(a) Random sampling *with or without replacement* using **sample()** function. (**Mandatory**)

➢ ***Introduction:-***

The **sample(x, n, replace = FALSE, prob = NULL)** function takes a sample from a vector **x** of size **n**. This sample can be **with** or **without replacement** and the probabilities of selecting each element to the sample can be either **the same for each element** or **a vector** informed by the user.

❖ Tossing **10** coins

sample(0:1, 10, replace = TRUE)
Output:- 0 0 1 0 0 1 1 0 0 1

❖ Roll **10** dice

sample(1:6, 10, replace = TRUE)
Output:- `1 4 3 6 1 2 5 5 2 5`

❖ Play lottery (**6** random numbers out of **50** *without replacement*)

sample(1:50, 6, replace = FALSE)
Output:- `31 15 25 20 22 48`

❖ ***Coin example:-***

sample(x, size = 5)
Output:- `1 2 0 0 3`

Now, let's perform our coin-flipping experiment just once.

```
coin = c("Heads", "Tails")
sample(coin, size = 1)
```
Output:- `"Tails"`

And now, let's try it **100** times

```
sample(coin, size = 100)
Error in sample(coin, size = 100) :
  cannot take a sample larger than the population when 'replace = FALSE'
```

Oops, we can't take a sample of size **100** from a vector of size **2**, unless we set the **replace** argument to **TRUE**.

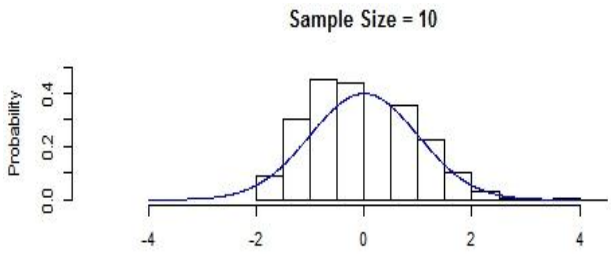
```
table(sample(coin, size = 100, replace = TRUE))
Heads Tails
   53    47
```

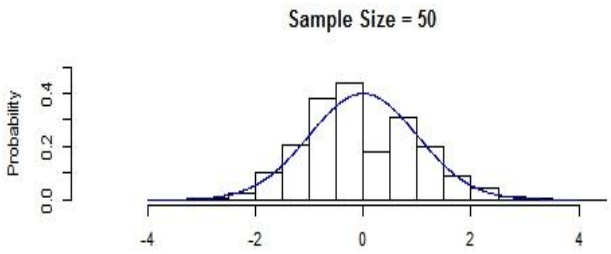
(b) Generate **n** random samples (take **n = 10, 50, 100, 200, 500, 1000** as an example), create a vector of Sample Means. Draw the **Density Plot** of Sample Means to visualize **Central Limit Theorem**. (**Mandatory**).

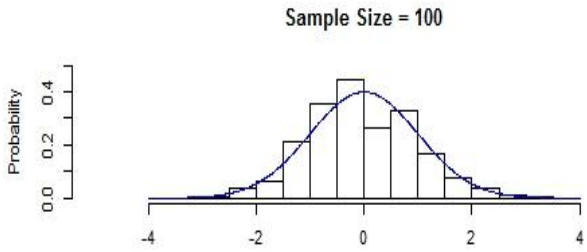
Solution:-

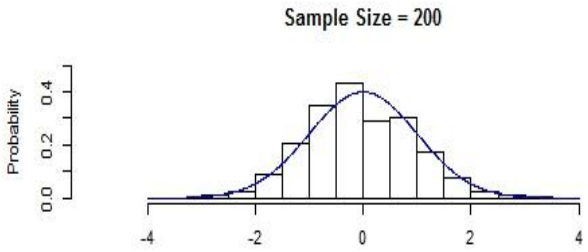
```
p <- 0.05
n <- 6
sims <- 4000
m <- c(10, 50, 100, 200, 500, 1000)
E.of.X <- n*p
V.of.X <- n*p*(1-p)
Z <- matrix(NA, nrow = sims, ncol = length(m))
for (i in 1:sims)
{
        for (j in 1:length(m))
        {
                samp <- rbinom(n = m[j], size = n, prob = p)
                sample.mean <- mean(samp)
                Z[i,j] <- (sample.mean - E.of.X) / sqrt(V.of.X/m[j])
        }
}
par(mfrow = c(3,2))
for (j in 1:6)
{
        hist(Z[,j], xlim = c(-5, 5), freq = FALSE, ylim = c(0, 0.5), ylab = "Probability",
        xlab = "", main = paste("Sample Size =", m[j]))
        x <- seq(-4, 4, by = 0.01)
        y <- dnorm(x)
        lines(x, y, col = "blue")
}
```

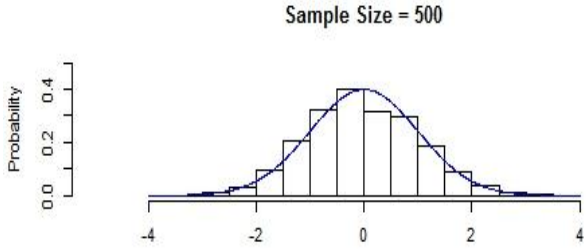
Output:-

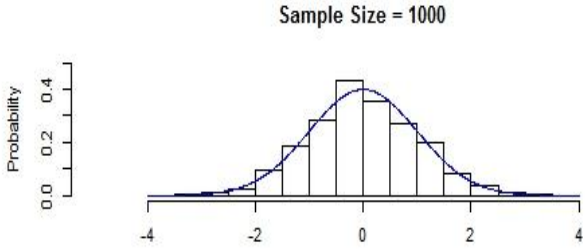

Sample Size = 10
Probability
0.0
0.2
0.4
-4
-2
0
2
4


Sample Size = 50
Probability
0.0
0.2
0.4
-4
-2
0
2
4


Sample Size = 100
Probability
0.0
0.2
0.4
-4
-2
0
2
4


Sample Size = 200
Probability
0.0
0.2
0.4
-4
-2
0
2
4


Sample Size = 500
Probability
0.0
0.2
0.4
-4
-2
0
2
4


Sample Size = 1000
Probability
0.0
0.2
0.4
-4
-2
0
2
4