Assignment 1

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Part I - R Basics

1. Calculate the following sums:

```
#S1
x <- c(1:2019)
sum(x)
```

```
## [1] 2039190
```

```
#S2
sum(x^3)
```

```
## [1] 4.158296e+12
```

```
#S3
sum(x^x)
```

```
## [1] Inf
```

```
s4 <- (c(1,-1)* x)

#S4
sum(s4^x)
```

```
## [1] Inf
```

```
#S5
sum(1/(x^2))
```

```
## [1] 1.644439
```

```
#S6
sum(1/x)
```

```
## [1] 8.187821
```

```
#S7
sum(1/(x^3))
```

```
## [1] 1.202057
```

```r
#S8
sum(1/(s4))
```

```
## [1] 0.6933948
```

2. The rnorm function generate random variables from normal distribution. Generate a sample of 1000 values from normal distribution with the mean 10 and standard deviation 1.

a. Calculate the mean and standard deviation of the sample.

```r
norm <- rnorm(1000, 10, 1)
mean(norm)
```

```
## [1] 10.01159
```

```r
sd(norm)
```

```
## [1] 1.011707
```

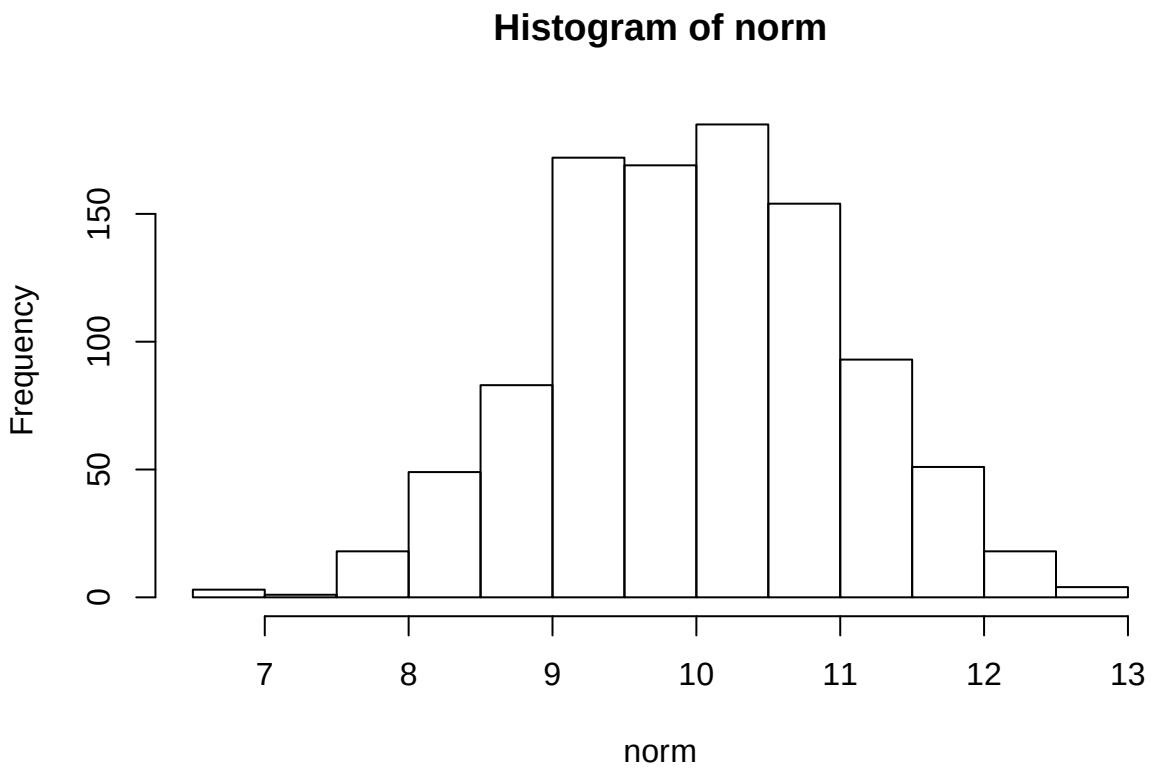
b. Out of 1000 samples, how many do you think are that great than 10? Check your estimation.

```r
#Should expect 500
sum(norm > 10)
```

```
## [1] 505
```

c. Use hist() function to show the histogram of the sample.

```r
hist(norm)
```



d. Estimate P(X > 1), where X follows N(2, 1)

```r
prob <- rnorm(1000, 2, 1)
#Probability that X > 1:
sum(prob > 1) / 1000
```

```
## [1] 0.847
```

3. Consider an experiment of tossing a fair dice.

a. Use the sample (with replacement) function to generate a sample of 1000 values from the experiment.

```r
x <- c(1:6)
s <- sample(x, 1000, replace = TRUE)
```

b. Calculate the mean and standard deviation of the sample.

```r
mean(s)
```

```
## [1] 3.506
```

```r
sd(s)
```

```
## [1] 1.725381
```

c. How many times the 6 occured?

```r
sum(s == 6)
```

```
## [1] 170
```

d. Use table function to show the frequency of the values.

```r
table(s)
```

```
## s
##   1   2   3   4   5   6
## 171 165 165 155 174 170
```

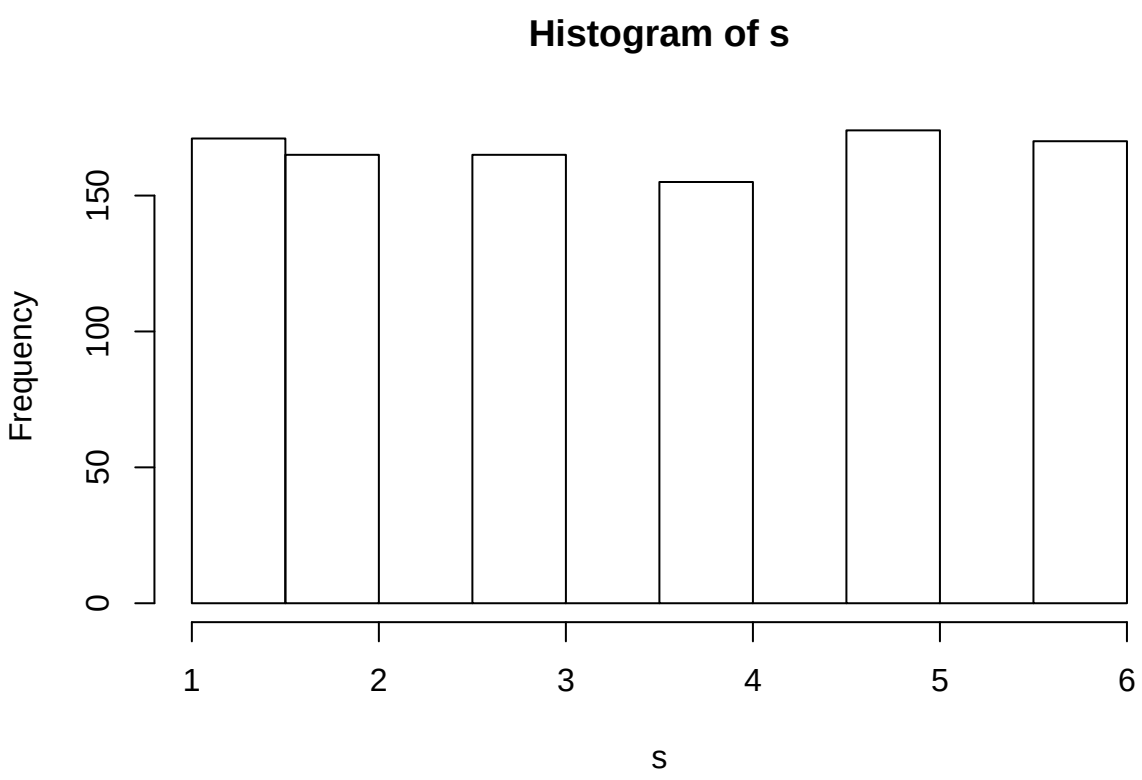
e. Use prop.table(table()) to show the relative frequency of the values.

```r
prop.table(table(s))
```

```
## s
##     1     2     3     4     5     6
## 0.171 0.165 0.165 0.155 0.174 0.170
```

f. Plot the frequency of the values.

```r
hist(s)
```



4. Consider an experiment of tossing a dice 3 times. Let X1, X2, and X3 be the number of tossing the first time, second time and third time, respectively. Use simulation to estimate the following probabilities:

a. P(X1 > X2 + X3)

```
exper <- matrix(data=(sample(x, 3000, replace = TRUE)), nrow = 1000, ncol = 3)
sum(exper[,1] > (exper[,2] + exper[,3])) / 1000
```

```
## [1] 0.093
```

b. P(X1^2 > X2^2 + X3^2)

```
sum(exper[,1]^2 > (exper[,2]^2 + exper[,3]^2)) / 1000
```

```
## [1] 0.218
```

5. Using simulation, estimate the probability of getting three tails in a row when tossing a coin 3 times.

Hint: one way is to generate a matrix with three columns where each rows is an observation of tossing a coin three times.

```r
# 1 is a head in this case
y <- c(0,1)

sim <- matrix(sample(y, 3000, replace= TRUE), nrow= 1000, ncol = 3)
sum((sim[,1] + sim[,2] + sim[,3]) == 0)/1000
```

```
## [1] 0.137
```

6. (Extra Credits/Optional) Using simulation, estimate the probability of getting three tails in a row when tossing a coin 10 times.

```r
coin <- matrix(sample(c(0,1), 10000, replace= TRUE), nrow= 1000, ncol = 10)

count <- 0

consec <- function(x){
   sum(max(rle(x)$lengths >=3 & rle(x)$values == 0))
  }

sum(apply(coin, 1, consec)) / 1000
```

```
## [1] 0.491
```

7. Central Limit Theorem (CLT). The CLT said that the mean of a sample of a distribution A (no matter what A is) follows normal distribution with the same mean as A. Following the below steps to confirm the CLT when A is uniform distribution.

- **Generate 100 samples of uniform distibution from 0 to 1. Each sample has 1000 observations. Use the runif function to do this.**

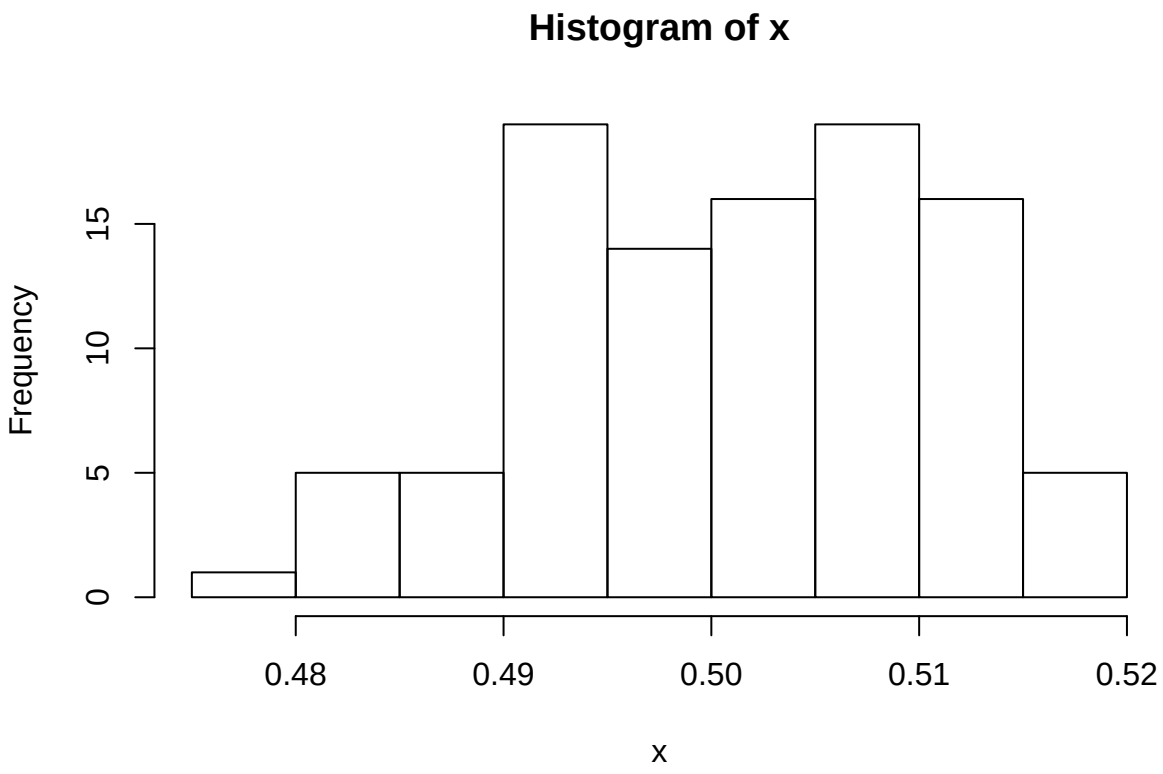
```r
uni <- matrix(runif(100000, 0, 1), nrow= 100, ncol = 1000)
```

- **Compute the means of the 100 samples. Create vector x containing these means. Hint: You want to put all the samples in a matrix and use rowSums or colSums function.**

```r
x <- rowSums(uni)/1000
```

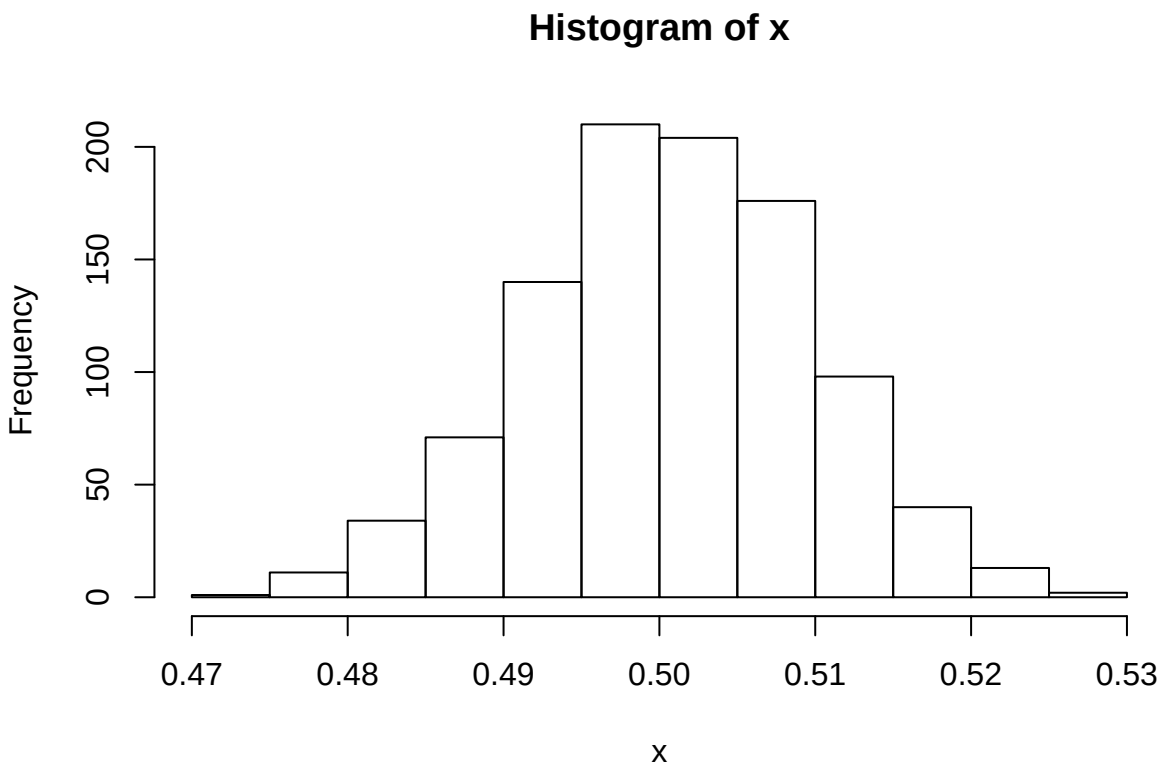
- **By CLT, x must follow normal distribution. Check this by plotting the histogram of x. Does it look like normal distribution? Use hist(x) to plot the histogram of x.**

```r
hist(x)
```



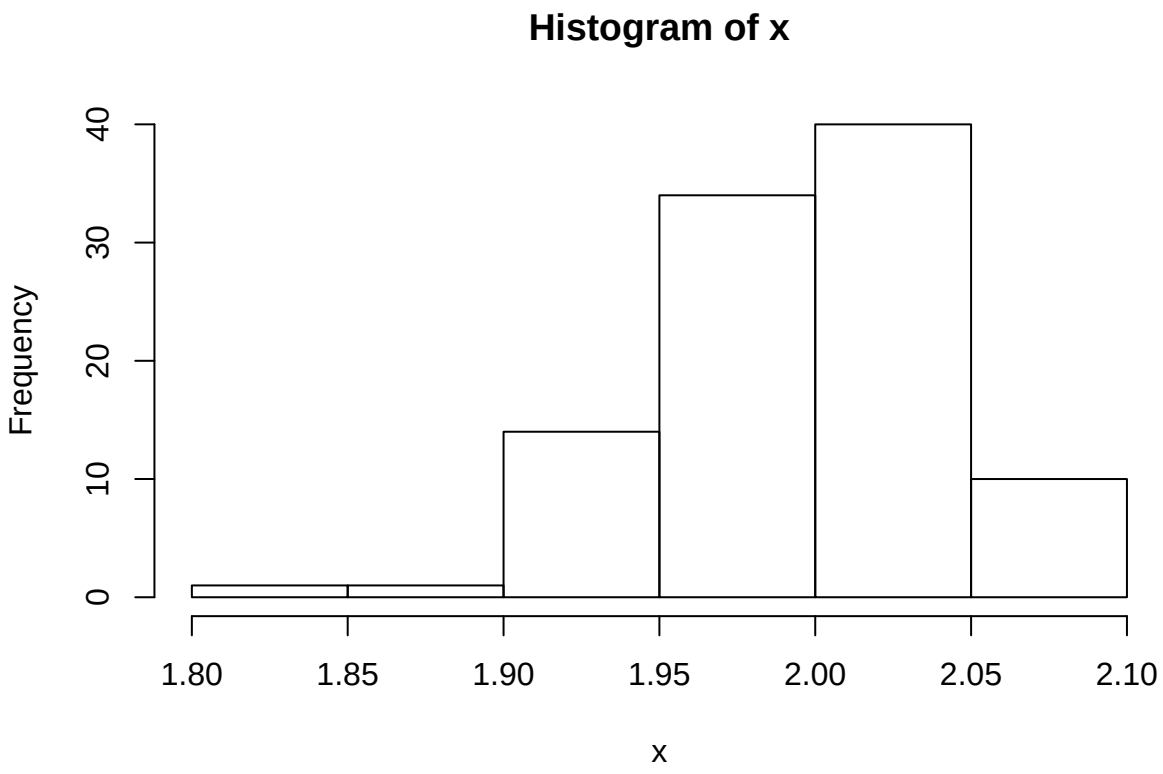
• **Increase the number (100 and 1000) to see if the distribution of x looks more like normal distribution.**

```
uni2 <- matrix(runif(1000000, 0, 1), nrow= 1000, ncol = 1000)

x <- rowSums(uni2) / 1000

hist(x)
```

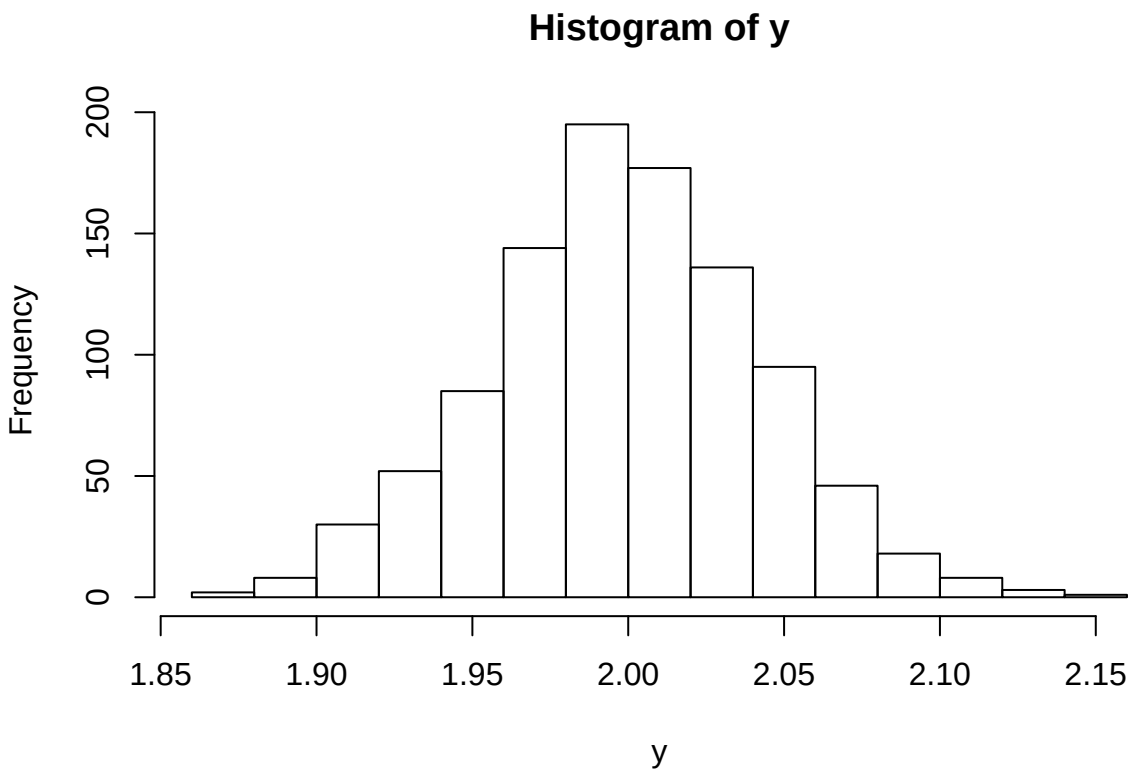


- **Try the same procedure with two other distributions for A.**

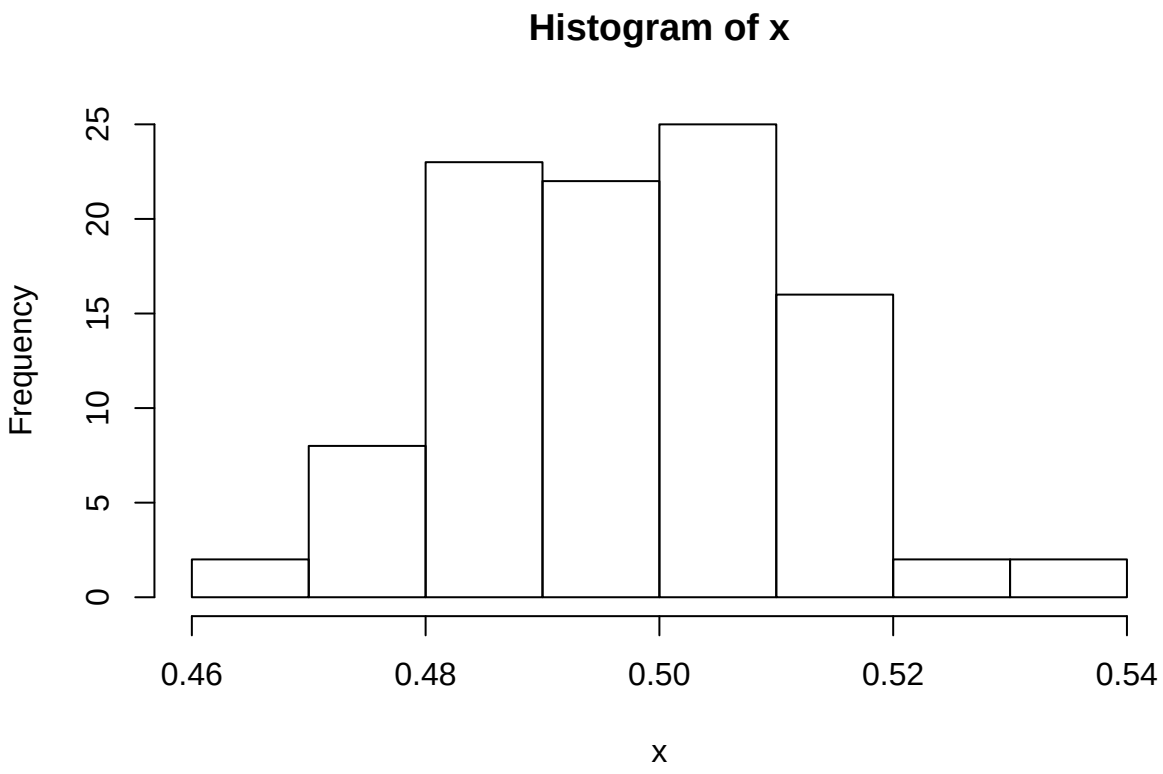
```
#Poisson
pois <- matrix(rpois(100000, 2), nrow= 100, ncol = 1000)

x <- rowSums(pois) / 1000

hist(x)
```



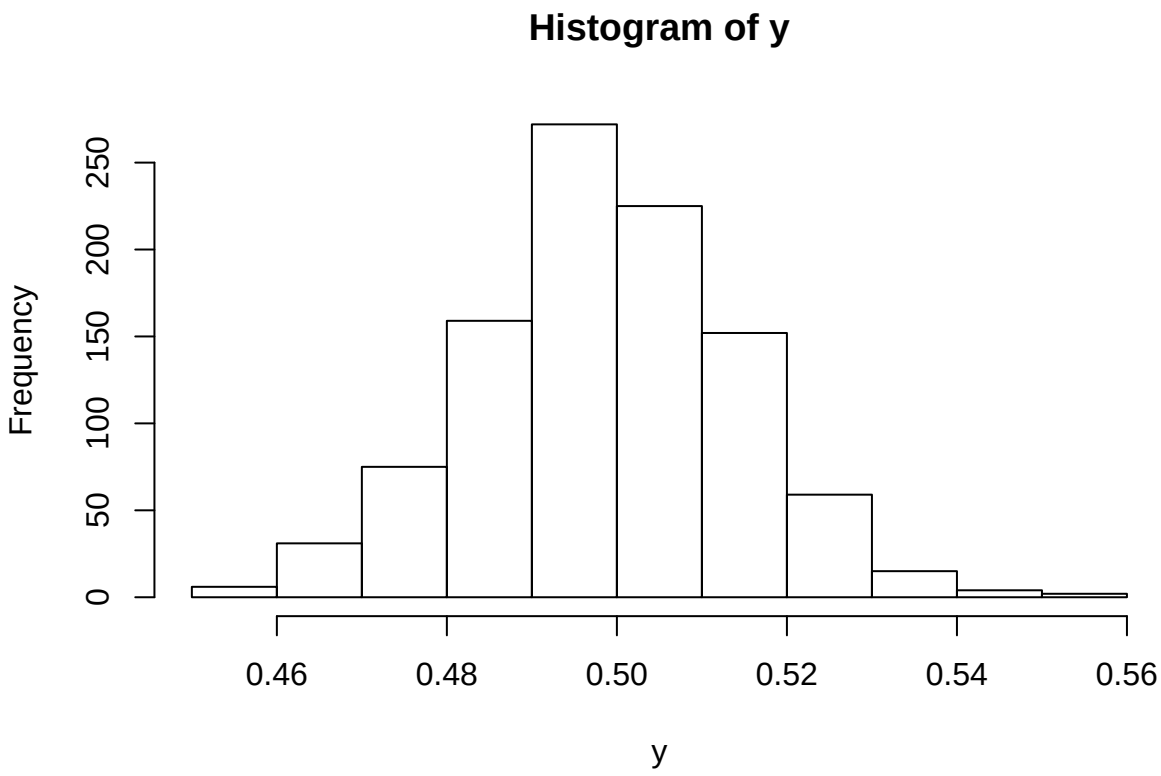

```
pois2 <- matrix(rpois(1000000, 2), nrow= 1000, ncol = 1000)

y <- rowSums(pois2) / 1000

hist(y)
```




```r
#Binomial
binom <- matrix(rbinom(100000, 1, 0.5), nrow= 100, ncol = 1000)

x <- rowSums(binom) / 1000

hist(x)
```




```
binom2 <- matrix(rbinom(1000000,1, 0.5), nrow= 1000, ncol = 1000)

y <- rowSums(binom2) / 1000

hist(y)
```



Part II - Working with Data

7. Use read.csv function to read in the titanic dataset. You can find the dataset on Blackboard or at Kaggle.com. Use str function to see a summary of the data.

```
titanic <- read.csv(file = "C:/Users/student/Documents/Senior Year/MATH 421/titanic.csv", header = T, s
str(titanic)
```

```
## 'data.frame':    891 obs. of  12 variables:
##  $ PassengerId: int  1 2 3 4 5 6 7 8 9 10 ...
##  $ Survived   : int  0 1 1 1 0 0 0 0 1 1 ...
##  $ Pclass     : int  3 1 3 1 3 3 1 3 3 2 ...
##  $ Name       : Factor w/ 891 levels "Abbing, Mr. Anthony",..: 109 191 358 277 16 559 520 629 417 58
##  $ Sex        : Factor w/ 2 levels "female","male": 2 1 1 1 2 2 2 2 1 1 ...
##  $ Age        : num  22 38 26 35 35 NA 54 2 27 14 ...
##  $ SibSp      : int  1 1 0 1 0 0 0 3 0 1 ...
##  $ Parch      : int  0 0 0 0 0 0 0 1 2 0 ...
##  $ Ticket     : Factor w/ 681 levels "110152","110413",..: 524 597 670 50 473 276 86 396 345 133 ...
##  $ Fare       : num  7.25 71.28 7.92 53.1 8.05 ...
##  $ Cabin      : Factor w/ 148 levels "","A10","A14",..: 1 83 1 57 1 1 131 1 1 1 ...
##  $ Embarked   : Factor w/ 4 levels "","C","Q","S": 4 2 4 4 4 3 4 4 4 2 ...
```

8. Use knitr::kable function to nicely print out the first 10 rows of the data in markdown.

```
knitr::kable(head(titanic, 10))
```

PassengerId	Survived	Pclass	Name	Sex	Age	SibSp	Parch
1	0	3	Braund, Mr. Owen Harris	male	22	1	0
2	1	1	Cumings, Mrs. John Bradley (Florence Briggs Thayer)	female	38	1	0
3	1	3	Heikkinen, Miss. Laina	female	26	0	0
4	1	1	Futrelle, Mrs. Jacques Heath (Lily May Peel)	female	35	1	0
5	0	3	Allen, Mr. William Henry	male	35	0	0
6	0	3	Moran, Mr. James	male	NA	0	0
7	0	1	McCarthy, Mr. Timothy J	male	54	0	0
8	0	3	Palsson, Master. Gosta Leonard	male	2	3	1
9	1	3	Johnson, Mrs. Oscar W (Elisabeth Vilhelmina Berg)	female	27	0	2
10	1	2	Nasser, Mrs. Nicholas (Adele Achem)	female	14	1	0

9. Use is.na function and sum function to count the total number of missing values in the data. Count the number of missing values in each columns.

```
sum(is.na(titanic))
```

```
## [1] 177
```

```
knitr::kable(colSums(is.na(titanic)))
```

	x
PassengerId	0
Survived	0
Pclass	0
Name	0
Sex	0
Age	177
SibSp	0
Parch	0
Ticket	0
Fare	0
Cabin	0
Embarked	0

10. Calculate the average Age of the passengers. You may want to use the parameter na.rm = TRUE in the function mean.

```
a <- mean(titanic$Age, na.rm = T)
a
```

```
## [1] 29.69912
```

11. Replace the missing values of age by the average age calculated previously.

```r
titanic[is.na(titanic)] <- a
```

12. Remove columns Name, PassengerID, Ticket, and Cabin.

```r
titanic_dropped = subset(titanic, select = -c(Name, PassengerId, Ticket, Cabin))
head(titanic_dropped,10)
```

```
##    Survived Pclass    Sex      Age SibSp Parch    Fare Embarked
## 1         0      3   male 22.00000     1     0  7.2500        S
## 2         1      1 female 38.00000     1     0 71.2833        C
## 3         1      3 female 26.00000     0     0  7.9250        S
## 4         1      1 female 35.00000     1     0 53.1000        S
## 5         0      3   male 35.00000     0     0  8.0500        S
## 6         0      3   male 29.69912     0     0  8.4583        Q
## 7         0      1   male 54.00000     0     0 51.8625        S
## 8         0      3   male  2.00000     3     1 21.0750        S
## 9         1      3 female 27.00000     0     2 11.1333        S
## 10        1      2 female 14.00000     1     0 30.0708        C
```

13. Calculate the mean age of female passengers

```r
mean(titanic_dropped$Age[titanic_dropped$Sex == "female"])
```

```
## [1] 28.21673
```

14. Calculate the median fare of the passengers in Class 1

```r
median(titanic_dropped$Fare[titanic_dropped$Pclass == 1])
```

```
## [1] 60.2875
```

15. Calculate the median fare of the female passengers that are not in Class 1

```r
median(titanic_dropped$Fare[titanic_dropped$Sex == "female" & titanic_dropped$Pclass != 1])
```

```
## [1] 14.45625
```

16. Calculate the median age of survived passengers who are female and Class 1 or Class 2

```r
median(titanic_dropped$Age[titanic_dropped$Sex == "female" & titanic_dropped$Pclass == 1 | 2])
```

```
## [1] 29.69912
```

17. Calculate the mean fare of female teenagers survived passengers

```r
mean(titanic_dropped$Fare[titanic_dropped$Sex == "female" & titanic_dropped$Survived == 1])
```

```
## [1] 51.93857
```

18. Calculate the mean fare of female teenagers survived passengers for each class

```r
mean(titanic_dropped$Fare[titanic_dropped$Sex == "female" & titanic_dropped$Survived == 1 & titanic_dro
```

```
## [1] 105.9782
```

```r
mean(titanic_dropped$Fare[titanic_dropped$Sex == "female" & titanic_dropped$Survived == 1 & titanic_dro
```

```
## [1] 22.28899
```

```r
mean(titanic_dropped$Fare[titanic_dropped$Sex == "female" & titanic_dropped$Survived == 1 & titanic_dro
```

```
## [1] 12.46453
```

19. Calculate the ratio of Survived and not Survived for passengers who are who pays more than the average fare

```r
sum(titanic_dropped$Survived[titanic_dropped$Fare > mean(titanic_dropped$Fare)]) / length(titanic_droppe
```

```
## [1] 0.5971564
```

20. Add column that standardizes the fare (subtract the mean and divide by standard deviation) and name it sfare

```r
m <- mean(titanic_dropped$Fare)
s <- sd(titanic_dropped$Fare)

sfare <- c((titanic_dropped$Fare - m) / s)
new_Titanic <- cbind(titanic_dropped, sfare)
head(new_Titanic,10)
```

```
##    Survived Pclass    Sex      Age SibSp Parch    Fare Embarked
## 1         0      3   male 22.00000     1     0  7.2500        S
## 2         1      1 female 38.00000     1     0 71.2833        C
## 3         1      3 female 26.00000     0     0  7.9250        S
## 4         1      1 female 35.00000     1     0 53.1000        S
## 5         0      3   male 35.00000     0     0  8.0500        S
## 6         0      3   male 29.69912     0     0  8.4583        Q
## 7         0      1   male 54.00000     0     0 51.8625        S
## 8         0      3   male  2.00000     3     1 21.0750        S
## 9         1      3 female 27.00000     0     2 11.1333        S
## 10        1      2 female 14.00000     1     0 30.0708        C
##          sfare
## 1  -0.50216314
```

```
## 2   0.78640362
## 3  -0.48857985
## 4   0.42049407
## 5  -0.48606443
## 6  -0.47784805
## 7   0.39559138
## 8  -0.22395734
## 9  -0.42401800
## 10 -0.04293139
```

21. Add categorical variable named cfare that takes value cheap for passengers paying less the average fare and takes value expensive for passengers paying more than the average fare.

```
bins <- c(0, mean(new_Titanic$Fare), Inf)
bin_names <- c("cheap", "expensive")
new_Titanic$cfare <- cut(new_Titanic$Fare, breaks = bins, labels = bin_names)
head(new_Titanic,10)
```

```
##    Survived Pclass    Sex      Age SibSp Parch    Fare Embarked
## 1         0      3   male 22.00000     1     0  7.2500        S
## 2         1      1 female 38.00000     1     0 71.2833        C
## 3         1      3 female 26.00000     0     0  7.9250        S
## 4         1      1 female 35.00000     1     0 53.1000        S
## 5         0      3   male 35.00000     0     0  8.0500        S
## 6         0      3   male 29.69912     0     0  8.4583        Q
## 7         0      1   male 54.00000     0     0 51.8625        S
## 8         0      3   male  2.00000     3     1 21.0750        S
## 9         1      3 female 27.00000     0     2 11.1333        S
## 10        1      2 female 14.00000     1     0 30.0708        C
##          sfare     cfare
## 1  -0.50216314     cheap
## 2   0.78640362 expensive
## 3  -0.48857985     cheap
## 4   0.42049407 expensive
## 5  -0.48606443     cheap
## 6  -0.47784805     cheap
## 7   0.39559138 expensive
## 8  -0.22395734     cheap
## 9  -0.42401800     cheap
## 10 -0.04293139     cheap
```

22. Add categorical variable named cage that takes value 0 for age 0-10, 1 for age 10-20, 2 for age 20-30, and so on

```
age_bins <- c(0,10,20,30,40,50,60,70,80,90,Inf)
age_bin_names <- c(0,1,2,3,4,5,6,7,8,9)
new_Titanic$cAge <- cut(new_Titanic$Age, breaks = age_bins, labels = age_bin_names)
head(new_Titanic,10)
```

```
##    Survived Pclass    Sex      Age SibSp Parch    Fare Embarked
## 1         0      3   male 22.00000     1     0  7.2500        S
## 2         1      1 female 38.00000     1     0 71.2833        C
```

```
## 3         1      3 female 26.00000     0     0  7.9250        S
## 4         1      1 female 35.00000     1     0 53.1000        S
## 5         0      3   male 35.00000     0     0  8.0500        S
## 6         0      3   male 29.69912     0     0  8.4583        Q
## 7         0      1   male 54.00000     0     0 51.8625        S
## 8         0      3   male  2.00000     3     1 21.0750        S
## 9         1      3 female 27.00000     0     2 11.1333        S
## 10        1      2 female 14.00000     1     0 30.0708        C
##          sfare     cfare cAge
## 1  -0.50216314     cheap    2
## 2   0.78640362 expensive    3
## 3  -0.48857985     cheap    2
## 4   0.42049407 expensive    3
## 5  -0.48606443     cheap    3
## 6  -0.47784805     cheap    2
## 7   0.39559138 expensive    5
## 8  -0.22395734     cheap    0
## 9  -0.42401800     cheap    2
## 10 -0.04293139     cheap    1
```

23. Show the frequency of Ports of Embarkation. It appears that there are two missing values in the Embarked variable. Assign the most frequent port to the missing ports. Hint: Use the levels function to modify the categories of categorical variables.

```
table(new_Titanic$Embarked)
```

```
##
##       C   Q   S
##   2 168  77 644
```

```
levels(new_Titanic$Embarked)[1] <- "S"
table(new_Titanic$Embarked)
```

```
##
##   S   C   Q
## 646 168  77
```