EE5193: Wireless Communication Lab

Lab sheet. No: 01

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Q1. Generate N random numbers which are uniformly distributed in the interval [−2, 2]by using in-built command in MATLAB. Write a function to plot a histogram of these numbers (without using the in-built histogram command of MATLAB). Your function should take N random numbers as input and give a histogram plot of these numbers. Compare your histogram plot with the plot generated by the in-built MATLAB command. Run the program for different values of N = 10, 100, 10000 and comment on the change in histogram. Use the histfit command which fits a curve to histogram and comment on the observation.

AIM: To generate 'n' random uniformly distributed in the interval [-2 2] without using in-built command for different values of N and compare the plot with histogram command.

Short Theory:

Histograms can give bar plot for numeric data that group the data into bins.by using histogram command we can easily visualise the generated numerical data follows which distribution.

Histfit is command in MATLAB that generated histogram plot for numerical data set and fits a normal density function.

Key Commands:

bar % creates a bar graph

histogram % creates bar plot for numeric data that group the data into bins.

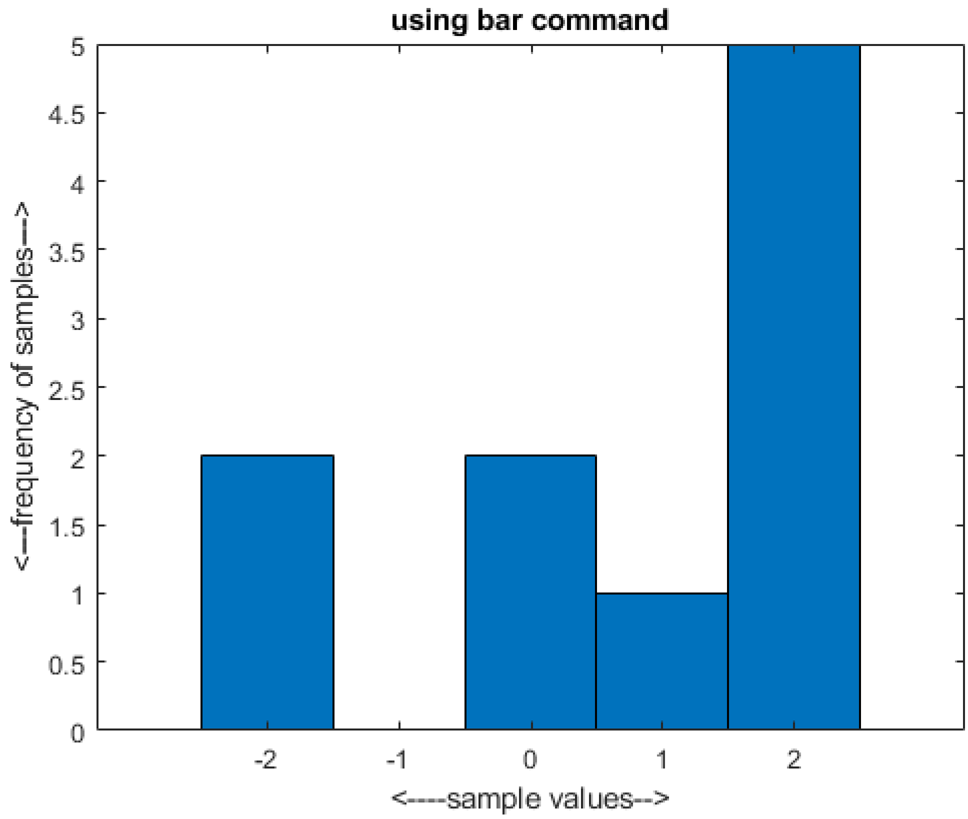
histfit % histogram fits normal distribution.

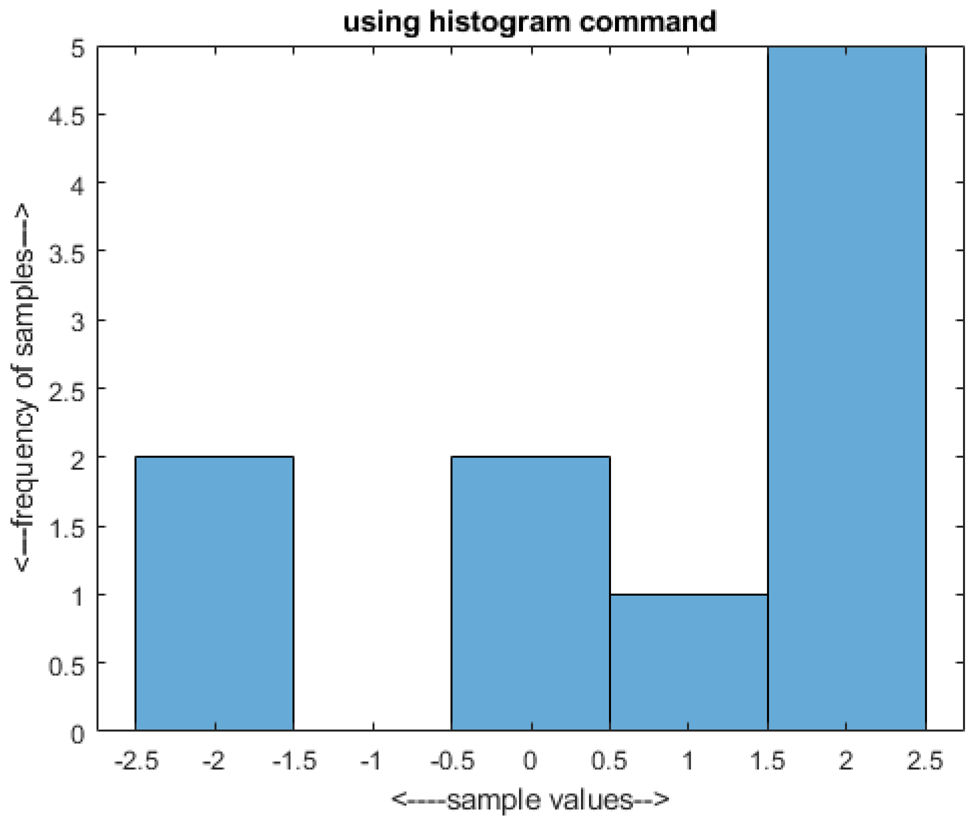
randi % generate integer random number that follows uniform distribution.

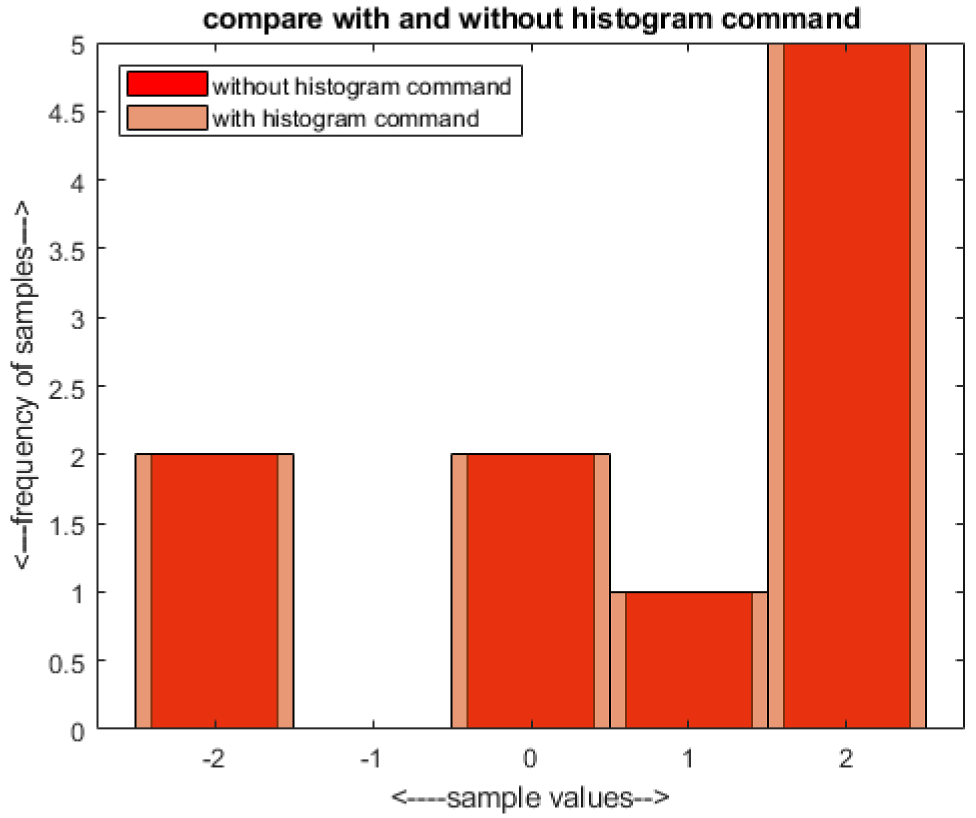
input % Request user input

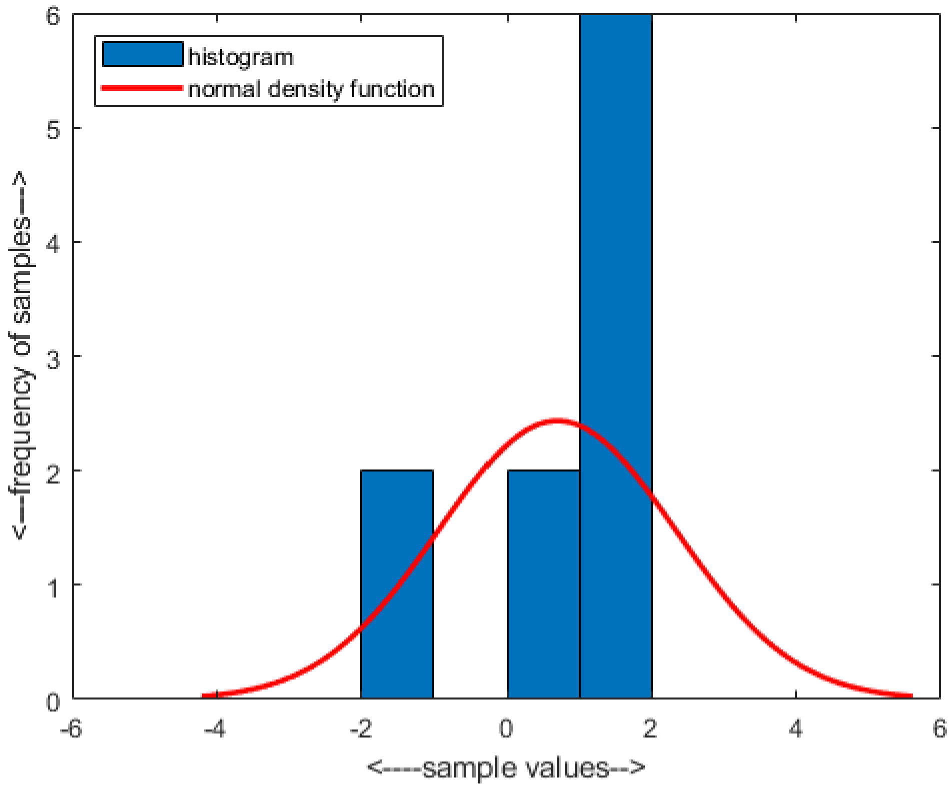
Plots:

For N=10,

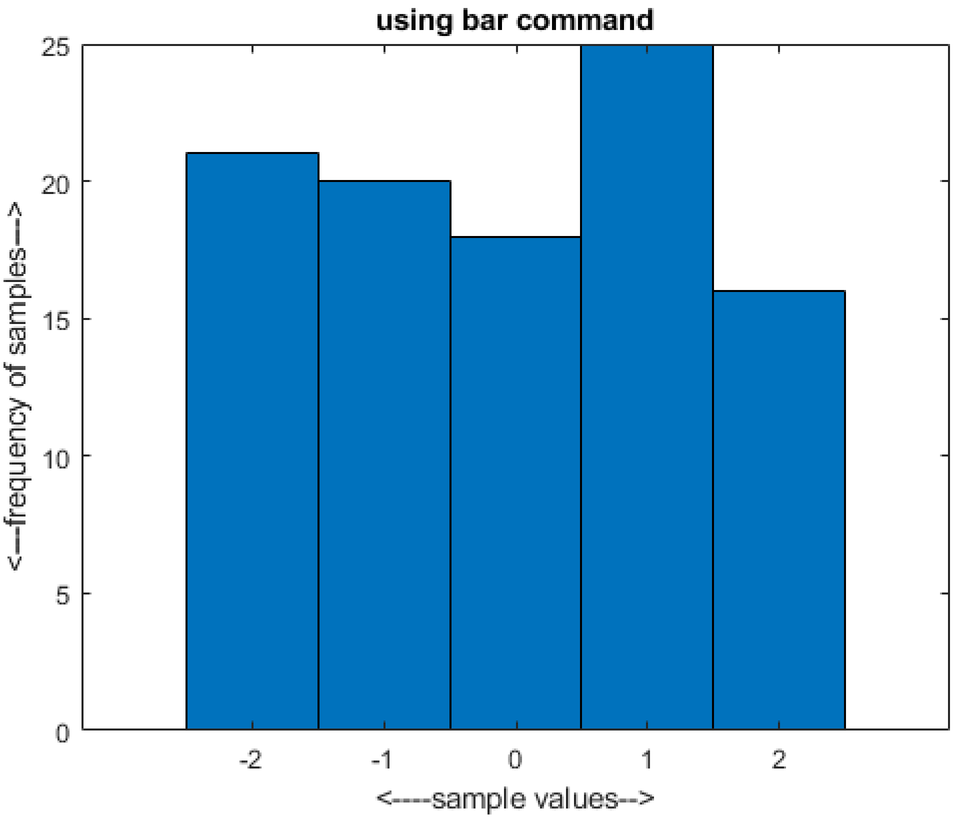

using bar command
<---frequency of samples--->
<----sample values-->
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-2
-1
0
1
2

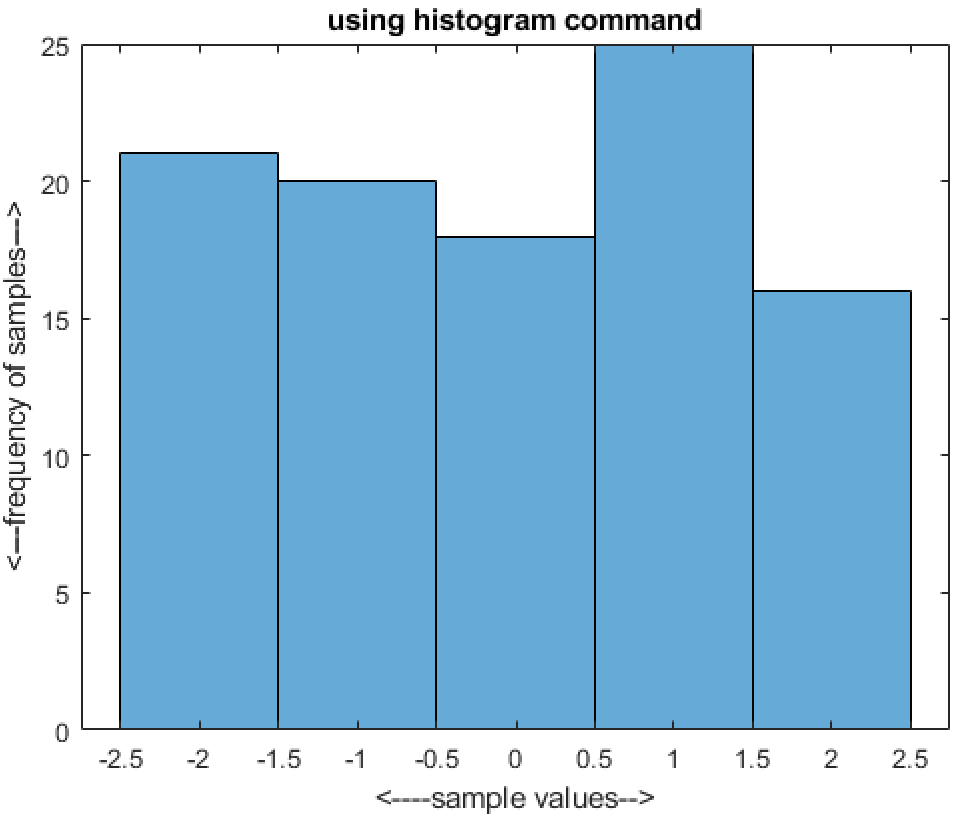

using histogram command
<---frequency of samples--->
<----sample values-->
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

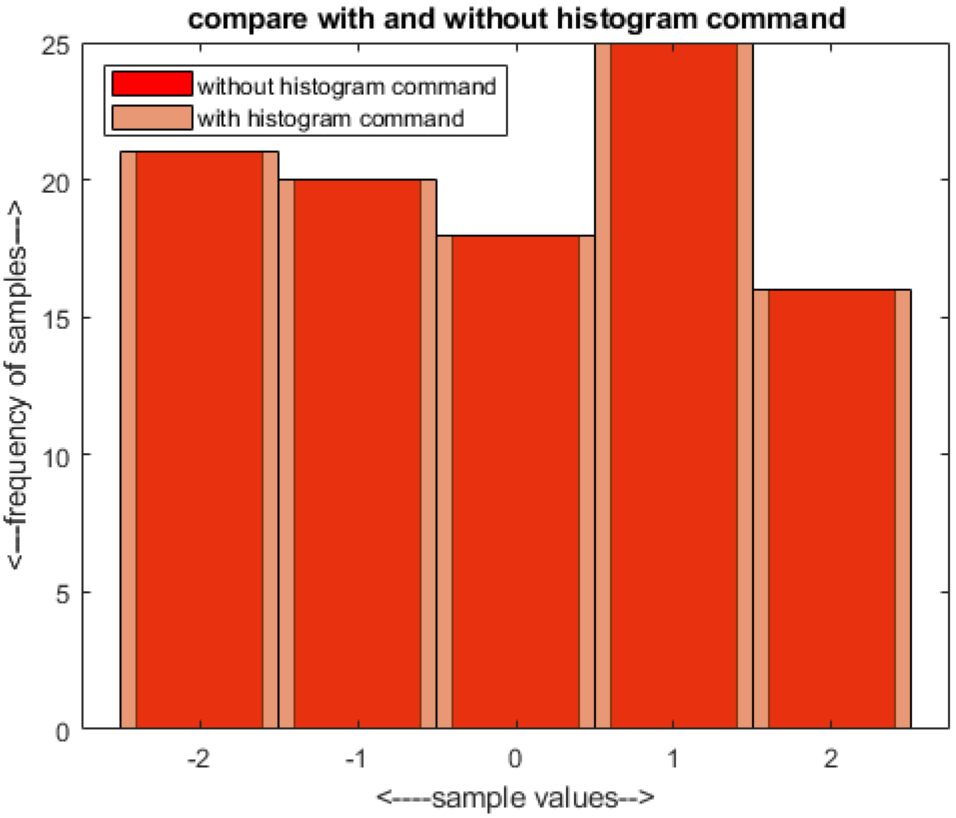

compare with and without histogram command
without histogram command
with histogram command
<---frequency of samples--->
<----sample values-->
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-2
-1
0
1
2

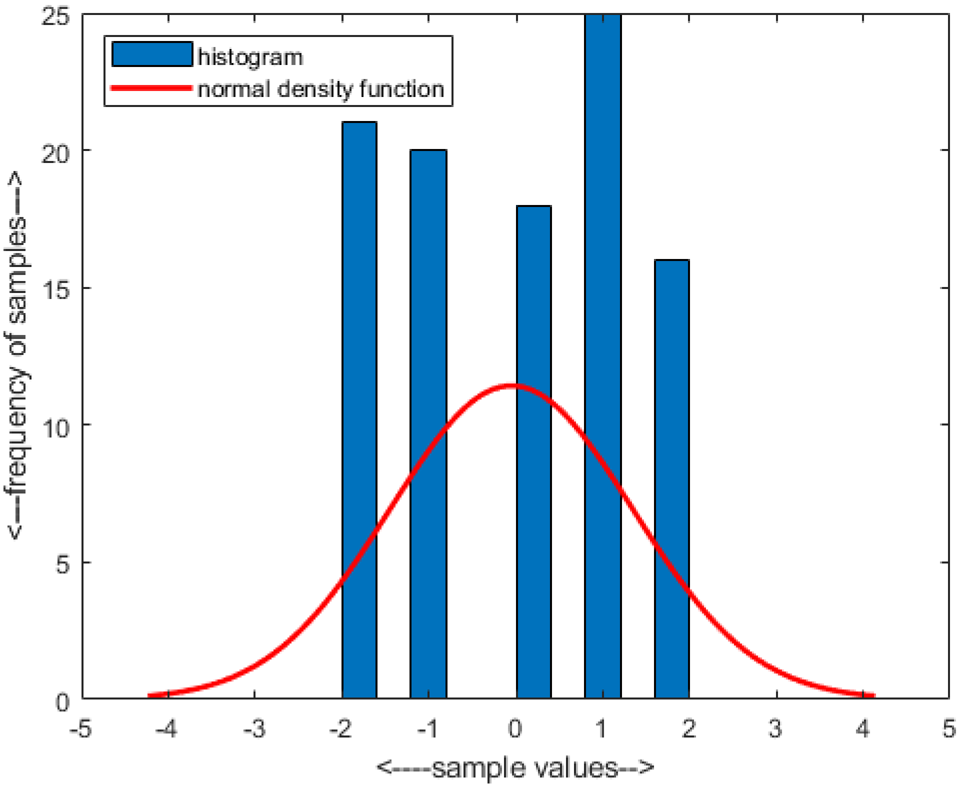

histogram
normal density function
<---frequency of samples--->
<----sample values-->
6
5
4
3
2
1
0
-6
-4
-2
0
2
4
6

For N=100;

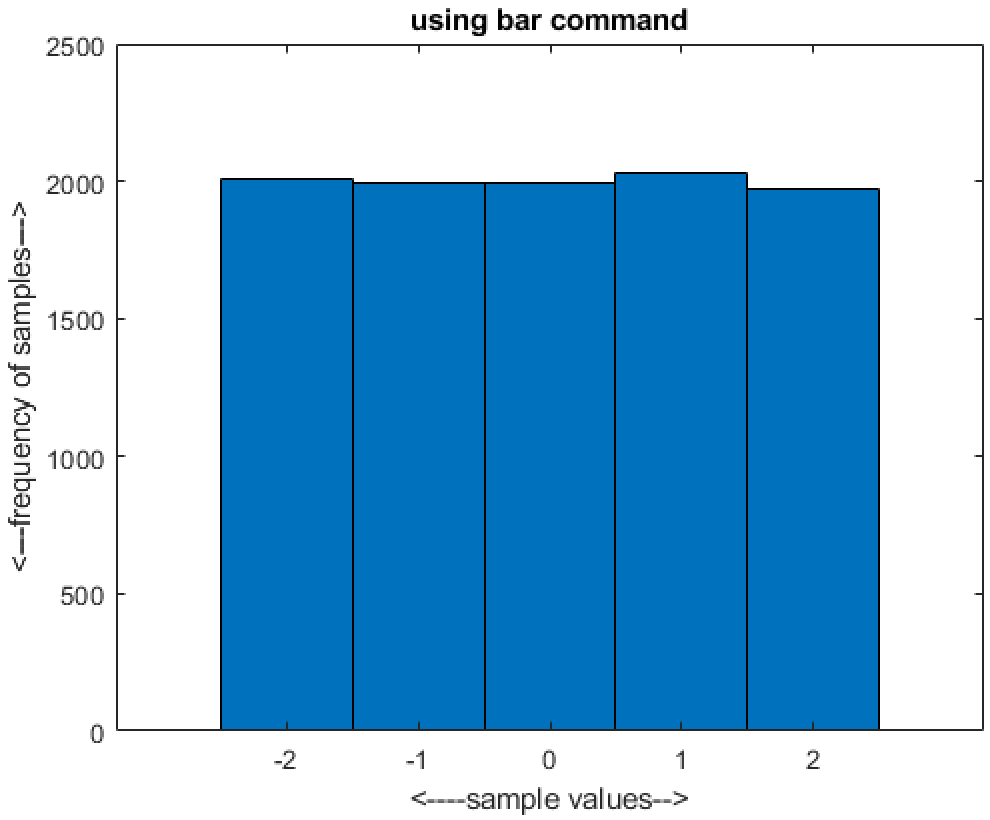

using bar command
25
20
15
10
5
0
-2
-1
0
1
2
<----sample values-->
<---frequency of samples-->

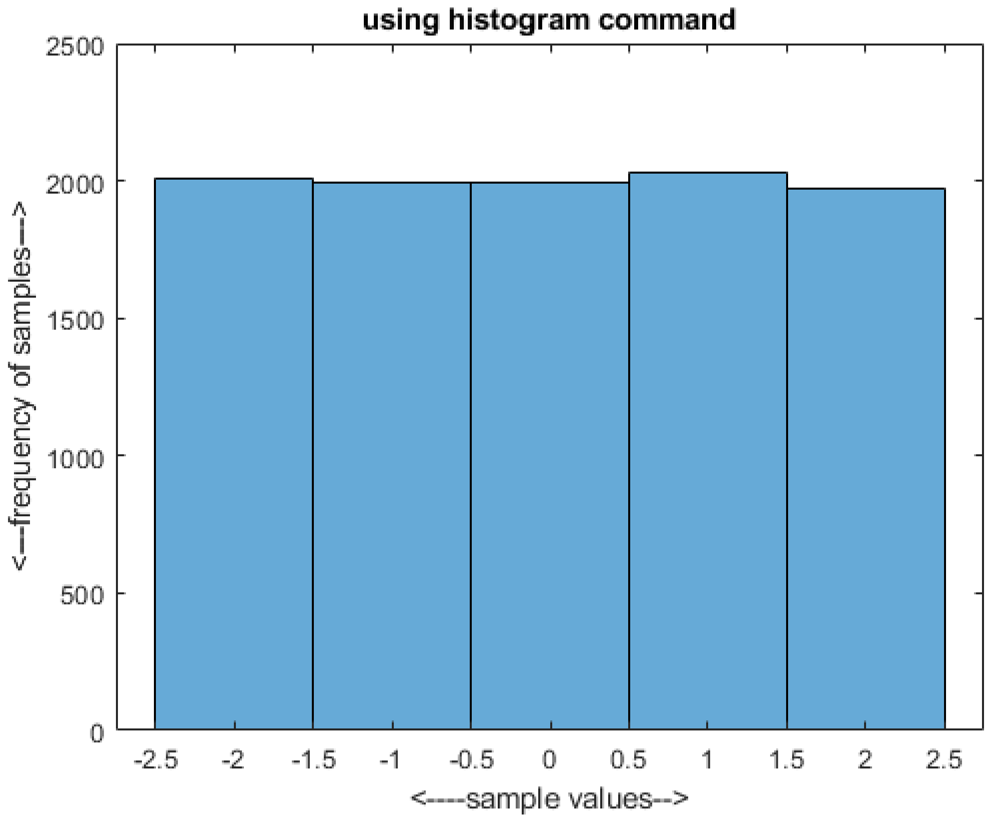

using histogram command
25
20
15
10
5
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
<----sample values-->
<---frequency of samples-->

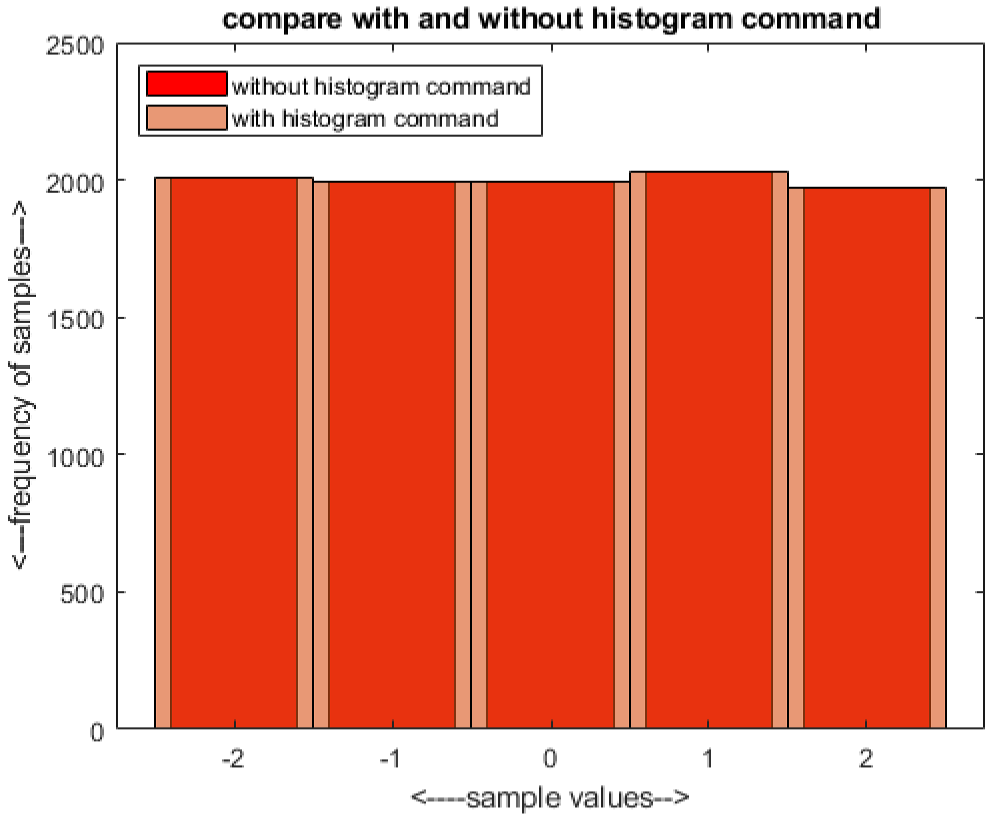

compare with and without histogram command
without histogram command
with histogram command
<---frequency of samples--->
<----sample values-->

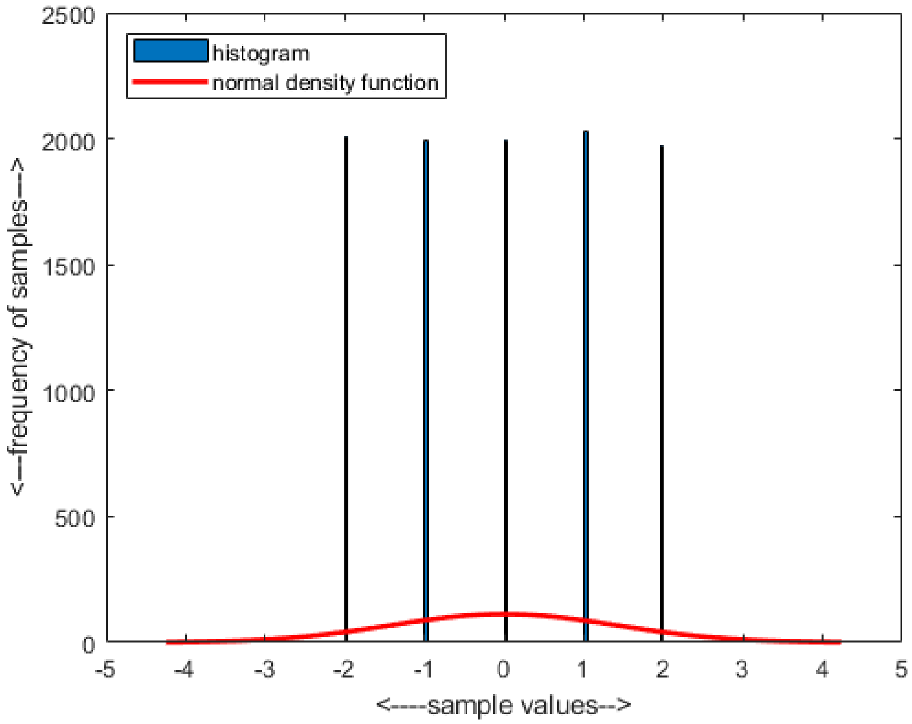

histogram
normal density function
<---frequency of samples--->
<----sample values-->

For N=10,000


using bar command
2500
2000
1500
1000
500
0
<----frequency of samples---->
-2
-1
0
1
2
<----sample values-->


using histogram command
2500
2000
1500
1000
500
0
<----frequency of samples---->
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
<----sample values-->





Inferences/comments:

If the N value(number of samples) increases the distribution become more likely uniform distribution.

Q2. Repeat Problem no. 1 by generating random numbers with Gaussian distribution with mean μ =0 and variance σ^2 = 1. Plot their histogram. Comment on your observation. Repeat the experiment for σ^2= 10 and σ^2 = 0.1. Compare the results with σ^2 = 1 case, and report your observations.

AIM:

To generate the random numbers with gaussian distribution with μ =0 and different values of variance σ^2 = 0.1,1,10 for different sample values N=10,100,10000.

Short Theory:

Gaussian probability distribution is perhaps the most used distribution in all of science. It can also called “bell shaped curve” or normal distribution. By using central limit theorem gaussian random variables are generated.

The probability density of the normal distribution can be computed as

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$$

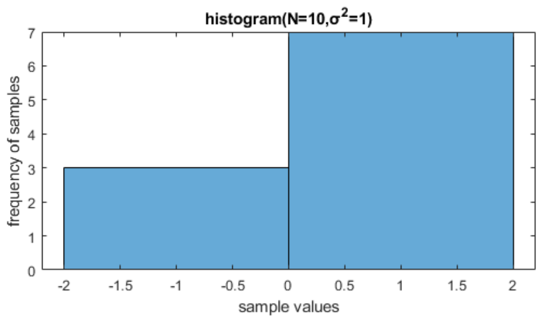
Key Commands:

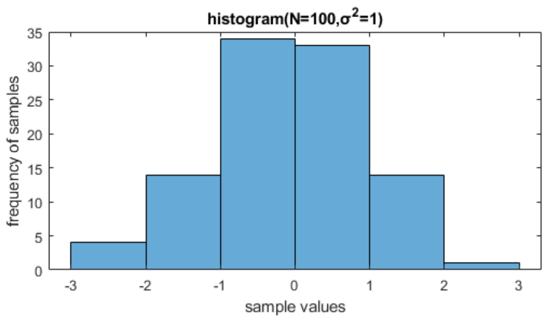
histogram % creates bar plot for numeric data that group the data into bins.

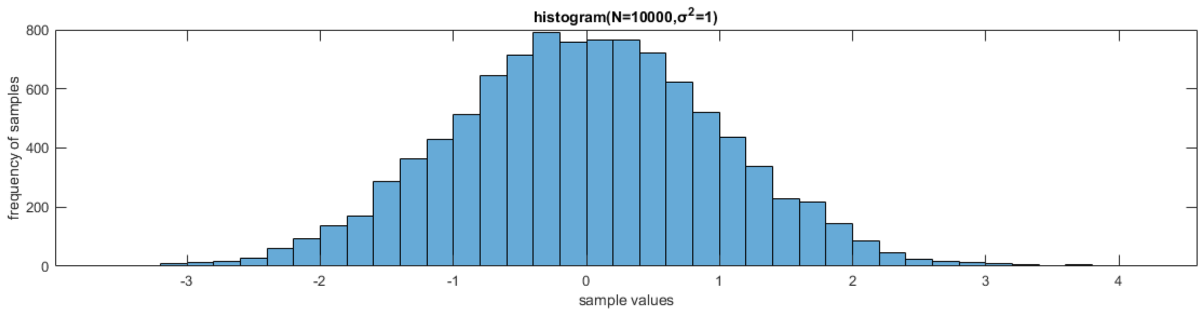
randn % generate random number that follows gaussian distribution.

Plots:

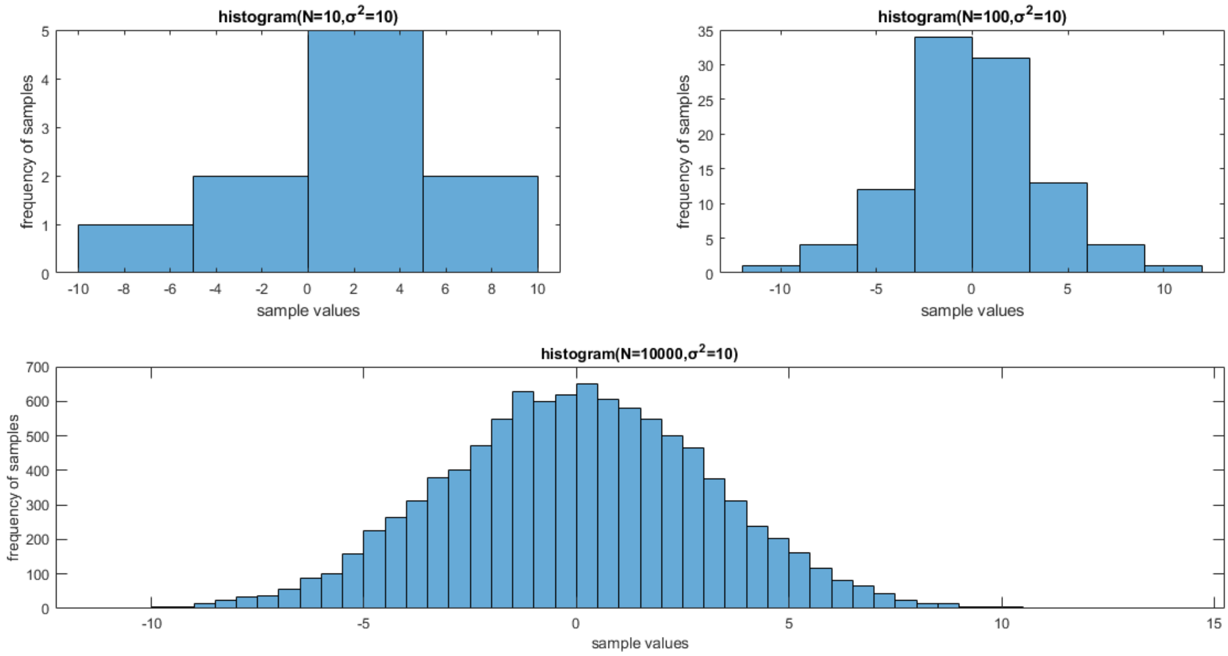
For σ =1



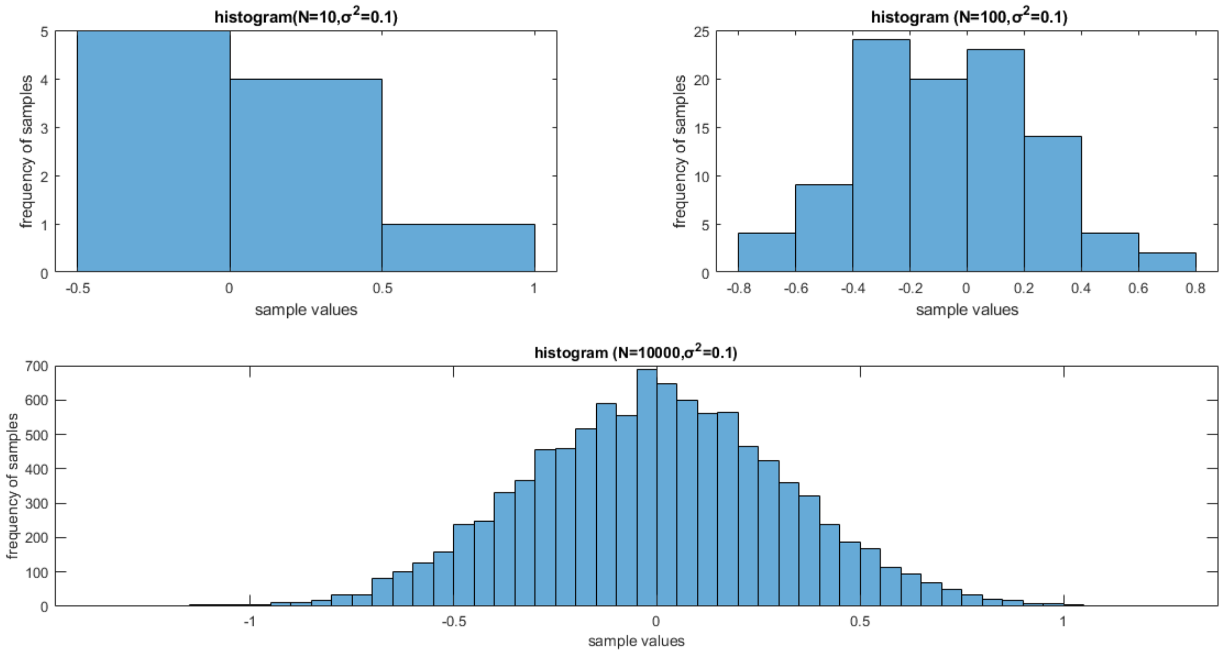




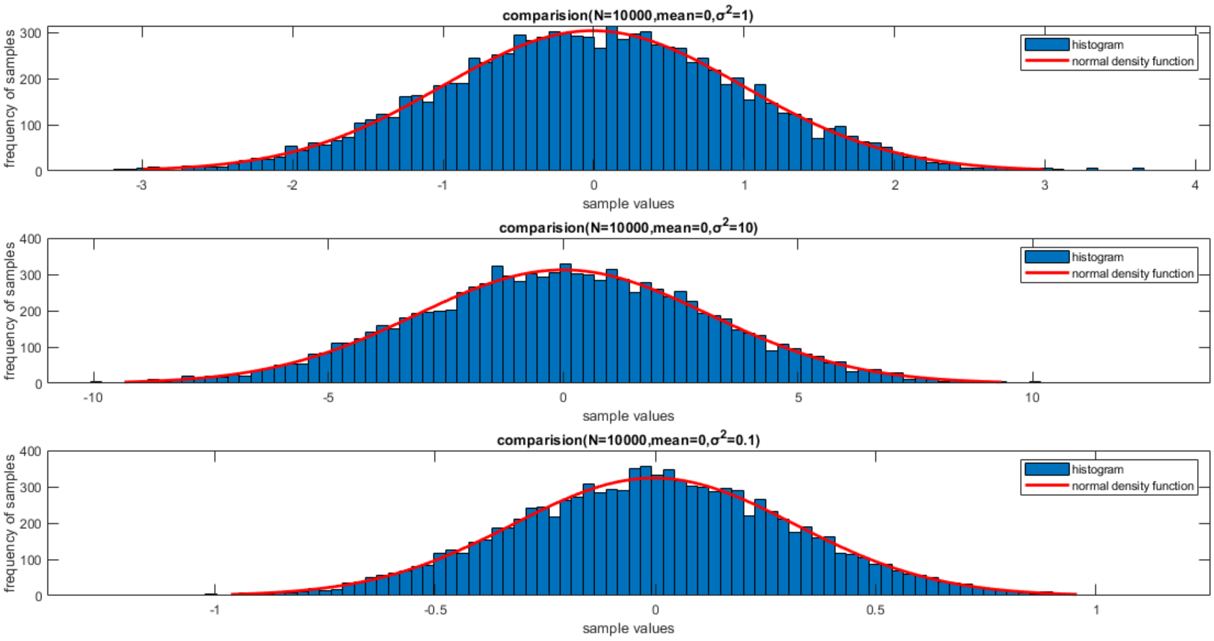
For σ =10



For σ =0.1



For N=10000 for σ =0.1,1,10



Inferences/comments:

1) If the N value(number of samples) increases the distribution become more likely gaussian distribution.
2) If the large value of N value(number of samples) we can clearly observe the variance of a gaussian distribution random variables.

Q3. Take the random numbers generated in Problem no. 1. Generate a standard Gaussian random variable using Central Limit Theorem (CLT) by taking sample size of n =10. Plot the histogram by generating N = 10, 000 random numbers. Change the sample size for generating Gaussian random variable to n = 1, 5, 10 and comment on the effect on histogram. Repeat the same experiment by taking random variables generated in Problem no. 2.

AIM: To generate the gaussian random variables using central limit theorem for different sample size n=1,5,10 from uniform random numbers and gaussian random numbers.

Short Theory:

The central limit theorem (CLT) establishes that, in many situations, when independent random variables are summed up, their properly normalized sum tends toward a normal distribution.

Let $x_1, x_2, \ldots, x_N$ be a set of N Independent random variables and each x having an arbitrary probability distribution $P(x_1, \ldots, x_N)$ with mean μ_i and a finite variance σ_i^2. Then normal form

$$X_{\text{norm}} \equiv \frac{\sum_{i=1}^{N} x_i - \sum_{i=1}^{N} \mu_i}{\sqrt{\sum_{i=1}^{N} \sigma_i^2}}$$

Key Commands:

Randi % generate integer random number that follows uniform distribution.

Reshape %we can use this command to reshape the vector to required size vector.

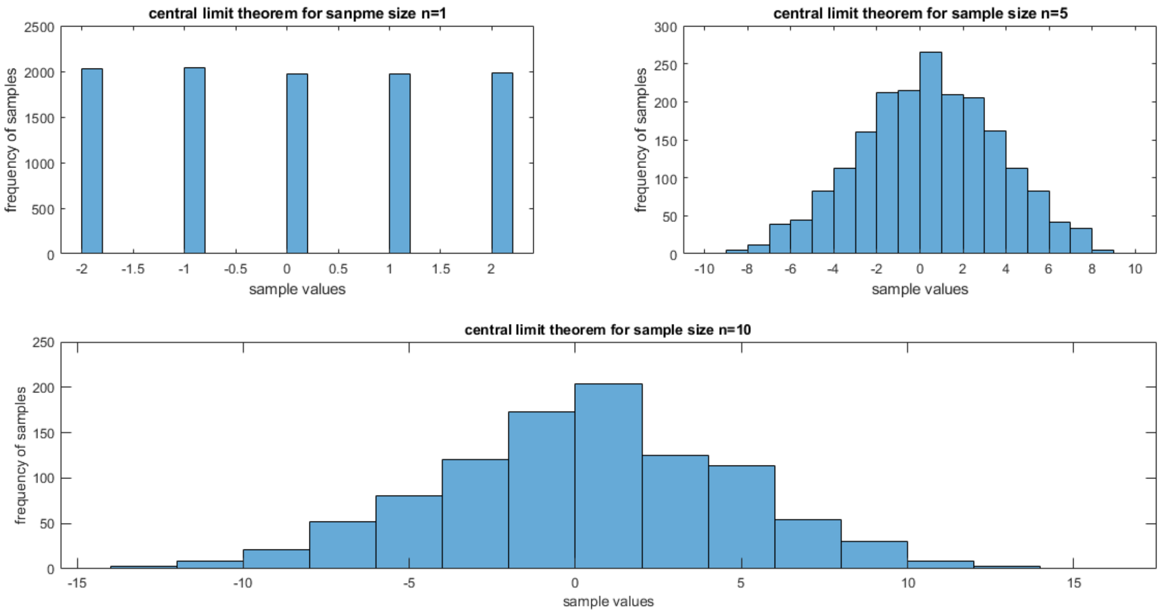
Histogram % creates bar plot for numeric data that group the data into bins.

Mean % this command gives the mean of the vector.

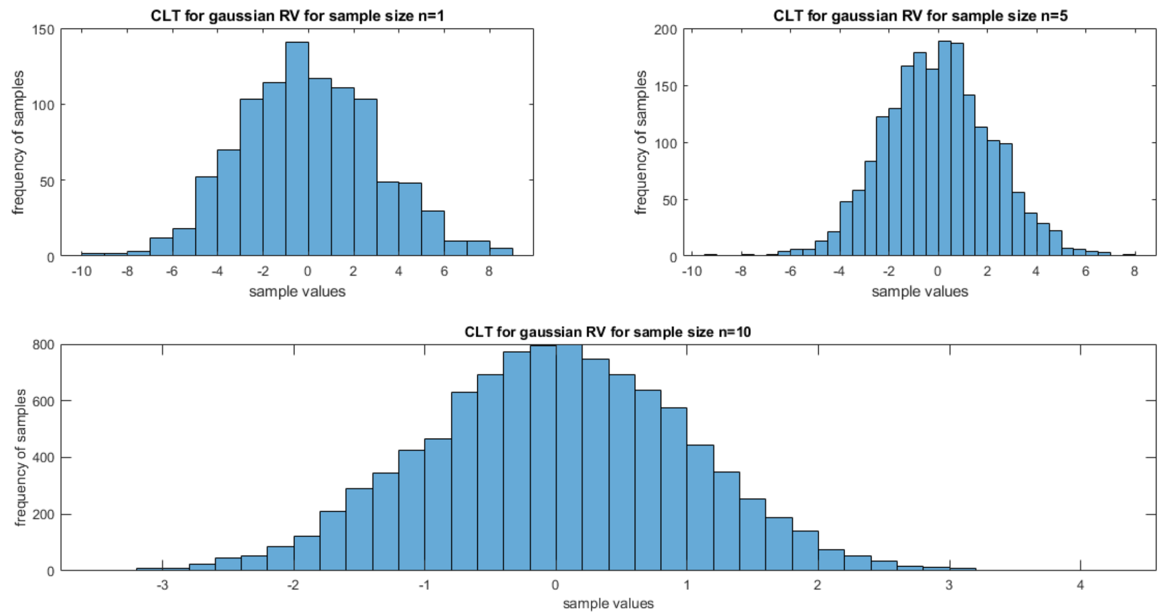
Var % this command gives the variance of the vector.

Plots:

Central limit theorem using uniform random variables N=10,000



Central limit theorem using gaussian random variables N=10,000



Inferences/comments:

If the sample size (n) increases the resulting distribution tends more like to gaussian(normal) distribution.

Q4. Generate a stream of 0/1 bits of size N = 1000 in which 0 occurs with probability 1/3 and 1 occurs with a probability of 2/3 by using the in-built MATLAB command to generate a uniform random variable between [0, 1]. Can you generate a stream of random variables which has the Gaussian distribution using this method? Justify your answer via a simulation study.

AIM: To generate the stream of bits 0/1 of size N=1000 in which 0 occurs with probability 1/3 and 1 occurs with a probability of 2/3 from uniform random variable between [0, 1].

Short Theory:

The generated random variables are uniform from 0 to 1 so we can assign the 0 value for less than or equals to generated random number, else remaining all generated random numbers assign to 1 value.

Key commands:

Rand % rand returns a uniformly distributed random number in the interval (0,1).

Code to generate stream of bits 0/1 for given probability condition:

```
clc;
clear all;
close all;
N=1000;
p=rand(1,N);
for i=1:N
    if p(i)<=1/3
        p(i)=0;
    else
        p(i)=1;
    end
end

display(p)
```

Inferences/comments:

Yes, we can generate a stream of random variables which has the Gaussian distribution by using The CDF Inversion Method. CDF inversion works by taking a random number α from Uniform distribution U(0, 1) and generating a Gaussian random number x through the inversion $x = \emptyset^{-1}(\alpha)$. Just as $\emptyset$ associates Gaussian numbers with a probability value between zero and one, $\emptyset^{-1}$ maps values between zero and one to Gaussian numbers.