Introduction to Statistics and Computation with Data: AppleBread Problem Solution 1

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```
#set.seed(2024)
library(tidyverse)
```

```
## Warning: package 'ggplot2' was built under R version 4.3.3
```

```
## Warning: package 'tidyr' was built under R version 4.3.3
```

```
## -- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
## v dplyr     1.1.4     v readr     2.1.5
## v forcats   1.0.0     v stringr   1.5.1
## v ggplot2   3.5.0     v tibble    3.2.1
## v lubridate 1.9.3     v tidyr     1.3.1
## v purrr     1.0.2
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

```
library(viridis)
```

```
## Loading required package: viridisLite
```

Challenge 1]

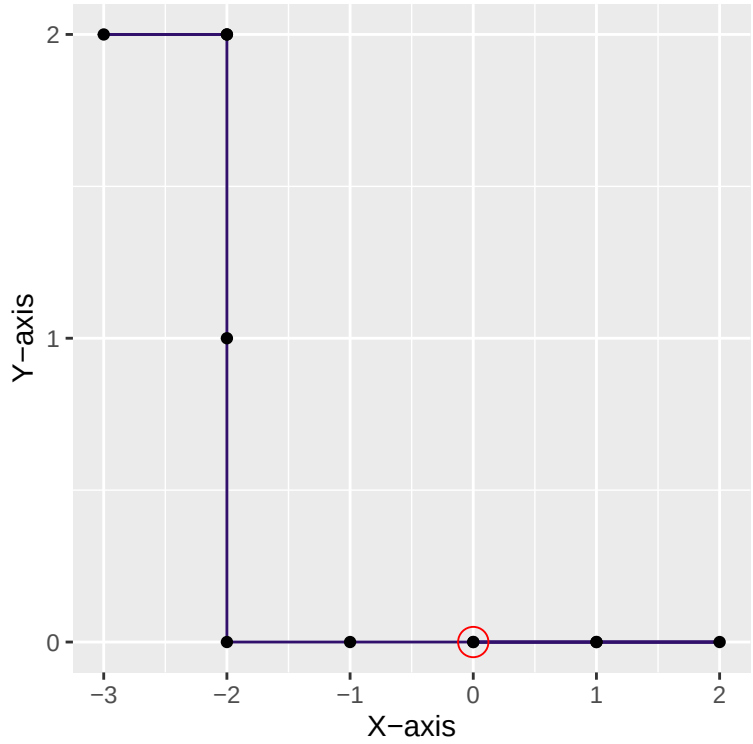
```
step= c(1, -1, 1i, -1i) #Creating a vector containing the possible moves
```

(a)

```
start_pt= 0 +0i #Initialization
moves= sample(step, 10, replace = T) #Randomly choosing moves with equal probability
positions= c(start_pt, start_pt + cumsum(moves)) #Storing the positions by cumulatively
#adding the moves to the start_pt
positions #Displaying the positions as complex numbers
```

```
##  [1]  0+0i  1+0i  2+0i  1+0i  0+0i -1+0i -2+0i -2+1i -2+2i -3+2i -2+2i
```

```
ggplot() +
  geom_path(mapping = aes(x = Re(positions),
                          y = Im(positions)),
            colour= "#30106B") + #Plotting the path
  geom_point(mapping= aes(Re(start_pt), Im(start_pt)),
             colour= "red", pch= 1, size= 5) + #Plotting the start_pt
  geom_point(mapping= aes(Re(positions), Im(positions))) +
  scale_x_continuous(breaks = seq(-10, 10, by = 1)) +
  scale_y_continuous(breaks = seq(-10, 10, by = 1)) +
  xlab("X-axis") + ylab("Y-axis")
```



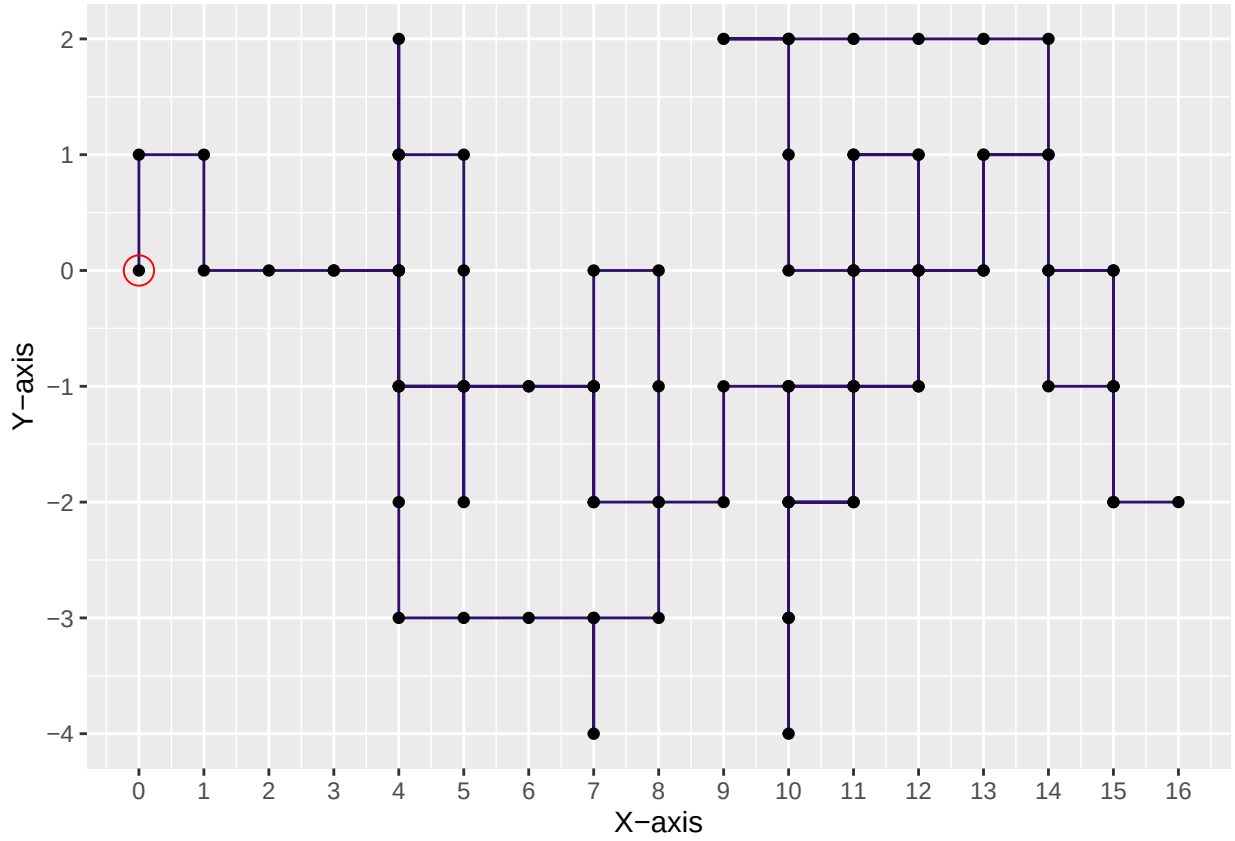
$Range(S_{10}) = \{(x, y) \in \mathbb{Z}^2 : \ 2|(x + y); |x| + |y| \leq 10\}$

(b)

```
start_pt= 0 +0i
moves= sample(step, 100, replace = T)
positions= c(start_pt, start_pt + cumsum(moves))
positions
```

```
##   [1]  0+0i  0+1i  1+1i  1+0i  2+0i  3+0i  4+0i  3+0i  4+0i  4+1i  4+2i  4+1i
##  [13]  4+0i  4-1i  5-1i  4-1i  4-2i  4-3i  5-3i  6-3i  7-3i  7-4i  7-3i  8-3i
##  [25]  8-2i  8-1i  8+0i  7+0i  7-1i  6-1i  5-1i  5+0i  5+1i  4+1i  4+0i  4-1i
##  [37]  5-1i  5-2i  5-1i  6-1i  7-1i  7-2i  7-1i  7-2i  8-2i  9-2i  9-1i 10-1i
##  [49] 10-2i 10-3i 10-4i 10-3i 10-2i 11-2i 11-1i 10-1i 11-1i 11+0i 11+1i 12+1i
##  [61] 12+0i 12+1i 11+1i 11+0i 12+0i 13+0i 12+0i 12-1i 11-1i 10-1i 10-2i 11-2i
##  [73] 11-1i 12-1i 12+0i 11+0i 10+0i 10+1i 10+2i  9+2i 10+2i 11+2i 12+2i 13+2i
##  [85] 14+2i 14+1i 13+1i 13+0i 13+1i 14+1i 14+0i 15+0i 15-1i 15-2i 15-1i 14-1i
##  [97] 14+0i 15+0i 15-1i 15-2i 16-2i
```

```
ggplot() +
  geom_path(mapping = aes(x = Re(positions),
                          y = Im(positions)),
            colour= "#30106B") +
  geom_point(mapping= aes(Re(start_pt), Im(start_pt)),
             colour= "red", pch= 1, size= 5) +
  geom_point(mapping= aes(Re(positions), Im(positions))) +
  scale_x_continuous(breaks = seq(-100, 100, by = 1)) +
  scale_y_continuous(breaks = seq(-100, 100, by = 1)) +
  xlab("X-axis") + ylab("Y-axis")
```



$Range(S_{100}) = \{(x, y) \in \mathbb{Z}^2 : \ 2|(x + y); |x| + |y| \leq 100\}$

(c)

```
start_pt= 0 +0i
current_position= start_pt
positions= c(start_pt); index= 2
while(Re(current_position)^2 + Im(current_position)^2 < (55)^2) #Checking condition for
#distance from the start greater than equal to 55
  {
  move= sample(step, 1)
  current_position= current_position +move
  #current_position
  positions[index]= current_position
  index= index +1
}
end_pt= current_position +move
print(paste("The last postion: ", end_pt))
```

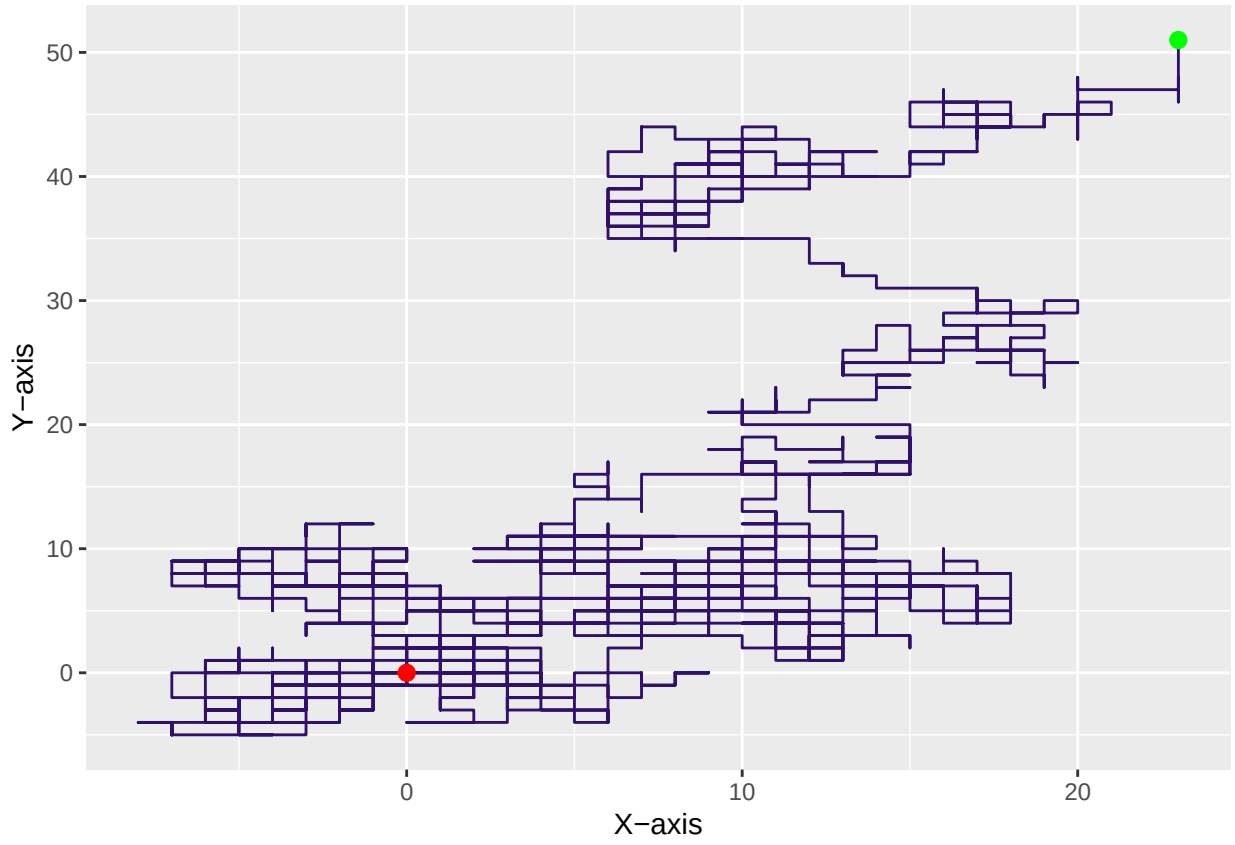
```
## [1] "The last postion:  23+51i"
```

```
print(paste("Distance: ", Mod(end_pt)))
```

```
## [1] "Distance:  55.9464029227975"
```

```
positions[index]= end_pt
```

```
ggplot() +
  geom_path(mapping = aes(x = Re(positions),
                          y = Im(positions)),
            colour= "#30106B") +
  geom_point(mapping= aes(Re(start_pt), Im(start_pt)),
             colour= "red", pch= 20, size= 4) +
  geom_point(mapping= aes(Re(end_pt), Im(end_pt)),
             colour= "green", pch= 20, size= 4) + #Plotting the end_point
  xlab("X-axis") + ylab("Y-axis")
```



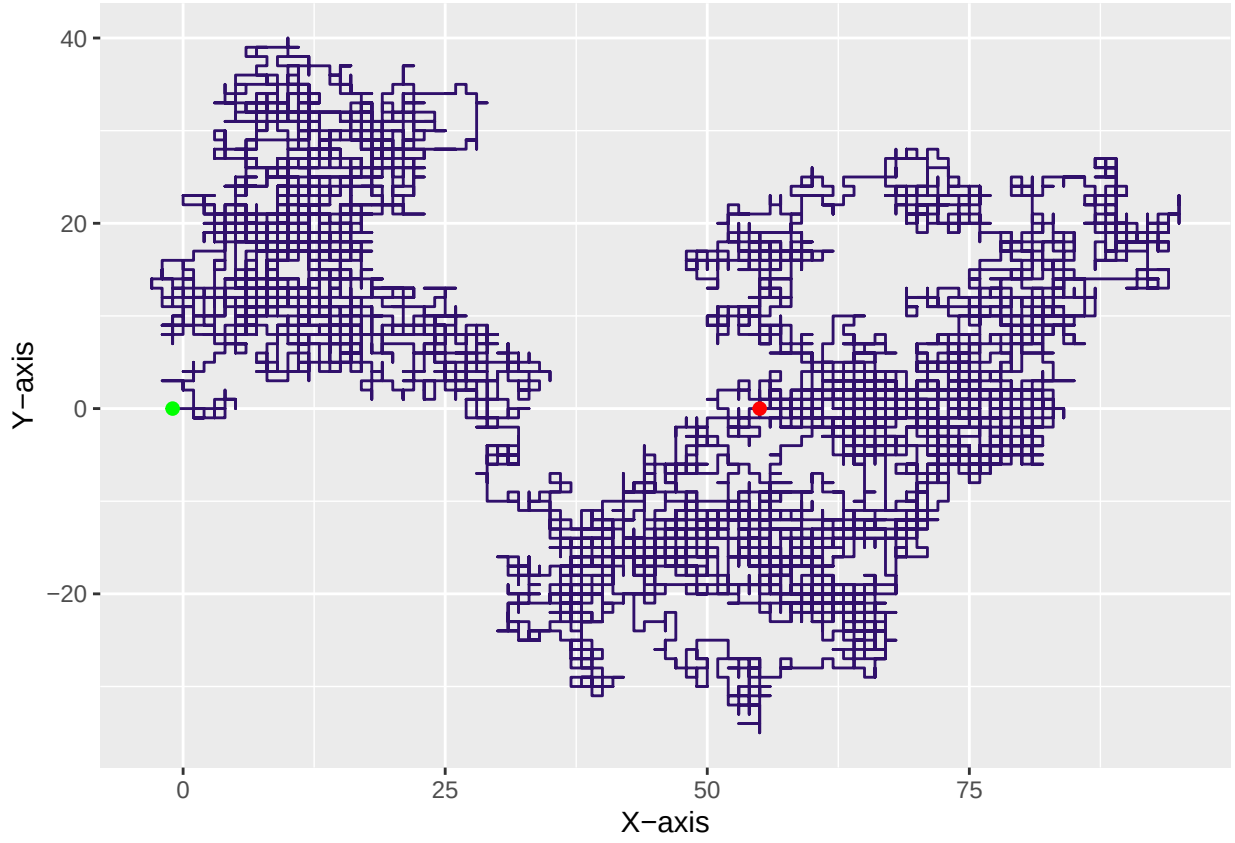
Only allowed points to reach are $\{(x, y) \in \mathbb{Z}^2 : |x| + |y| \geq 55\}$.

$Range(S_n) = \{(x, y) \in \mathbb{Z}^2\}$, Since $n \to \infty$.

(d)

```
start_pt= 55 +0i
current_position= start_pt
positions= c(start_pt); index= 2
while(Re(current_position)^2 + Im(current_position)^2 >0) {
  move= sample(step, 1)
  current_position= current_position +move
  positions[index]= current_position
  index= index +1
}
end_pt= current_position +move
positions[index]= end_pt
```

```
ggplot() +
  geom_path(mapping = aes(x = Re(positions),
                          y = Im(positions)),
            colour= "#30106B") +
  geom_point(mapping= aes(Re(start_pt), Im(start_pt)),
             colour= "red", pch= 20, size= 3) +
  geom_point(mapping= aes(Re(end_pt), Im(end_pt)),
             colour= "green", pch= 20, size= 3) +
  xlab("X-axis") + ylab("Y-axis")
```



Only allowed point to reach is $(0, 0)$.

$Range(S_n) = \{(x, y) \in \mathbb{Z}^2\}$, Since $n \to \infty$.