MA 323 : MONTE CARLO SIMULATION

LAB 5

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BOX-MULLER METHOD AND MARSAGLIA & BRAY METHOD

QUESTION-1

a) A total of four plots were generated for each of the methods.

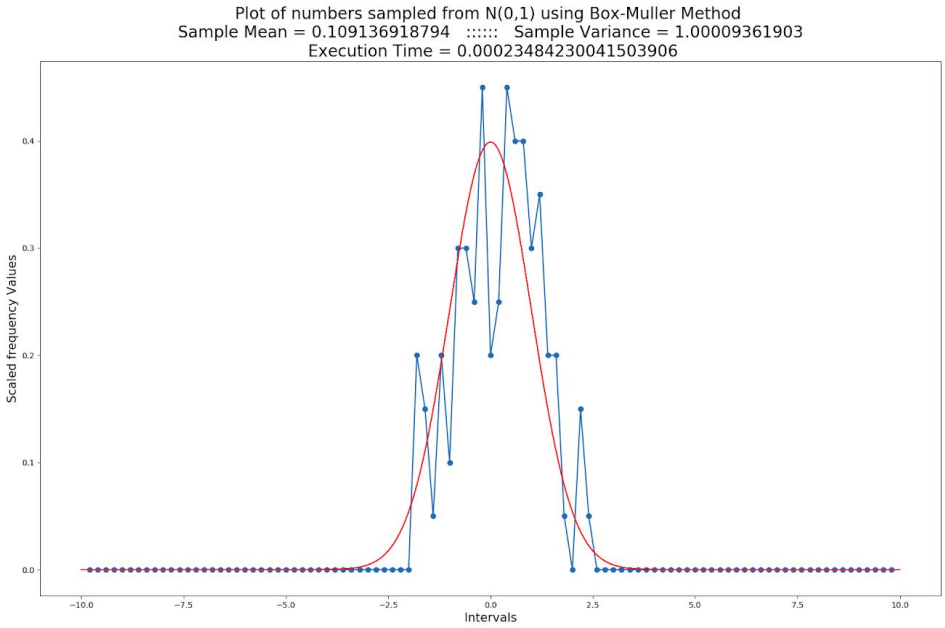
In each case it is found that as the number of rounds in Simulation increases the sample mean and variance converge to mean and variance of normal density from which it is sampled.

NOTE: Exact value of sample mean and sample variance are given on plot.

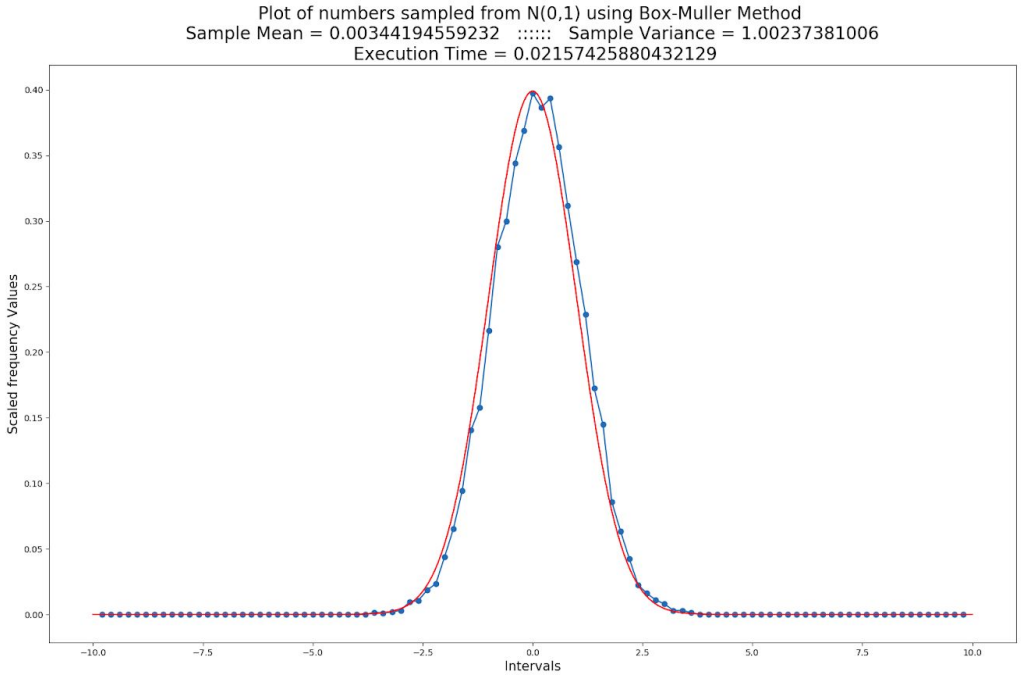
b) The plots are as follows:

BOX-MULLER METHOD

1. **Number of Generated Numbers = 100**

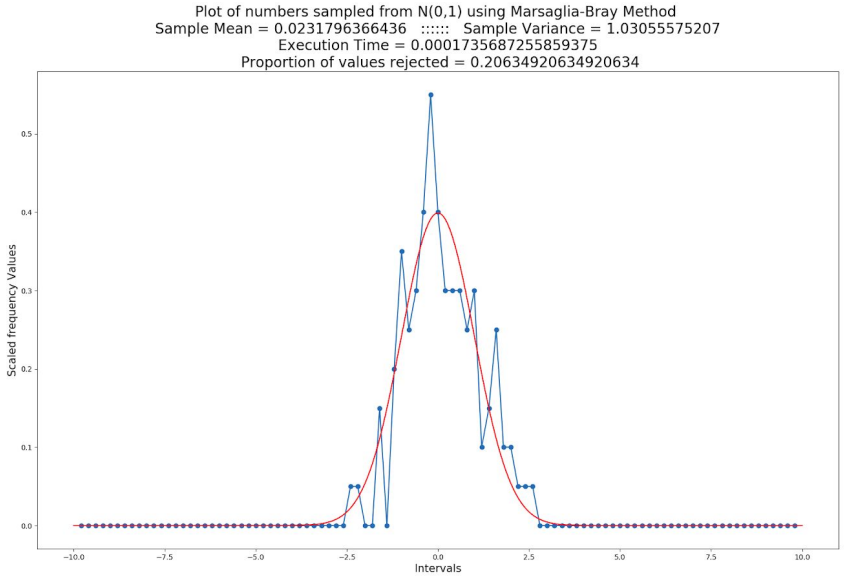


2. Number of Generated Numbers = 10000

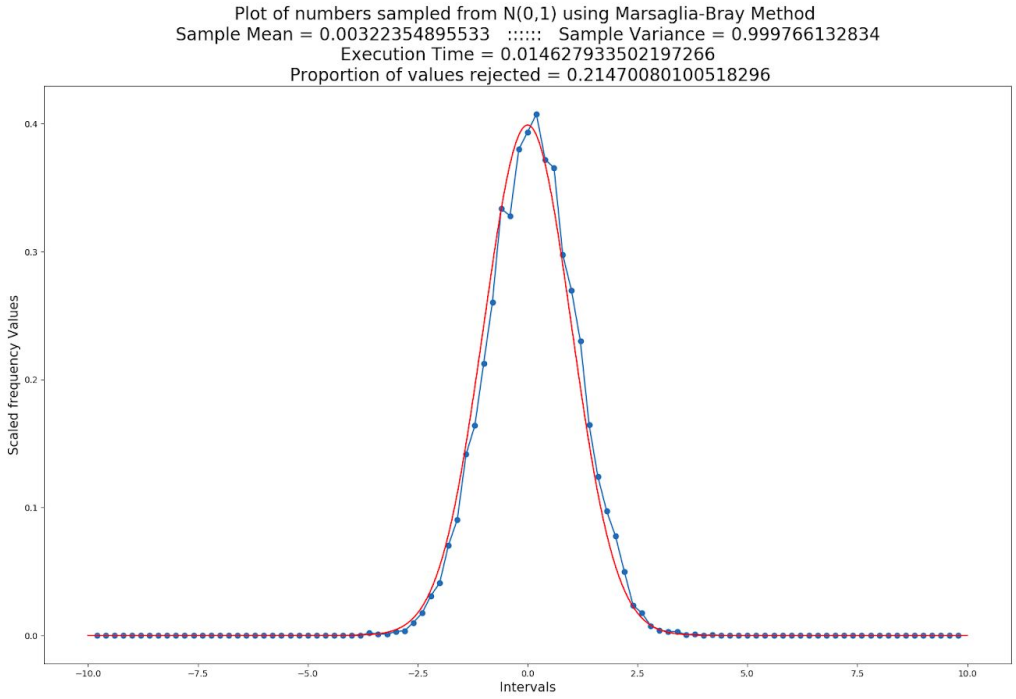


MARSAGLIA-BRAY METHOD

1. Number of Generated Numbers = 100



2. **Number of Generated Numbers = 10000**



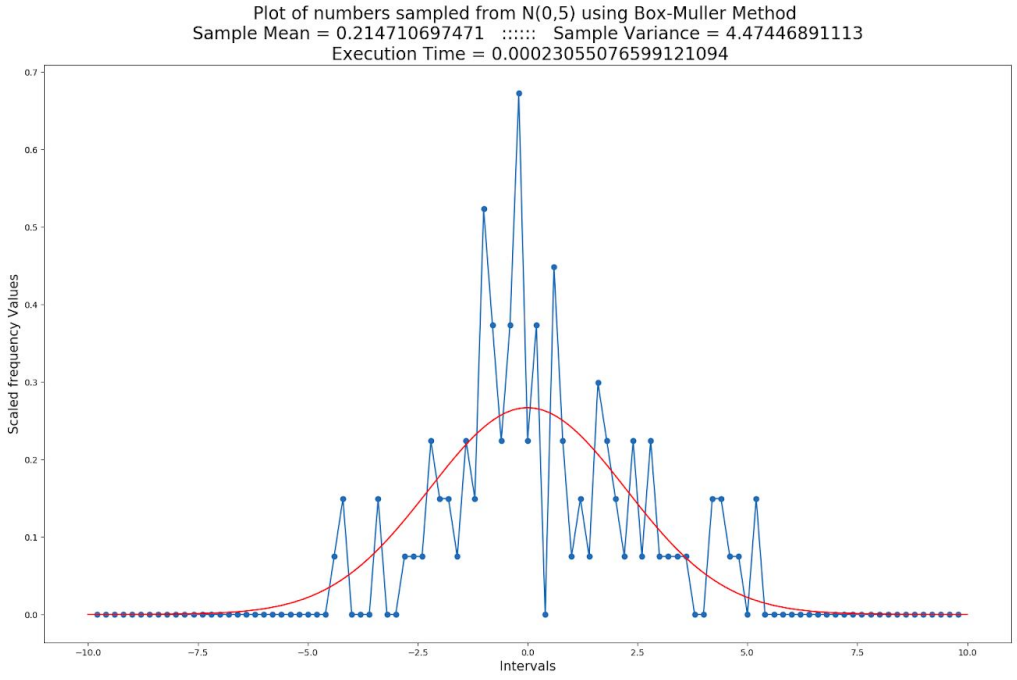
c) To generate sample from **N(mu, sigma^2)** we use **X = sigma*Z + mu** where **Z ~ N(0,1)**.

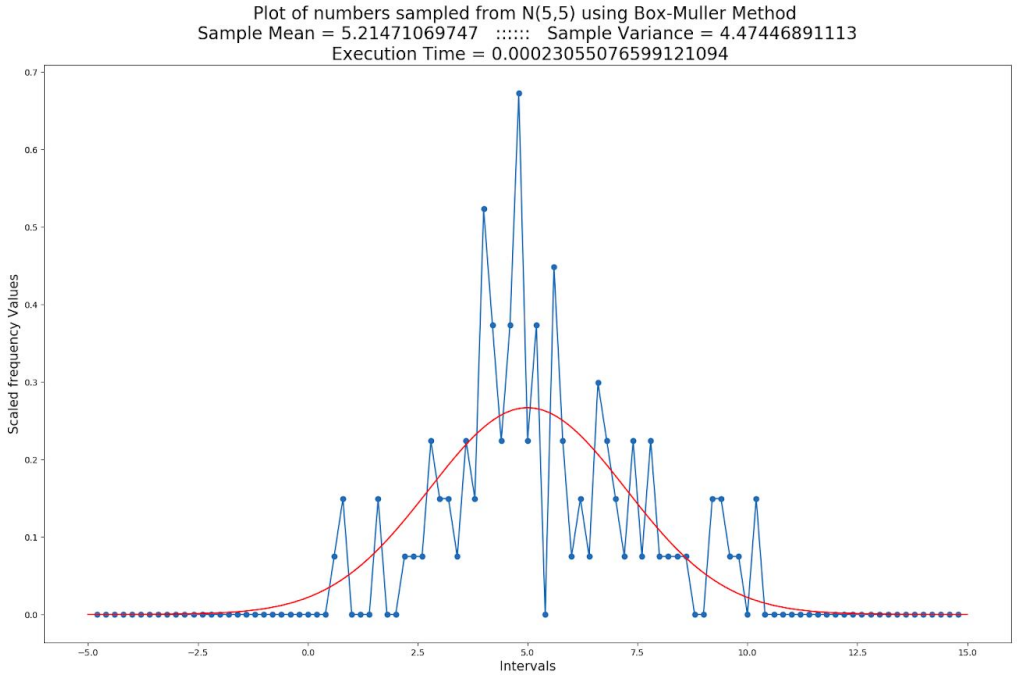
Here we can observe that for 100 numbers generated, the plot has the approximate shape of respective Normal densities but the frequency values are pretty random. However as the number of rounds in simulation increases, the frequency plot tends towards the density function of **N(mu, sigma^2)** i.e. the two plots overlap**.**

Also in case of **N(0,5) and N(5,5)** we are just shifting the plot along the X-axis. So the shape of the plot remains the same.

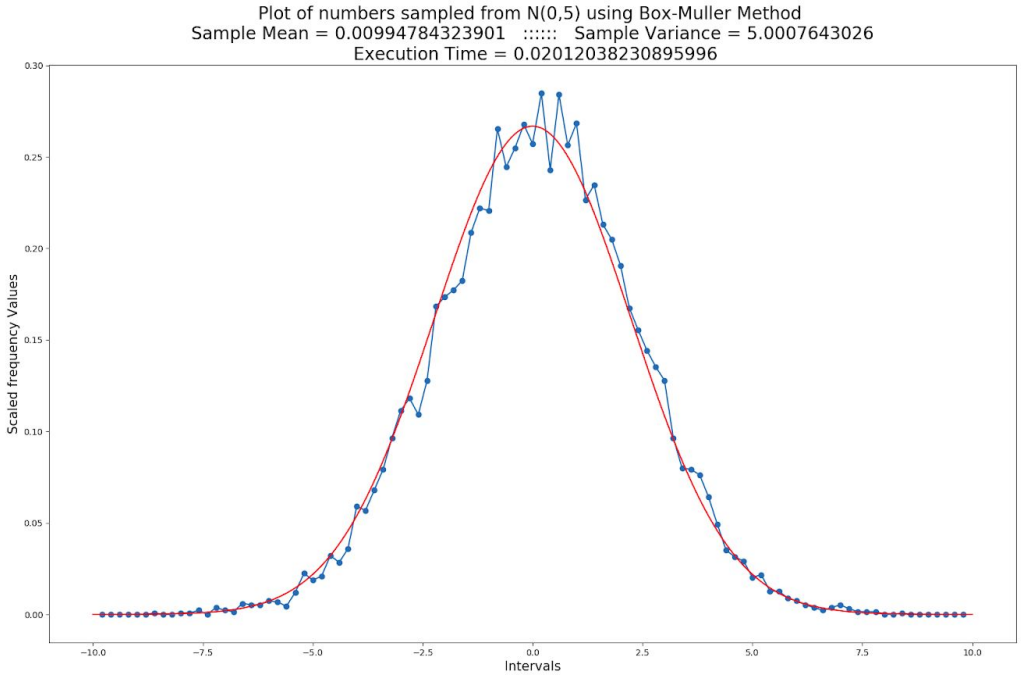
<u>Box-Muller Method</u>

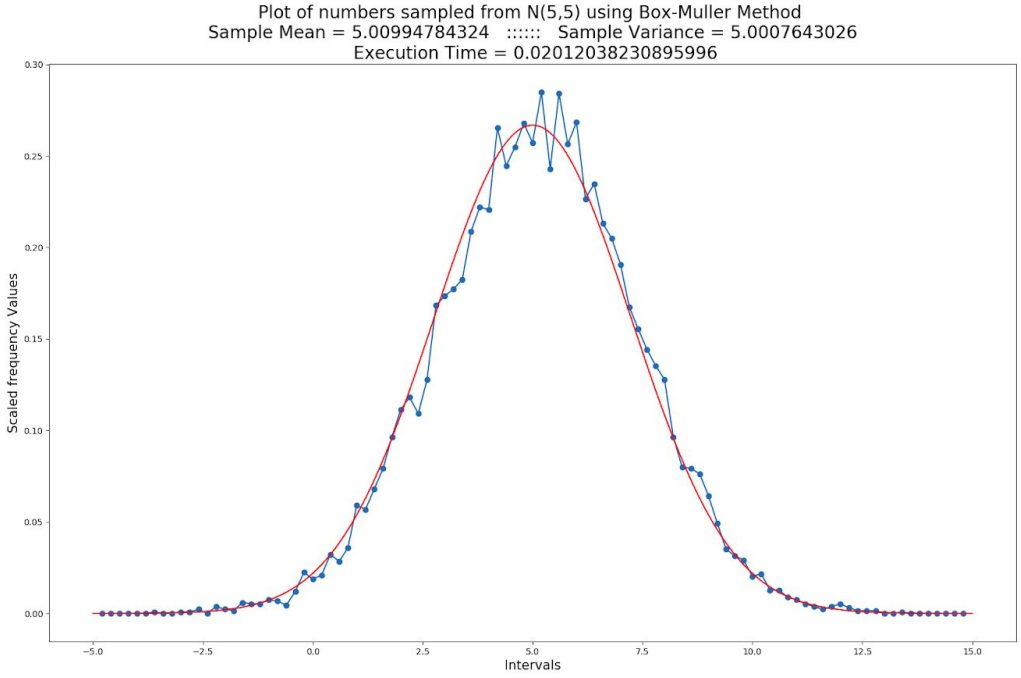
1. **Number of Generated Numbers = 100**


Plot of numbers sampled from N(0,5) using Box-Muller Method
Sample Mean = 0.214710697471 :::::: Sample Variance = 4.47446891113
Execution Time = 0.00023055076599121094
Scaled frequency Values
Intervals


Plot of numbers sampled from N(5,5) using Box-Muller Method
Sample Mean = 5.21471069747 :::::: Sample Variance = 4.47446891113
Execution Time = 0.00023055076599121094
Scaled frequency Values
Intervals

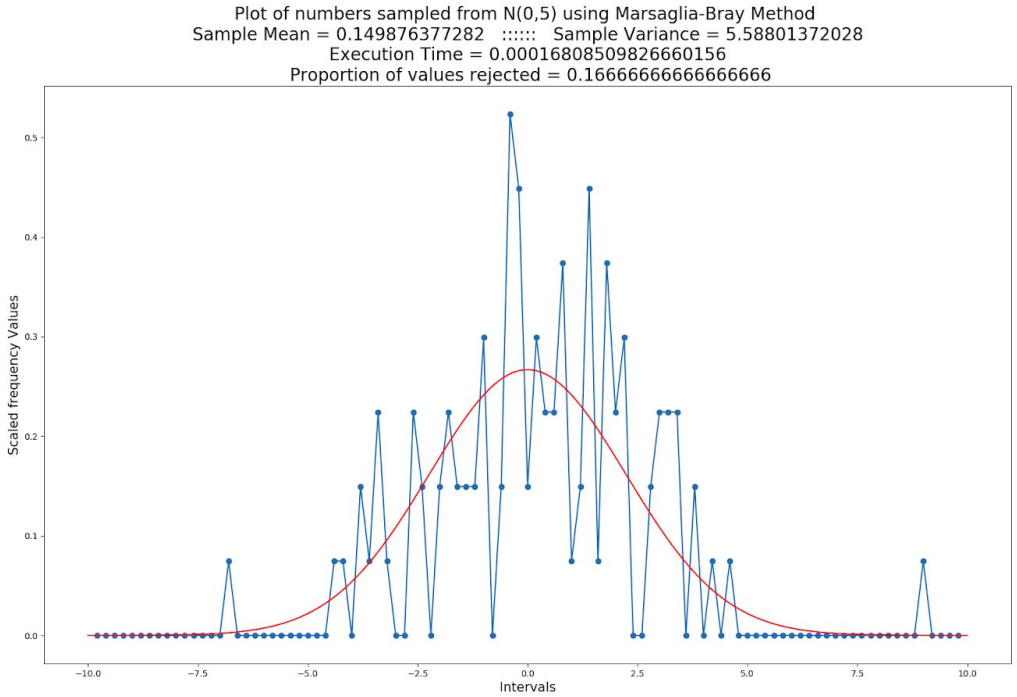
2. Number of Generated Numbers = 10000

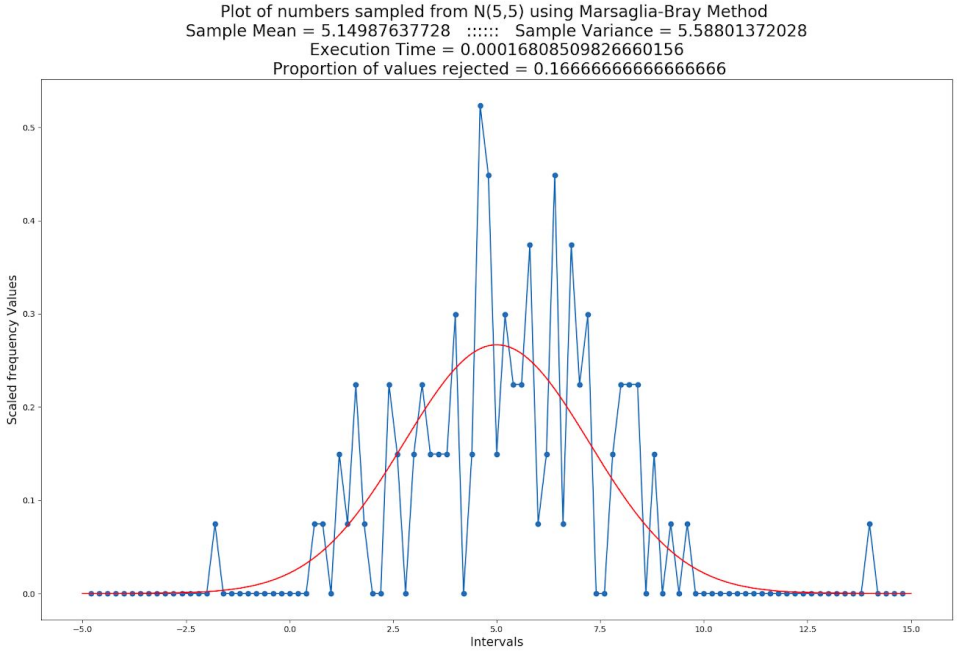




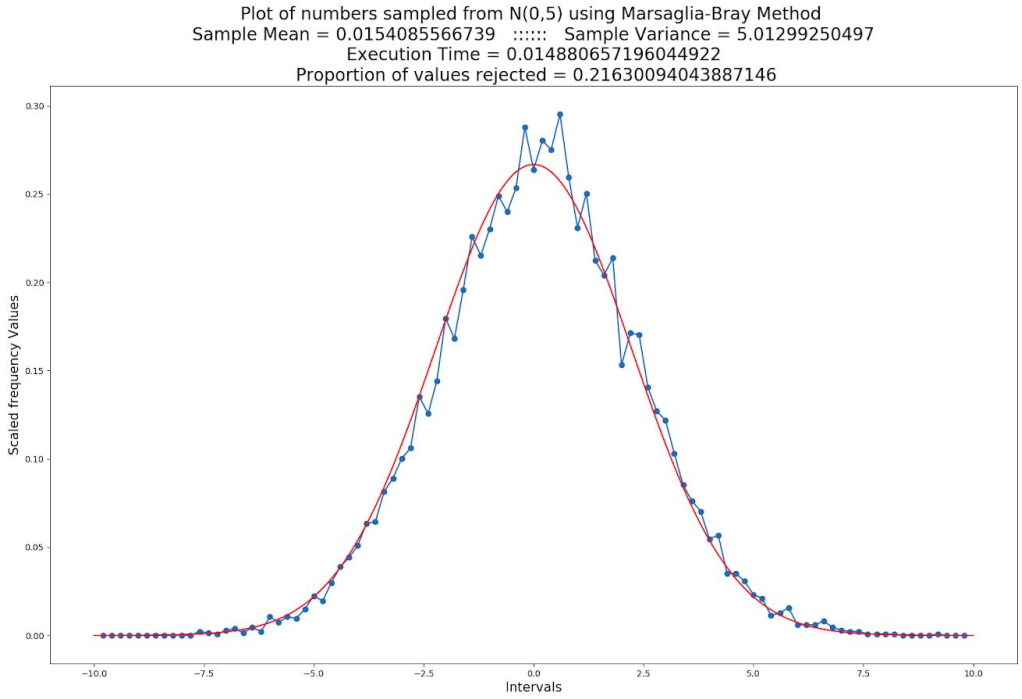
Marsaglia-Bray Method

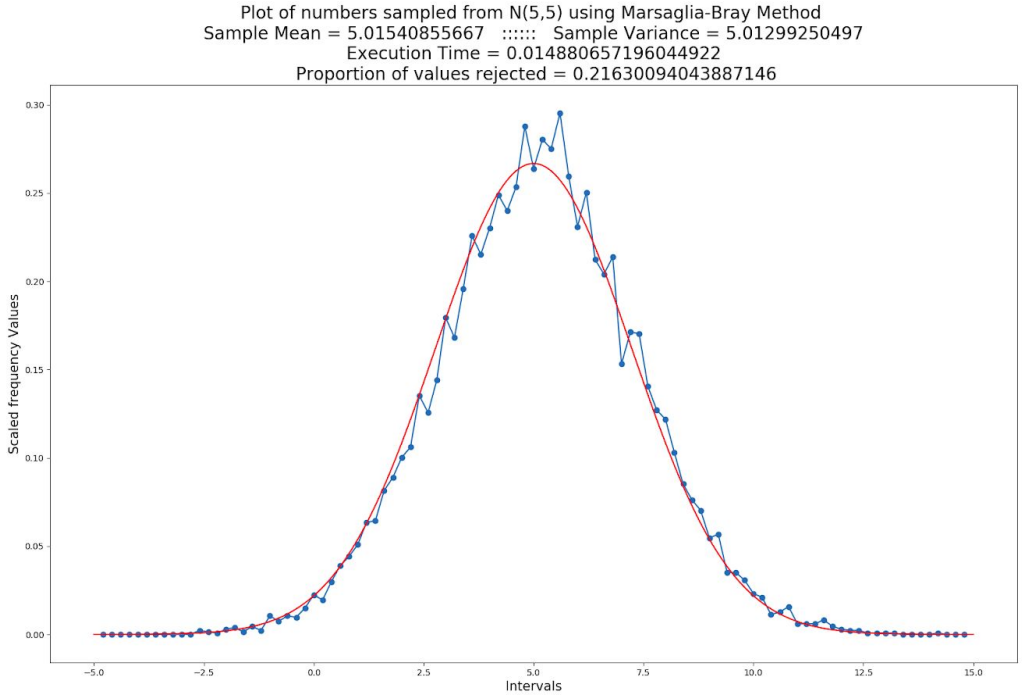
1. Number of Generated Numbers = 100





2. Number of Generated Numbers = 10000





QUESTION-2

On tracking the computation times for both the methods, we get that the Box-Muller Method is slower than the Marsaglia-Bray Method. The computation times are as follows:

1. **Box-Muller Method**
    - **100 numbers :** 0.00023
    - **10000 numbers :** 0.0215
2. **Marsaglia-Bray**
    - **100 numbers :** 0.0001735
    - **10000 numbers :** 0.01462

As expected the computation time for the Marsaglia-Bray method is less than that of the Box-Muller method because of the overhead involved in evaluating Sin and Cos values is greater than time taken by while loop in Marsaglia-Bray method.

QUESTION-3

The value of **1 - (pi/4) = 0.214601836...**

Area of Square = 2x2 = 4 sq. units.

Area of unit circle = pi x $(1)^2$ = pi sq. units.

Now **chance that a generated number is accepted** = Area of circle/Area of square = pi/4

Chance of getting rejected = **1 - (pi/4)**

Also on tracking this value while generating the samples, we get that the proportion of values rejected is around 0.214 i.e. as the number of rounds in simulation increases this value approaches the value of 1-(pi/4).

NOTE: See graph for exact value.