R Notebook

Code ▾

Hide

```
# Wk= X1+...Xk (Binomial Random Variable)
Wk<-2*rbinom(200,1,0.5)-1
Wk
```

```
  [1]  1 -1 -1 -1 -1 -1 -1 -1  1  1  1 -1  1  1  1 -1  1  1  1 -1 -1  1 -1 -1 -1 -1
 [27]  1  1 -1 -1 -1 -1  1  1  1 -1  1 -1 -1  1  1 -1  1 -1  1  1 -1  1  1  1 -1  1
 [53] -1  1 -1 -1 -1  1 -1  1 -1  1  1  1  1 -1 -1  1  1 -1  1  1  1 -1 -1  1 -1 -1
 [79]  1 -1  1  1  1  1  1  1  1 -1 -1 -1  1  1 -1 -1 -1 -1  1 -1 -1  1 -1  1  1 -1
[105] -1 -1  1  1  1  1  1  1 -1 -1  1  1 -1 -1  1  1 -1  1 -1  1  1 -1  1 -1 -1 -1
[131] -1 -1  1  1  1  1  1  1 -1  1  1  1 -1 -1  1 -1 -1  1  1 -1 -1 -1 -1  1  1  1
[157]  1  1 -1  1 -1 -1 -1  1 -1 -1 -1  1 -1 -1 -1 -1  1 -1 -1  1  1  1 -1 -1 -1  1
[183]  1 -1 -1  1  1 -1 -1  1  1  1  1  1 -1 -1 -1 -1  1 -1
```

Hide

```
w<-sum(Wk)
w
```

```
[1] 2
```

Hide

```
#Another method would be by using the sample function.
Wk1<-sample(c(1,-1),200,replace=T,prob=c(0.5,0.5))
Wk1
```

```
  [1] -1  1 -1  1  1 -1  1 -1  1 -1 -1  1 -1 -1 -1  1  1 -1  1  1 -1 -1 -1 -1 -1 -1
 [27] -1 -1 -1  1  1 -1  1 -1 -1  1  1  1 -1  1 -1  1  1  1  1 -1  1  1 -1 -1  1  1
 [53] -1 -1 -1  1 -1  1 -1  1  1 -1  1 -1 -1 -1  1  1 -1  1  1  1 -1  1  1 -1 -1  1
 [79] -1 -1 -1  1  1  1 -1  1  1  1  1 -1  1  1 -1  1 -1 -1  1 -1 -1 -1  1  1  1 -1
[105]  1  1 -1 -1  1 -1  1 -1 -1  1 -1  1 -1  1  1 -1 -1 -1  1  1 -1 -1 -1 -1 -1 -1
[131]  1 -1 -1 -1 -1 -1  1 -1  1  1  1  1 -1  1 -1  1 -1 -1  1  1 -1  1 -1  1  1  1
[157]  1 -1 -1 -1 -1 -1 -1  1  1 -1  1 -1  1 -1  1  1  1 -1  1 -1 -1 -1  1  1 -1 -1
[183] -1  1 -1 -1  1  1 -1  1  1  1  1  1 -1 -1  1 -1 -1  1
```

Hide

```
#a) create a vector below to simulate the probability of Wk >= 10

Forward <- rep(0,200)
for (i in 1:100000){Forward[i] <- as.numeric(sum(2*rbinom(200,1,0.5)-1) >= 10)}
#Simulation Result
Forward
```

```
  [1] 0 1 1 1 1 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0
 [40] 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 1 1 1 0 1 0 0 0 0 1 1 0 0 1 0 0
 [79] 1 0 0 1 1 1 0 1 0 1 1 0 0 0 1 1 0 0 1 1 0 0 0 0 0 1 0 0 1 0 1 1 0 0 0 0 0 0 0
[118] 0 1 0 0 0 0 0 1 0 0 0 1 0 0 1 1 0 0 1 0 1 0 1 0 0 0 0 0 0 0 0 0 0 1 1 0 1 0 0
[157] 0 0 0 0 1 0 0 1 0 0 0 1 1 0 0 0 0 0 0 1 0 1 0 0 0 0 1 1 0 0 1 0 0 0 0 0 0 0 0
[196] 0 0 1 1 0 0 1 1 1 0 0 0 0 1 0 0 1 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
[235] 1 0 0 0 1 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1
[274] 0 1 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0
[313] 1 0 1 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 1 0 1 0 0 1 0 0 0 0 1 1
[352] 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 1 0 1
[391] 0 0 0 0 0 1 0 0 0 1 0 0 1 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0
[430] 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 1 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 1 1 1 0 1 1 1
[469] 1 1 1 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 0 1 0 1 0 0
[508] 0 1 0 1 1 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 1 1 0 1 0 1 1 0 0 0 0 0
[547] 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 1 0 0 0 1 0 0 0 0 0 1 0 1 0 0 0 0 1 0 0 0 0 0
[586] 0 0 1 0 1 0 0 0 0 1 1 0 1 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 1 0 1 0 0 0 0 1 0 0 0
[625] 0 0 0 0 0 0 0 0 1 1 1 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 1 1
[664] 0 0 0 0 1 0 0 0 0 0 1 0 1 0 0 0 0 0 1 0 0 1 0 0 0 1 1 1 0 0 1 0 0 0 1 0 1 0 0
[703] 0 1 0 0 1 1 0 0 1 0 0 0 1 0 0 1 1 0 0 1 0 0 0 0 1 0 0 1 0 0 0 0 0 1 0 0 0 0 1
[742] 0 1 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 0 1 0 1
[781] 0 0 0 0 1 0 0 0 0 1 0 0 0 0 1 0 0 1 0 1 0 1 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0
[820] 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 0 0 0
[859] 0 0 0 1 0 0 1 0 0 1 0 1 1 0 1 0 0 0 1 0 0 1 1 1 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0
[898] 0 0 0 0 1 1 0 0 1 0 0 1 1 0 0 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 1 1
[937] 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 1 0 0 0 0 1 0 1 0 0 0 1
[976] 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0
[ reached getOption("max.print") -- omitted 99000 entries ]
```

Hide

```r
mean(Forward)
```

```
[1] 0.25825
```

Hide

```r
#b) create a vector below to simulate the probability of max(1<=k<=200) Wk >= 10

Forward1 <- rep(0,200)
for (i in 1:100000){Forward1[i] <- as.numeric(max(cumsum(2*rbinom(200,1,0.5)-1)) >= 10)}
Forward1
```

```
  [1] 1 1 0 0 0 0 0 0 1 1 1 0 1 1 1 1 1 0 1 0 1 1 0 1 1 1 1 0 1 1 1 0 1 0 1 0 0 1 0
 [40] 0 0 1 1 1 1 1 1 1 1 0 0 0 0 1 0 1 1 1 0 0 0 0 0 1 1 1 0 0 1 0 0 1 1 1 0 0 1 0
 [79] 0 1 0 1 0 1 0 0 1 1 1 1 1 0 1 1 1 0 1 0 0 1 0 1 0 0 0 1 0 0 0 1 0 1 0 1 1 0 1
[118] 1 1 1 1 0 0 0 0 0 1 1 0 0 0 1 0 0 1 0 1 1 1 1 0 0 1 1 0 1 0 0 0 0 0 0 0 1 0 1
[157] 1 1 0 1 0 0 0 1 0 0 1 0 1 1 0 0 1 0 0 0 1 0 1 1 0 1 0 1 0 1 1 0 0 1 0 1 0 1 1
[196] 0 1 0 1 0 1 1 0 1 1 1 0 0 1 0 0 1 0 1 0 1 1 1 0 1 0 0 1 0 1 0 0 0 0 1 0 0 0 0
[235] 1 0 0 1 0 1 1 1 1 0 0 1 1 1 1 0 0 0 1 0 1 0 1 1 0 0 1 0 1 1 0 1 0 1 0 0 0 0 1
[274] 0 1 1 0 0 1 0 0 0 1 0 0 1 1 0 0 0 0 1 1 1 0 0 1 0 0 1 1 0 1 0 0 0 0 1 0 0 0 0
[313] 0 0 0 0 1 1 1 1 1 0 0 1 1 0 0 0 0 1 1 1 0 1 1 1 0 1 0 0 1 1 0 0 0 0 0 1 0 0 1
[352] 0 1 1 1 0 0 0 1 0 0 0 1 1 1 0 0 0 1 1 0 1 0 0 0 0 1 0 0 1 0 1 0 0 1 1 1 0 1 1
[391] 0 0 0 0 0 1 0 0 0 0 1 0 1 0 0 0 0 1 1 1 1 1 0 1 0 0 0 1 1 1 1 1 1 1 1 0 1 0 0
[430] 1 1 1 1 0 0 0 1 1 0 1 1 0 1 0 1 0 0 0 1 0 0 1 0 1 1 1 0 0 0 1 1 1 1 0 0 0 0 0
[469] 1 1 1 0 0 0 1 1 0 1 0 0 1 0 0 0 0 0 0 1 0 0 0 1 0 1 0 0 0 1 1 1 0 0 0 0 0 1 1
[508] 1 0 1 1 1 1 0 1 1 1 1 1 0 1 0 0 0 1 0 0 0 0 1 0 0 0 0 0 1 0 1 0 1 0 1 0 1 1 1
[547] 0 1 0 1 0 1 1 0 1 0 0 0 1 0 1 0 0 1 0 0 0 1 0 0 1 0 1 1 0 0 1 0 1 0 1 0 0 0 0
[586] 0 0 0 0 0 0 1 0 1 1 1 0 0 1 1 1 0 0 1 0 0 0 0 0 0 1 1 1 1 0 0 1 1 0 0 1 1 0 1
[625] 1 0 1 1 0 0 1 1 0 1 0 0 1 0 1 1 1 0 1 0 1 1 1 0 1 1 1 1 0 0 1 1 0 1 0 0 1 1 0
[664] 0 1 1 0 0 1 1 0 1 0 1 1 1 0 1 0 1 1 0 0 0 0 0 0 1 1 0 1 1 0 1 1 0 1 1 1 1 1 0
[703] 0 1 1 1 0 0 0 0 1 0 1 1 1 1 0 0 0 0 0 1 1 0 0 0 0 0 1 1 1 1 1 1 1 0 1 1 1 1 1
[742] 1 0 1 1 0 1 1 0 0 0 1 1 1 1 0 0 0 0 0 1 1 1 1 0 0 0 1 1 1 1 0 0 1 0 0 1 0 0 1
[781] 0 1 1 0 1 1 1 1 1 1 0 1 0 1 0 1 1 1 1 1 0 0 1 1 0 1 0 0 1 0 0 0 0 1 1 0 0 1 0
[820] 0 1 0 0 1 0 1 0 1 0 0 0 0 1 1 0 0 1 1 0 0 0 0 0 1 0 0 0 0 1 0 0 1 0 1 1 0 0 0
[859] 0 0 1 1 1 1 1 1 0 0 1 1 1 0 1 1 0 0 1 1 0 1 1 0 0 1 1 0 1 0 0 1 1 1 1 0 1 1 0
[898] 0 1 1 0 0 1 1 1 1 1 1 1 0 0 0 0 1 0 1 0 0 1 1 0 1 0 0 1 0 1 1 0 0 0 1 0 0 1 1
[937] 1 0 0 1 0 0 1 0 0 0 1 1 0 0 0 1 0 0 0 0 1 0 0 1 1 0 0 0 0 0 0 1 0 0 1 0 0 1 1
[976] 1 1 1 1 0 0 0 0 1 0 0 1 0 0 1 1 0 1 0 1 1 0 1 1 0
[ reached getOption("max.print") -- omitted 99000 entries ]
```

Hide

```
mean(Forward1)
```

```
[1] 0.48127
```

Hide

```
#c)

# Theoretical

# pbinom
#Note: 2*sum(Bj) >=1*200+10
pbinom(104, 200, 0.5, lower.tail = FALSE)
```

```
[1] 0.2623112
```

Hide

```
# pbinom is calculating the cumulative probability of getting a result equal to or bigger tha
n 10 and for the simulation result runned 100 000 times, 26.4% of the times the values were b
igger or equal to 10, whereas theoretically 26.23% of the times the values where bigger or eq
ual to 10, but it can vary.
```

Hide

```
#2-Vk= Y1+...Yk (Binomial Random Variable)
Vk<-2*rbinom(200,1,0.55)-1
Vk
```

```
  [1] -1  1  1  1  1  1  1  1 -1  1 -1 -1  1 -1 -1  1 -1 -1  1 -1 -1 -1  1  1 -1  1
 [27] -1  1  1 -1 -1 -1  1  1 -1  1 -1 -1 -1  1  1 -1  1  1 -1  1 -1 -1  1  1 -1  1
 [53]  1 -1  1 -1  1 -1  1 -1 -1  1 -1  1  1 -1  1 -1  1  1  1 -1 -1  1  1 -1 -1  1
 [79]  1  1  1 -1  1 -1 -1  1  1  1  1 -1 -1  1  1 -1  1  1 -1 -1  1  1 -1 -1  1 -1
[105] -1  1 -1 -1  1 -1  1 -1  1  1  1  1 -1 -1  1 -1  1  1  1 -1  1  1  1 -1 -1 -1
[131]  1  1 -1 -1  1 -1  1  1 -1  1  1  1 -1  1  1 -1  1  1 -1  1  1  1  1  1  1 -1
[157] -1  1 -1 -1 -1  1 -1  1  1 -1 -1 -1  1  1  1 -1  1  1 -1  1 -1 -1 -1 -1  1  1
[183]  1 -1 -1  1 -1  1 -1 -1 -1  1  1 -1  1 -1  1 -1  1 -1
```

Hide

```
#Another method would be by using the sample function.
Vk1<-sample(c(1,-1),200,replace=T,prob=c(0.55,0.45))
Vk1
```

```
  [1] -1 -1 -1 -1 -1  1 -1 -1  1  1 -1 -1  1  1  1  1 -1  1 -1 -1 -1  1 -1 -1  1 -1
 [27]  1 -1 -1 -1 -1 -1 -1  1  1  1  1 -1 -1 -1 -1  1  1 -1  1  1  1 -1 -1 -1  1  1
 [53]  1  1 -1 -1  1  1 -1 -1 -1 -1  1 -1 -1 -1  1  1 -1  1  1  1 -1  1 -1 -1  1 -1
 [79] -1  1  1  1  1  1  1 -1  1 -1  1 -1 -1 -1  1  1 -1 -1 -1 -1  1 -1 -1  1 -1  1
[105]  1 -1 -1  1 -1  1 -1  1 -1 -1  1  1 -1  1  1 -1  1  1 -1  1  1  1  1  1  1  1
[131] -1 -1 -1 -1  1  1 -1 -1 -1 -1  1  1 -1 -1 -1  1 -1 -1 -1  1  1  1 -1 -1  1 -1
[157]  1 -1 -1  1 -1 -1  1 -1 -1  1 -1 -1 -1  1  1  1 -1  1 -1 -1  1  1  1 -1  1 -1
[183] -1 -1  1 -1  1  1  1 -1 -1 -1 -1  1  1  1  1  1 -1 -1
```

Hide

```
#a) create a vector below to simulate the probability of Wk >= 10

Forward2 <- rep(0,200)
for (i in 1:100000){Forward2[i] <- as.numeric(sum(2*rbinom(200,1,0.55)-1) >= 10)}
#Simulation Result
Forward2
```

```
  [1] 0 1 0 1 1 1 1 1 1 0 1 1 1 1 1 0 1 1 1 0 1 1 1 1 1 1 1 0 1 1 0 1 1 1 1 1 1 0 1
 [40] 1 1 0 1 1 1 0 1 1 1 1 1 1 0 1 1 0 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 0 1 0 1
 [79] 0 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 0 0 1 1 1 1 0 1 0 0 0 1 1 1 1 1 1 1 1 1 1
[118] 1 0 0 1 0 1 0 1 1 1 0 1 1 1 1 1 1 0 1 1 1 0 0 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1
[157] 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 0 1 0 1 1 1 1 0 1 1 1 1 1 1 0 0 0 1 1 1 1
[196] 1 0 0 0 0 1 1 1 1 1 1 1 0 1 1 1 0 1 1 0 0 1 1 0 1 1 1 0 1 1 1 0 1 1 1 1 0 1 0
[235] 1 1 1 1 0 1 1 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 0 1 1 0 1 1 1 1 1 1 1 0 1 0 1 1
[274] 1 0 1 1 1 0 1 1 1 1 1 1 0 1 1 1 0 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 0 1 1 1
[313] 1 0 1 0 0 1 1 0 1 1 1 0 1 1 1 1 1 1 0 1 1 1 0 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1
[352] 1 1 1 1 1 0 1 1 0 1 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 0 0 0 1
[391] 1 1 1 1 0 1 1 1 1 0 0 1 0 0 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 0 1 1 1 1 1 0
[430] 1 1 1 0 1 0 1 1 1 0 0 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 0 1 1 0 0 0 1 1 1 0 0 1 1
[469] 1 1 1 1 1 1 1 1 0 1 0 0 1 1 1 1 1 0 0 1 1 1 1 1 0 1 0 0 1 1 1 1 1 1 0 1 1 1 1
[508] 1 1 0 1 1 1 1 1 1 0 1 1 0 1 1 1 1 0 1 1 1 1 1 0 1 0 1 1 1 1 1 1 1 0 0 1 1 0 1
[547] 1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1
[586] 1 1 1 1 1 1 1 1 1 1 1 0 1 1 0 0 0 1 1 1 1 1 0 1 0 1 1 1 0 1 1 1 1 0 1 1 1 1 1
[625] 1 1 1 1 1 1 1 0 1 1 1 1 0 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 0 1 0 1 1 1 0
[664] 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1 0 0 1 1 1 1 1 0 1 1 1 0 1 1 1 1 1 1 0 1 1 0 0
[703] 1 1 1 1 1 1 1 1 1 1 1 0 1 0 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 0 1 1 1 1 1 0 0
[742] 0 1 1 1 1 0 1 1 1 1 1 0 0 1 1 0 1 1 0 1 1 1 1 1 0 1 1 1 1 1 1 0 0 0 1 1 1 1 0
[781] 1 1 1 1 0 0 1 1 0 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 0 1 1 1
[820] 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 0 1 0 1 0 1 1 0 1 1 0 0 1 1 0 1 1 1 1
[859] 1 1 1 1 0 1 0 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 0 1 1 1 0 1 1 1 1 1 1 1
[898] 0 0 1 1 0 1 0 0 1 1 1 1 1 1 0 1 1 1 1 1 0 1 1 0 1 0 1 1 0 1 1 1 0 1 1 1 1 1 0
[937] 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 0 1 1 1 1 1 1 0 0 1 0 1 0 1 1 1 0 1 0 1 1 1
[976] 1 1 1 1 0 1 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 0 1
 [ reached getOption("max.print") -- omitted 99000 entries ]
```

Hide

```
mean(Forward2)
```

```
[1] 0.78305
```

Hide

```
#b) create a vector below to simulate the probability of max(1<=k<=200) Wk >= 10

Forward3 <- rep(0,200)
for (i in 1:100000){Forward3[i] <- as.numeric(max(cumsum(2*rbinom(200,1,0.55)-1)) >= 10)}
Forward3
```

```
   [1] 1 0 1 1 1 0 1 1 1 0 1 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 0 1
  [40] 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 0 1 1 1 1 1 1 0 1 1 1 1 0 1 1 1 1 1 1 1 0 1 0
  [79] 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 0
 [118] 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 0 1 1 1 1 1 1 1
 [157] 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 [196] 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 0 1 1 1 1 0 1
 [235] 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 [274] 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 1 1
 [313] 1 1 1 1 0 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 0 1 1 0 1 1 1 1 0 1 0
 [352] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 0 0 1 1
 [391] 1 1 0 0 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 0 1 1 1 0 1 1 1 1
 [430] 1 1 1 1 1 0 1 1 0 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1
 [469] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 0 1 0 1
 [508] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 0 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1
 [547] 1 0 1 1 1 1 0 1 1 1 0 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 [586] 1 1 1 1 1 0 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 0 0 1
 [625] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1
 [664] 1 1 1 1 1 1 0 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 0 1 1 1 1 0 0 1
 [703] 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 0 1 1 1 1 1 1 1 1 1
 [742] 1 1 1 1 1 1 0 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0 1 1 1 1 1 1 1 0
 [781] 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1
 [820] 1 1 1 1 1 1 1 1 1 0 1 1 0 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 [859] 1 0 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 0 1 1 1 1 1 1
 [898] 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 0
 [937] 1 0 1 1 1 1 1 1 1 1 1 0 1 0 1 1 1 1 1 1 1 1 0 1 1 1 0 1 1 1 1 1 0 1 1 1 1 1 1
 [976] 1 1 1 1 1 1 1 0 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 0 1
 [ reached getOption("max.print") -- omitted 99000 entries ]
```

Hide

```
mean(Forward3)
```

```
[1] 0.8889
```

Hide

```
# Theoretical

# pbinom
#Note: 2*sum(Bj) >=1*200+10
pbinom(104, 200, 0.55, lower.tail = FALSE)
```

```
[1] 0.78305
```

Hide

```
# pbinom is calculating the cumulative probability of getting a result equal to or bigger tha
n 10 and for the simulation result runned 100 000 times, 78.3% of the times the values were b
igger or equal to 10, whereas theoretically 78.31% of the times the values where bigger or eq
ual to 10, but it can vary.
```

Hide

```
#3- Uk= Z1+...Zk (Normal Random Variable)
Uk<-rnorm(200,mean=0, sd=1)
Uk
```

```
  [1] -0.869127604 -2.020300768 -1.285650697 -0.326393481 -0.087500036  0.249767239
  [7]  0.356693924  0.182340957  0.437081046 -0.412481818 -1.979036354  0.406420867
 [13]  0.044685302 -1.406610792  2.599205007  1.040369149  2.030855803  0.337940269
 [19]  2.238440970  1.126256353  0.426141308  1.715821099  0.006734780  1.115350850
 [25]  0.191985217 -1.050180773 -0.007805107 -0.560920301  1.111927215 -0.542579865
 [31] -0.172802541  0.541566836  0.286392109 -1.974744114 -0.642683631 -0.694615982
 [37]  0.394270999  0.486367520 -1.662690556 -0.770712255  2.581219947  0.363621338
 [43]  0.690701874 -2.950612702 -1.102123566  0.123677549 -0.880728729  0.437706832
 [49]  1.117407778 -1.055084808  0.028939497 -0.562933648  0.734026747 -0.175986284
 [55]  0.459950447 -1.695172276 -0.838864958 -0.463708743 -1.144437255  1.364497290
 [61] -0.893480464 -1.329004306 -0.573795394 -0.881043228 -0.506268116 -0.922617566
 [67] -1.797258635 -1.086255133 -0.506521379  0.555207584 -1.410592161 -1.330286671
 [73]  1.822881236 -0.325560901 -0.046735685  0.392948955 -0.869001800 -0.979325216
 [79]  0.357429049 -0.785561308  0.107853762  0.704790219 -0.540002898 -0.056695314
 [85] -1.740317440 -0.488958209  1.475799046  0.470515006  0.888574680  0.001011775
 [91] -0.936729929  0.152848770 -1.922397395  1.675913842  0.088970520  1.349154574
 [97] -1.292249759 -1.487036974  0.660398039  0.925530089 -0.019795788 -0.158646656
[103] -0.188074865 -1.427963502 -0.894978742 -0.816198678 -0.515069632  0.595300387
[109]  0.548866030  0.117366914  0.170271072 -0.439981548  0.219280804 -0.614253024
[115] -0.219524208 -0.713776904 -0.245057008  0.570538559  0.856696823 -0.381232514
[121] -1.060901490 -0.695882233 -0.842275412  0.309310923 -0.459707428 -0.519805584
[127] -1.193648545 -1.301454459 -0.866412962 -1.127753550 -2.286410971  0.630110886
[133]  0.974269578 -1.636131314  0.410987194  1.013308232  1.360474169  0.696167278
[139] -0.379220647 -0.099377775 -2.512788325 -0.408544384  2.265503048  1.382585878
[145]  0.086741588 -1.591264297  1.069864490 -0.255661813 -0.582064819  0.227617972
[151] -0.415090817  0.550478048  0.143404285 -0.713768013  0.495659158  1.197113169
[157]  1.120591630  0.855748042  1.113502552 -0.992186598  0.215697566 -1.365558221
[163]  0.342391799  0.828804986  2.067183632  1.497159008 -1.642404132 -0.967888058
[169] -0.955438617  0.558787300 -1.144891258 -1.539764303 -1.488569654  0.398855370
[175] -0.308604992 -1.264105009  1.021337733 -0.179949376 -0.336202234  0.442611481
[181] -0.217111775  0.037576295  0.807411799 -0.183342727  1.108883727 -0.237071745
[187]  0.262104055  0.834387744 -0.355860204  0.256551626 -1.834036528  1.156058376
[193] -1.343437704 -0.595666033  0.403331982 -0.363511892  0.036138899  0.048143091
[199]  0.973880052 -0.411447919
```

Hide

```
sum(Uk)
```

```
[1] -24.21671
```

Hide

```r
#a) create a vector below to simulate the probability of Wk >= 10

Forward4 <- rep(0,200)
for (i in 1:100000){Forward4[i] <- as.numeric(sum(rnorm(200,mean=0, sd=1)) >= 10)}

#Simulation Result
Forward4
```

```
  [1] 0 1 0 1 0 0 1 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0
 [40] 0 1 0 0 0 1 0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
 [79] 0 0 0 0 0 0 0 0 0 1 0 0 1 0 1 1 0 0 0 1 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0
[118] 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 1 0 0 0 0
[157] 1 0 0 0 1 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 1 1 1 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 1
[196] 0 0 0 0 1 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 1 1 1 0 0 0
[235] 1 0 0 0 0 1 0 0 0 1 1 0 0 0 0 0 1 0 0 0 0 1 1 0 0 0 1 1 0 1 0 0 0 0 0 0 0 1 0
[274] 0 0 0 0 0 1 0 0 0 0 0 1 0 1 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 1 0 0
[313] 0 0 1 0 1 0 0 0 1 0 0 0 1 0 0 0 0 0 1 1 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 1 1 0
[352] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 1 0 1 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0
[391] 1 0 1 1 1 1 0 0 0 0 0 0 0 0 1 1 0 0 0 1 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0
[430] 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 1 0 0 1 1 0 0 0 0 0
[469] 0 0 0 1 1 0 0 1 1 1 0 1 1 0 0 1 0 0 0 0 1 1 0 0 0 0 1 1 0 0 1 0 0 1 1 1 0 0 0
[508] 0 0 0 0 0 0 0 0 1 1 1 1 0 0 0 0 1 0 0 0 0 1 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 1 0
[547] 1 0 0 0 0 1 1 0 1 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0
[586] 0 1 0 1 0 0 0 0 0 0 1 1 0 0 0 0 0 0 1 0 0 0 1 1 1 0 0 0 0 0 1 1 1 1 0 0 1 0 0
[625] 0 1 0 1 0 0 0 0 0 0 1 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 1 1 0 1 0 1 0 0 1 1 0 0 0
[664] 0 0 0 0 0 0 0 1 0 0 0 0 1 0 1 1 1 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0
[703] 1 0 0 0 0 0 1 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 1 1 1
[742] 0 0 0 0 0 1 1 1 0 0 0 0 0 0 1 0 1 0 1 0 0 0 1 1 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0
[781] 1 0 0 0 0 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 0 0 0 0 0 1 0 0 0 1 0 0 1 0 0 0 0 0 0
[820] 0 0 1 1 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 1 1 1 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 1 1
[859] 0 0 1 0 0 1 0 0 1 0 1 0 0 0 0 0 0 1 0 1 0 1 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1
[898] 1 0 0 1 1 0 1 0 1 0 1 0 0 0 1 1 1 0 1 0 1 0 0 1 0 0 0 0 1 0 1 0 0 0 0 1 0 1 0
[937] 0 0 1 1 0 0 1 1 1 0 0 0 1 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0
[976] 0 0 1 1 0 0 0 0 1 1 0 1 0 1 1 0 1 1 0 1 1 0 1 0 0
 [ reached getOption("max.print") -- omitted 99000 entries ]
```

Hide

```r
mean(Forward4)
```

```
[1] 0.24056
```

Hide

```r
#b) create a vector below to simulate the probability of max(cumsum(1<=k<=200)) Wk >= 10

Forward5 <- rep(0,200)
for (i in 1:100000){Forward5[i] <- as.numeric(max(cumsum(rnorm(200))) >= 10)}
Forward5
```

```
   [1] 0 1 1 0 1 0 1 1 1 0 0 0 1 1 1 0 0 0 0 1 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 1 1
  [40] 0 0 0 1 0 1 0 1 1 0 0 0 1 0 1 0 0 0 1 0 0 1 1 1 1 0 1 0 1 1 0 1 1 0 1 0 0 1 1
  [79] 0 0 0 1 0 1 0 0 1 1 0 1 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 1 0 1 0 0 1 1 0 0 1 1
 [118] 1 1 0 1 0 0 1 1 0 1 0 1 0 0 1 0 0 1 1 0 0 1 1 0 0 0 1 0 1 0 1 0 1 1 0 1 1 0 0
 [157] 1 1 0 1 0 1 0 0 1 1 0 1 1 0 0 0 1 0 0 0 0 1 0 1 1 0 0 0 1 1 0 0 1 1 0 1 1 1 0
 [196] 1 1 0 0 1 0 1 1 0 0 1 0 1 1 1 0 1 0 0 0 0 0 0 1 0 0 0 0 1 1 0 1 0 1 0 1 1 1
 [235] 1 1 1 0 0 0 0 0 0 1 1 0 0 0 1 0 0 1 1 1 1 1 1 0 0 0 0 1 0 0 0 1 1 1 1 0 0 1 0
 [274] 0 0 1 1 0 0 0 0 0 1 1 0 0 1 1 1 1 0 0 1 1 1 0 0 0 0 1 0 1 1 1 1 1 0 0 1 1 1 1
 [313] 0 1 0 0 0 0 0 1 0 1 0 0 1 0 1 1 1 1 0 0 1 0 1 1 1 1 1 1 0 1 1 1 1 0 0 0 0 0 1
 [352] 0 1 0 1 1 0 0 1 1 1 0 0 0 1 1 0 0 1 0 0 0 0 0 0 0 0 0 1 1 0 0 1 1 1 1 1 1 0 0
 [391] 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 1 1 1 1 0 1 1 0 1 1 0 1 1 0 0 0 0 0
 [430] 0 1 0 0 0 1 1 0 0 1 1 1 0 1 0 0 1 1 1 0 1 1 1 0 0 1 1 0 0 0 1 1 1 0 1 0 0 0 0
 [469] 1 0 1 1 1 0 1 0 0 1 0 1 0 1 1 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 1 0 0 1 1 1 0
 [508] 0 1 0 1 0 1 1 1 1 0 1 1 0 1 0 1 1 0 1 1 0 1 0 1 0 1 0 1 0 1 1 0 0 1 0 0 0 0 1
 [547] 0 0 1 1 0 1 0 0 0 0 0 0 0 1 0 0 0 1 1 0 0 1 0 0 1 0 0 1 1 1 1 1 0 0 1 0 1 1
 [586] 1 1 1 1 1 0 0 1 0 0 1 0 1 1 0 1 0 1 0 0 0 1 0 1 1 1 1 1 1 1 1 1 0 0 0 1 1 0 1
 [625] 1 0 0 0 1 1 1 0 0 0 0 0 0 0 1 1 1 1 0 0 0 1 0 0 1 1 1 1 1 1 0 0 1 1 1 1 1 0 0
 [664] 0 0 0 1 1 0 0 0 0 1 0 1 0 0 0 0 0 1 0 1 1 0 0 1 0 1 1 1 1 0 1 1 1 0 1 1 0 1 1
 [703] 1 1 1 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 1 0 0 1 1 1 1 0 0 1 0 1 0 0 1 1 0 0
 [742] 1 1 1 1 0 1 1 0 1 1 0 0 0 0 0 1 1 0 0 0 1 1 1 1 0 0 0 0 1 1 0 1 1 1 1 1 0 0 0
 [781] 1 1 0 0 1 0 1 1 0 1 1 0 1 1 1 0 1 1 1 1 1 1 1 1 1 1 0 1 0 1 1 0 0 0 1 1 1 0 0
 [820] 0 0 0 1 0 0 1 0 0 0 0 1 0 0 0 0 1 1 0 1 0 1 0 0 1 0 0 0 0 1 0 1 0 1 0 1 0 0 0
 [859] 1 0 1 0 0 1 1 0 0 0 0 0 1 0 0 1 1 0 1 0 1 0 0 1 1 1 0 1 0 1 0 1 0 1 1 1 1 0 0
 [898] 1 0 1 0 0 0 0 0 0 0 1 1 0 0 0 0 1 0 1 1 0 0 1 1 1 1 1 0 0 1 0 1 1 0 0 1 0 1 1
 [937] 0 0 1 0 1 1 0 1 0 0 0 0 1 1 1 1 0 1 0 1 1 1 1 1 0 0 0 0 1 1 0 0 0 0 0 0 0 1 0
 [976] 0 1 0 1 1 0 1 1 1 0 0 0 0 0 0 0 1 1 0 0 1 0 1 0 0
 [ reached getOption("max.print") -- omitted 99000 entries ]
```

Hide

```
mean(Forward5)
```

```
[1] 0.4541
```

Hide

```
#Theoretically

pnorm(10/(sqrt(200)), lower.tail = FALSE)
```

```
[1] 0.2397501
```

Hide

```
# pnorm is calculating the cumulative probability of getting a result equal to or bigger than
10 and for the simulation result runned 100 000 times, 23.96% of the times the values were bi
gger or equal to 10, whereas theoretically 23.98% of the times the values where bigger or equ
al to 10, but it can vary.
```