

# Statistical Inference Course Project - Part 1

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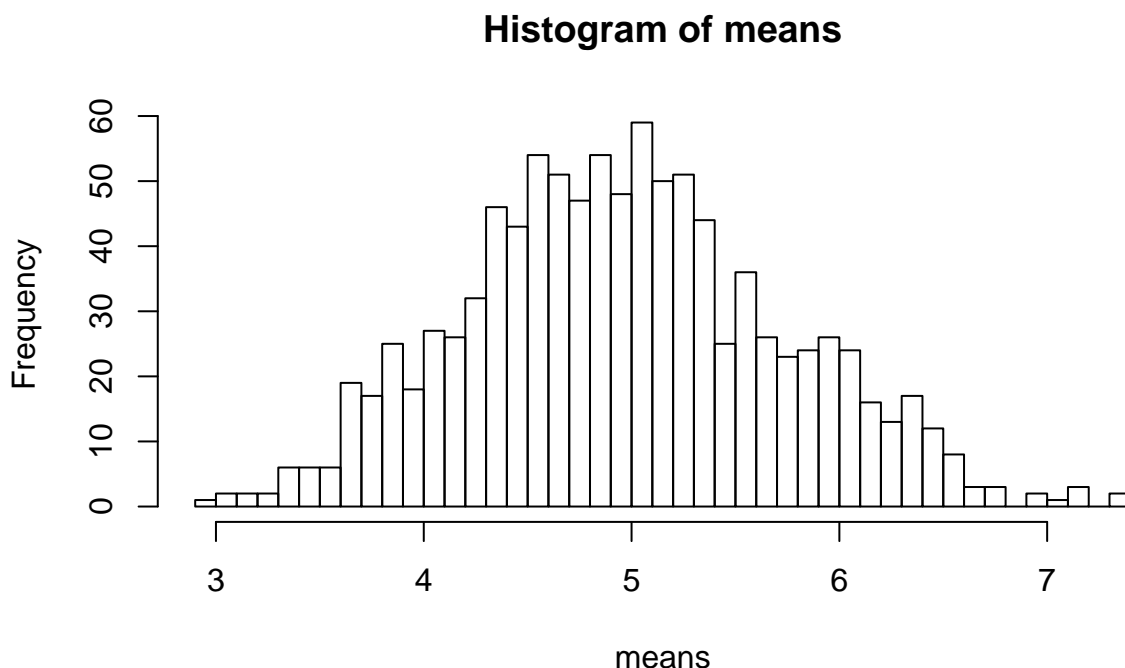
*February 3, 2016*

## Overview:

This report investigates the exponential distribution in R and compares it with the Central Limit Theorem. The report comprises of a simulation exercise to explore the properties of the distribution of averages of 40 exponentials. The sample and theoretical mean and variance are compared to those of theoretical, and it is concluded that the distribution is approximately normal.

## Simulations:

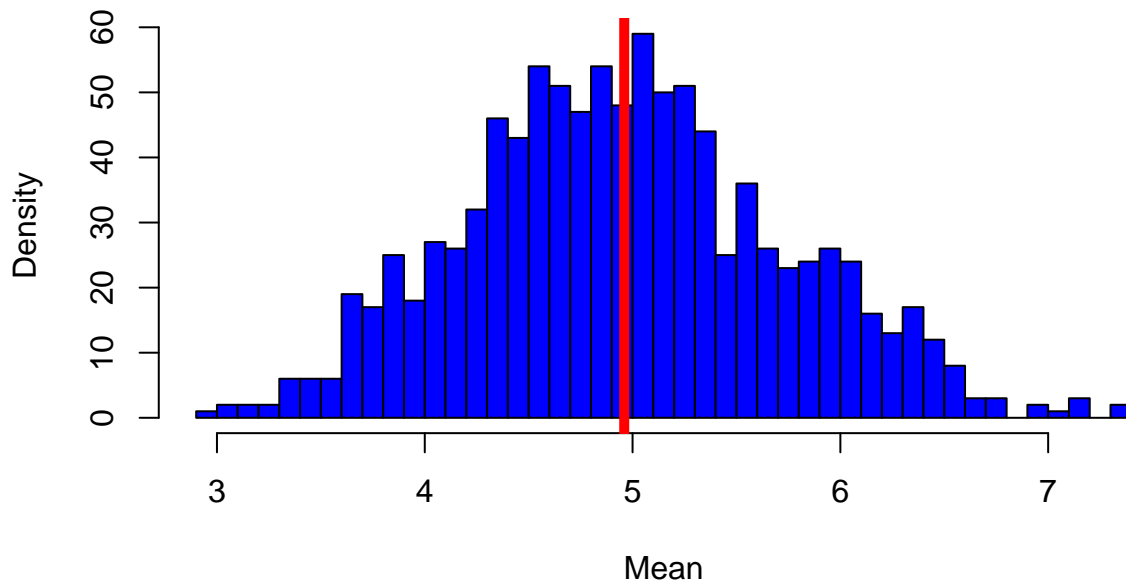
The exponential distribution is simulated in R with `rexp(n, lambda)` where `lambda` is the rate parameter, where both the mean and standard deviation of the distribution are  $1/\lambda$ . `lambda` is set to 0.2 for all of the simulations in which the distribution of averages of 40 exponentials with 1000 simulations are investigated. In this section, we first set the seed (February 3, 2016), `lambda` (0.2), and exponential size (40). Iterating results over 1000 times, the `rexp` function is used to find averages. The Histogram below shows mean of 1000 random exponentials.



## Sample Mean versus Theoretical Mean:

In this section, the report presents the distribution of the sample means and then address the questions regarding the differences between the simulation distribution and theoretical normal distribution. The sample and theoretical means are reported for the comparison.

### Distribution of 1000 averages of 40 exponential



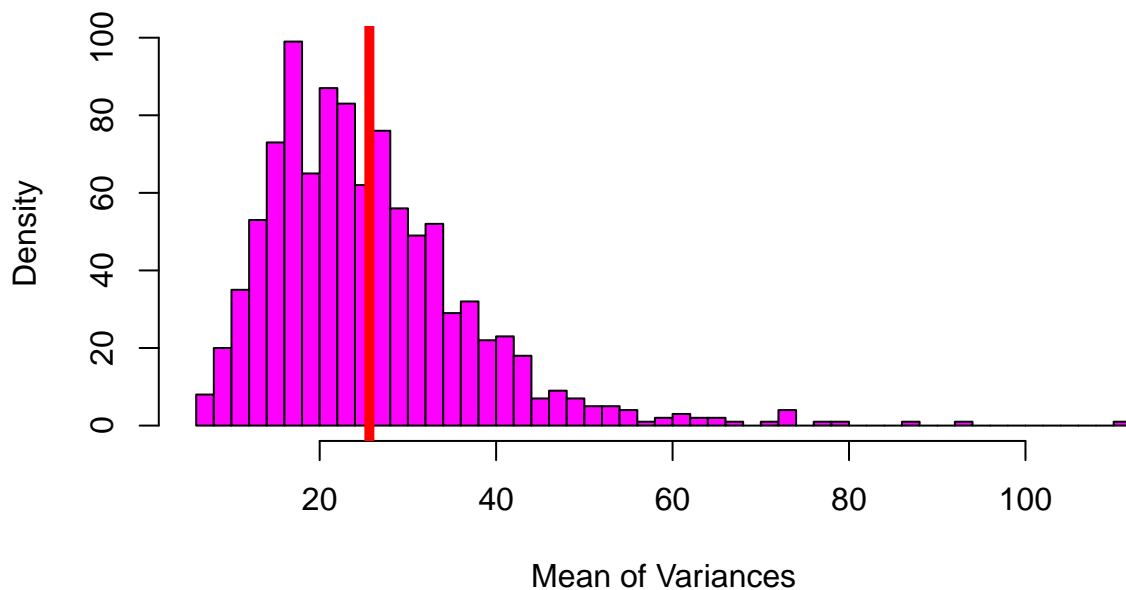
*Conclusion:* Referring to the theoretical and sample mean values, the two values very close.

```
##      Theoretical Sample
## Mean           5    4.96
```

### Sample Variance versus Theoretical Variance:

The mean of variances of 40 random exponential distribution for 1000 simulation runs is plotted as follows.

### Distribution of 1000 variances of 40 exponential

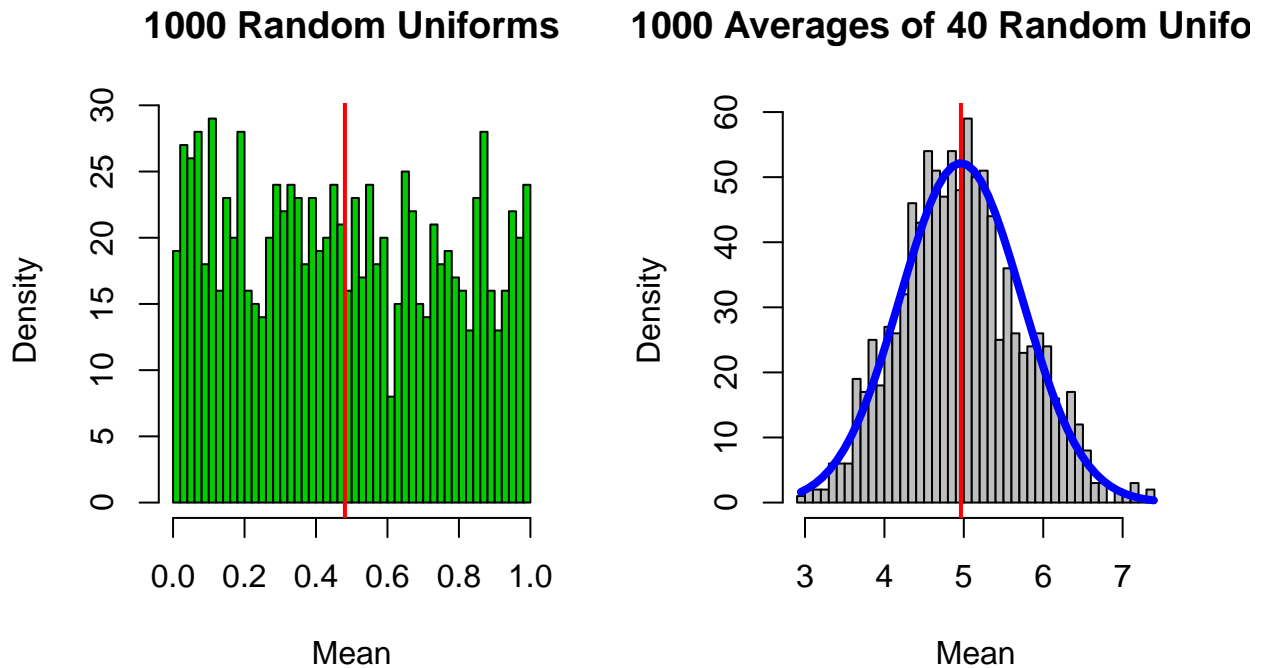


*Conclusion:* It is observable in the graph that the sample variance is very close to the theoretical variance.

```
##          Theoretical Sample
## Variance      25  25.63
```

## Distribution:

To answer the third question for investigating whether the distribution looks approximately like normal distribution, two different simulations are run and corresponding graphs are plotted. The first graph shows the distribution of 1000 random exponentials, and the second graph shows the average of 1000 simulations of 40 exponentials as follows.



*Conclusion:* As it can be seen in the last two diagrams, both graphs have similar sample-means around the middle of the plot. However, the average of 40 exponentials for a large number of simulations (corresponding to the right-side plot) looks like normal distribution while the collection of random unifoms (left-side graph) looks different from a normal distribution.

This simulation confirms the Central Limit Theorem (CLT), as the distribution of averages of a distribution behaves like a normal distribution for the sufficiently large sample sizes.

## Code for Simulations:

```
set.seed(20160203)
lambda <- 0.2
size <- 40
means <- NULL
variance <- NULL

for (i in 1:1000) means = c(means, mean(rexp(size, lambda)))
for (i in 1:1000) variance = c(variance, var(rexp(size, lambda)))
hist(means,breaks=50)
```

## Code for Sample Mean versus Theoretical Mean:

```
sample_mean <- round(mean(means), 2)
theo_mean <- 1/lambda
hist(means, main="Distribution of 1000 averages of 40 exponential",
     xlab= "Mean", ylab="Density",
     breaks= 50, col="blue")
abline(v= sample_mean, col="red",lwd= 5)

matrix(data=c(theo_mean, sample_mean),
       nrow=1, ncol=2, byrow=TRUE,
       dimnames=list(c("Mean"), c("Theoretical", "Sample")))
```

## Code for Sample Variance versus Theoretical Variance:

```
sample_var <- round(mean(variance), 2)
theo_var <- (1/lambda)^2

hist(variance,
     main="Distribution of 1000 variances of 40 exponential",
     xlab= "Mean of Variances", ylab="Density", breaks= 50, col="magenta")
abline(v= sample_var, col="red",lwd= 5)

matrix(data=c(theo_var, sample_var), nrow=1, ncol=2, byrow=TRUE,
       dimnames=list(c("Variance"), c("Theoretical", "Sample")))
```

## Code for Distribution:

```

x <- runif(1000)
mns = NULL
for (i in 1 : 1000) mns = c(mns, mean(runif(40)))

par(mfrow=c(1,2))

hist(x, breaks = 50,main="1000 Random Uniforms",
     xlab= "Mean", ylab="Density", col="Green3")
abline(v= mean(x), col="red",lwd= 2)

hg<-hist(means,breaks= 50,col="grey",
        main="1000 Averages of 40 Random Uniforms",
        xlab= "Mean",ylab="Density")
x_fit<-seq(min(means),max(means),length= 50)
y_fit<-dnorm(x_fit,mean=mean(means), sd=sd(means))
y_fit<-y_fit*diff(hg$mids[1:2])*length(means)
abline(v=mean(means),col="red",lwd=2)
lines(x_fit, y_fit,col="blue",lwd=4)

```