0.1
0.2 - 0.3: 0.1
0.3 - 0.4: 0.1
0.4 - 0.5: 0
0.5 - 0.6: 0.1
0.6 - 0.7: 0.1
0.7 - 0.8: 0.1
0.8 - 0.9: 0.1
0.9 - 1.0: 0.1
Rand 3:
The appearance frequency:
0.0 - 0.1: 0.1
0.1 - 0.2: 0.1
0.2 - 0.3: 0.1
0.3 - 0.4: 0
0.4 - 0.5: 0.2
0.5 - 0.6: 0.1
0.6 - 0.7: 0
0.7 - 0.8: 0
0.8 - 0.9: 0.3
0.9 - 1.0: 0.1
(base) Thoas-MacBook-Pro:week11 thoatran$

```

For  $N = 1000$ , we have the output:

```
week11 — -bash — 80x40
(base) Thoas-MacBook-Pro:week11 thoatran$ g++ -std=c++11 -o randCount randCount.
cpp
(base) Thoas-MacBook-Pro:week11 thoatran$ ./randCount
Rand1:
The appearance frequency:
0.0 - 0.1: 0.088
0.1 - 0.2: 0.084
0.2 - 0.3: 0.111
0.3 - 0.4: 0.104
0.4 - 0.5: 0.119
0.5 - 0.6: 0.11
0.6 - 0.7: 0.091
0.7 - 0.8: 0.11
0.8 - 0.9: 0.098
0.9 - 1.0: 0.085
Rand2:
The appearance frequency:
0.0 - 0.1: 0.099
0.1 - 0.2: 0.107
0.2 - 0.3: 0.094
0.3 - 0.4: 0.1
0.4 - 0.5: 0.094
0.5 - 0.6: 0.098
0.6 - 0.7: 0.106
0.7 - 0.8: 0.109
0.8 - 0.9: 0.09
0.9 - 1.0: 0.103
Rand 3:
The appearance frequency:
0.0 - 0.1: 0.118
0.1 - 0.2: 0.099
0.2 - 0.3: 0.094
0.3 - 0.4: 0.116
0.4 - 0.5: 0.102
0.5 - 0.6: 0.098
0.6 - 0.7: 0.1
0.7 - 0.8: 0.086
0.8 - 0.9: 0.094
0.9 - 1.0: 0.093
(base) Thoas-MacBook-Pro:week11 thoatran$
```

For  $N = 1000000$ , the output will be:

```
week11 — -bash — 80x40
(base) Thoas-MacBook-Pro:week11 thoatran$ g++ -std=c++11 -o randCount randCount.
cpp
(base) Thoas-MacBook-Pro:week11 thoatran$ ./randCount
Rand1:
The appearance frequency:
0.0 - 0.1: 0.10002
0.1 - 0.2: 0.0995618
0.2 - 0.3: 0.100225
0.3 - 0.4: 0.099427
0.4 - 0.5: 0.0995139
0.5 - 0.6: 0.100717
0.6 - 0.7: 0.100163
0.7 - 0.8: 0.0999522
0.8 - 0.9: 0.0996936
0.9 - 1.0: 0.0996596
Rand2:
The appearance frequency:
0.0 - 0.1: 0.0998653
0.1 - 0.2: 0.100075
0.2 - 0.3: 0.0999122
0.3 - 0.4: 0.0997315
0.4 - 0.5: 0.100249
0.5 - 0.6: 0.100279
0.6 - 0.7: 0.0994809
0.7 - 0.8: 0.0999861
0.8 - 0.9: 0.0997085
0.9 - 1.0: 0.0996457
Rand 3:
The appearance frequency:
0.0 - 0.1: 0.0995548
0.1 - 0.2: 0.100202
0.2 - 0.3: 0.100085
0.3 - 0.4: 0.0998553
0.4 - 0.5: 0.0997235
0.5 - 0.6: 0.0994989
0.6 - 0.7: 0.09941
0.7 - 0.8: 0.100248
0.8 - 0.9: 0.0998094
0.9 - 1.0: 0.100546
(base) Thoas-MacBook-Pro:week11 thoatran$
```