

Lab 1

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You should have RStudio installed to edit this file. You will write code in places marked “TO-DO” to complete the problems. Some of this will be a pure programming assignment. The tools for the solutions to these problems can be found in the class practice lectures. I want you to use the methods I taught you, not for you to google and come up with whatever works. You won’t learn that way.

To “hand in” the homework, you should compile or publish this file into a PDF that includes output of your code. Once it’s done, push by the deadline to your repository in a directory called “labs”.

- Print out the numerical constant pi with ten digits after the decimal point using the internal constant pi.

```
#TO-DO
options(digits=11)
x <- pi
x
```

```
## [1] 3.1415926536
```

- Sum up the first 103 terms of the series $1 + 1/2 + 1/4 + 1/8 + \dots$

```
#TO-DO
sum(1/(2^(0:102)))
```

```
## [1] 2
```

- Find the product of the first 37 terms in the sequence $1/3, 1/6, 1/9 \dots$

```
#TO-DO
prod(1/(3*(1:37)))
```

```
## [1] 1.613528728e-61
```

```
prod(1/(seq(from =3, by =3,length.out = 37)))
```

```
## [1] 1.613528728e-61
```

- Find the product of the first 387 terms of $1 * 1/2 * 1/4 * 1/8 * \dots$

```
#TO-DO
prod(1/(2^(0:386)))
```

```
## [1] 0
```

```
prod(1/(seq(from = 2, by=2, length.out = 387)))
```

```
## [1] 0
```

```
#numeric underflow
```

Is this answer *exactly* correct?

#TO-DO The answer is not exactly correct because we experience numerical underflow. (If it goes under a certain amount, then it is treated as if it is 0 when it really is not).

- Figure out a means to express the answer more exactly. Not compute exactly, but express more exactly.

```
#TO-DO
sum(log(1/(2^(0:386))))
```

```
## [1] -51771.856063
```

```
-log(2)*sum((0:386))
```

```
## [1] -51771.856063
```

- Create the sequence $x = [\text{Inf}, 20, 18, \dots, -20]$.

```
#TO-DO
x <- c(Inf, seq(from = 20, to=-20, by=-2))
x
```

```
## [1] Inf 20 18 16 14 12 10 8 6 4 2 0 -2 -4 -6 -8 -10 -12 -14
## [20] -16 -18 -20
```

Create the sequence $x = [\log_3(\text{Inf}), \log_3(100), \log_3(98), \dots, \log_3(-20)]$.

```
#TO-DO
x <- c(Inf, seq(from = 100, to = -20, by=-2))
x <- log(x, base=3)
```

```
## Warning: NaNs produced
```

```
x
```

```
## [1]          Inf 4.19180654858 4.17341725189 4.15464876786 4.13548512895
## [6] 4.11590933734 4.09590327429 4.07544759936 4.05452163807 4.03310325630
## [11] 4.01116871959 3.98869253500 3.96564727304 3.94200336639 3.91772888179
## [16] 3.89278926071 3.86714702345 3.84076143031 3.81358809222 3.78557852143
## [21] 3.75667961083 3.72683302786 3.69597450568 3.66403300988 3.63092975357
## [26] 3.59657702662 3.56087679501 3.52371901429 3.48497958377 3.44451784579
## [31] 3.40217350273 3.35776278143 3.31107361282 3.26185950714 3.20983167673
## [36] 3.15464876786 3.09590327429 3.03310325630 2.96564727304 2.89278926071
## [41] 2.81358809222 2.72683302786 2.63092975357 2.52371901429 2.40217350273
## [46] 2.26185950714 2.09590327429 1.89278926071 1.63092975357 1.26185950714
## [51] 0.63092975357          -Inf          NaN          NaN          NaN
## [56]          NaN          NaN          NaN          NaN          NaN
## [61]          NaN          NaN
```

Comment on the appropriateness of the non-numeric values.

#TO-DO $\log(\text{Inf}) = \text{Inf}$ because \log of infinity comes out as infinity $\log(0) = -\text{Inf}$ because \log of 0 diverges so it becomes $-\text{Inf}$ $\log(\text{negative numbers}) = \text{NaN}$ because \log of any negative numbers is undefined

- Create a vector of booleans where the entry is true if $x[i]$ is positive and finite.

```
#TO-DO
y = !is.nan(x) & is.finite(x) & x>0
y
```

```
## [1] FALSE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [13] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [25] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [37] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
## [49] TRUE TRUE TRUE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
## [61] FALSE FALSE
```

- Locate the indices of the non-real numbers in this vector. Hint: use the `which` function. Don't hesitate to use the documentation via `?which`.

```
#TO-DO
which(y == FALSE)
```

```
## [1] 1 52 53 54 55 56 57 58 59 60 61 62
```

- Locate the indices of the infinite quantities in this vector.

```
#TO-DO
which(is.infinite(x) == TRUE)
```

```
## [1] 1 52
```

- Locate the indices of the min and max in this vector. Hint: use the `which.min` and `which.max` functions.

```
#TO-DO
which.max(x)
```

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

```
which.min(x)
```

```
## [1] 52
```

- Count the number of unique values in `x`.

```
#TO-DO
length(unique(x))
```

```
## [1] 53
```

- Cast `x` to a factor. Do the number of levels make sense?

```
#TO-DO
as.factor(x)
```

```
## [1] Inf 4.19180654857877 4.1734172518943 4.15464876785729
## [5] 4.13548512895119 4.11590933734319 4.09590327428938 4.07544759935851
## [9] 4.05452163806914 4.03310325630434 4.01116871959141 3.98869253500376
## [13] 3.96564727304425 3.94200336638929 3.91772888178973 3.89278926071437
## [17] 3.86714702345081 3.84076143030548 3.81358809221559 3.78557852142874
## [21] 3.75667961082847 3.72683302786084 3.69597450568212 3.66403300987579
## [25] 3.63092975357146 3.59657702661571 3.56087679500731 3.52371901428583
## [29] 3.48497958377173 3.44451784578705 3.40217350273288 3.3577627814323
## [33] 3.31107361281783 3.26185950714291 3.20983167673402 3.15464876785729
## [37] 3.09590327428938 3.03310325630434 2.96564727304425 2.89278926071437
## [41] 2.8135880922156 2.72683302786084 2.63092975357146 2.52371901428583
## [45] 2.40217350273288 2.26185950714291 2.09590327428938 1.89278926071437
## [49] 1.63092975357146 1.26185950714291 0.630929753571457 -Inf
## [53] NaN NaN NaN NaN
## [57] NaN NaN NaN NaN
## [61] NaN NaN
## 53 Levels: -Inf 0.630929753571457 1.26185950714291 ... NaN
```

```
#there are 53 unique values so there are 53 unique nominal categories
```

- Cast `x` to integers. What do we learn about R's infinity representation in the integer data type?

```
#TO-DO
as.integer(x)
```

```
## Warning: NAs introduced by coercion to integer range
```

```
## [1] NA 4 4 4 4 4 4 4 4 4 4 3 3 3 3 3 3 3 3 3 3 3 3
## [26] 3 3 3 3 3 3 3 3 3 3 3 3 3 2 2 2 2 2 2 2 2 1 1 1
## [51] 0 NA NA NA NA NA NA NA NA NA NA NA NA
```

#infinities get converted to NA because there is no Inf or NaN as an integer

- Use `x` to create a new vector `y` containing only the real numbers in `x`.

#TO-DO

```
y= x[(!is.nan(x) & is.finite(x) & x>0)]
```

#this works because the inside of the square brackets returns true and false. It subsets the vector.
`y`

```
## [1] 4.19180654858 4.17341725189 4.15464876786 4.13548512895 4.11590933734
## [6] 4.09590327429 4.07544759936 4.05452163807 4.03310325630 4.01116871959
## [11] 3.98869253500 3.96564727304 3.94200336639 3.91772888179 3.89278926071
## [16] 3.86714702345 3.84076143031 3.81358809222 3.78557852143 3.75667961083
## [21] 3.72683302786 3.69597450568 3.66403300988 3.63092975357 3.59657702662
## [26] 3.56087679501 3.52371901429 3.48497958377 3.44451784579 3.40217350273
## [31] 3.35776278143 3.31107361282 3.26185950714 3.20983167673 3.15464876786
## [36] 3.09590327429 3.03310325630 2.96564727304 2.89278926071 2.81358809222
## [41] 2.72683302786 2.63092975357 2.52371901429 2.40217350273 2.26185950714
## [46] 2.09590327429 1.89278926071 1.63092975357 1.26185950714 0.63092975357
```

- Use the left rectangle method to numerically integrate x^2 from 0 to 1 with rectangle width size $1e-6$.

#TO-DO

```
sum((seq(from = 0, to = (1 - 1e-6), by= 1e-6)^2) * 1e-6)
```

```
## [1] 0.33333283333
```

#to make it more efficient so that the computer does the multiplications only once.

```
sum((seq(from = 0, to = (1 - 1e-6), by= 1e-6)^2))* 1e-6
```

```
## [1] 0.33333283333
```

- Calculate the average of 100 realizations of standard Bernoullis in one line using the `sample` function.

#TO-DO

```
mean(sample(c(0,1), size=100, replace=TRUE))
```

```
## [1] 0.56
```

- Calculate the average of 500 realizations of Bernoullis with $p = 0.9$ in one line using the `sample` and `mean` functions.

#TO-DO

```
mean(sample(c(0,1), size=500, replace=TRUE, p = c(0.9,0.1)))
```

```
## [1] 0.116
```

- Calculate the average of 1000 realizations of Bernoullis with $p = 0.9$ in one line using `rbinom`.

```
#T0-D0
mean(rbinom(n= 1000, size=1, prob=0.9))
```

```
## [1] 0.906
```

- In class we considered a variable `x_3` which measured “criminality”. We imagined $L = 4$ levels “none”, “infraction”, “misdemeanor” and “felony”. Create a variable `x_3` here with 100 random elements (equally probable). Create it as a nominal (i.e. unordered) factor.

```
#T0-D0
x_3 = as.factor(sample(c("none", "infraction", "misdemeanor", "felony"), size=100, replace=TRUE))
x_3
```

```
## [1] infraction none      misdemeanor none      felony      misdemeanor
## [7] misdemeanor none      felony      none      none      felony
## [13] infraction felony      misdemeanor infraction misdemeanor misdemeanor
## [19] infraction misdemeanor none      infraction infraction felony
## [25] none      misdemeanor misdemeanor none      infraction felony
## [31] infraction misdemeanor none      felony      infraction misdemeanor
## [37] none      felony      none      none      felony      infraction
## [43] misdemeanor infraction infraction misdemeanor infraction misdemeanor
## [49] felony      felony      none      infraction infraction misdemeanor
## [55] misdemeanor infraction none      infraction none      none
## [61] none      felony      infraction felony      misdemeanor felony
## [67] infraction felony      felony      none      misdemeanor misdemeanor
## [73] none      infraction infraction misdemeanor felony      infraction
## [79] none      none      none      none      misdemeanor felony
## [85] felony      misdemeanor infraction misdemeanor misdemeanor infraction
## [91] infraction misdemeanor none      felony      felony      infraction
## [97] felony      felony      none      misdemeanor
## Levels: felony infraction misdemeanor none
```

- Use `x_3` to create `x_3_bin`, a binary feature where 0 is no crime and 1 is any crime.

```
#T0-D0
x_3_bin = as.numeric(x_3 != "none")
x_3_bin
```

```
## [1] 1 0 1 0 1 1 1 0 1 0 0 1 1 1 1 1 1 1 1 0 1 1 1 0 1 1 1 1 0 1 1 1 0
## [38] 1 0 0 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 0 1 0 0 0 1 1 1 1 1 1 1 0 1 1 0 1
## [75] 1 1 1 1 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 0 1
```

- Use `x_3` to create `x_3_ord`, an ordered factor variable. Ensure the proper ordinal ordering.

```
#T0-D0
x_3_ord = factor(x_3, levels = c("none", "infraction", "misdemeanor", "felony"), ordered = TRUE)
x_3_ord
```

```
## [1] infraction none      misdemeanor none      felony      misdemeanor
## [7] misdemeanor none      felony      none      none      felony
```

```
## [13] infraction felony misdemeanor infraction misdemeanor misdemeanor
## [19] infraction misdemeanor none infraction infraction felony
## [25] none misdemeanor misdemeanor none infraction felony
## [31] infraction misdemeanor none felony infraction misdemeanor
## [37] none felony none none felony infraction
## [43] misdemeanor infraction infraction misdemeanor infraction misdemeanor
## [49] felony felony none infraction infraction misdemeanor
## [55] misdemeanor infraction none infraction none none
## [61] none felony infraction felony misdemeanor felony
## [67] infraction felony felony none misdemeanor misdemeanor
## [73] none infraction infraction misdemeanor felony infraction
## [79] none none none none misdemeanor felony
## [85] felony misdemeanor infraction misdemeanor misdemeanor infraction
## [91] infraction misdemeanor none felony felony infraction
## [97] felony felony none misdemeanor
## Levels: none < infraction < misdemeanor < felony
```

#can also use order instead of factor

- Convert this variable into three binary variables without any information loss and put them into a data matrix.

#TO-DO

```
X = matrix( NA,nrow= 100, ncol = 3)
colnames(X) = c("infraction", "misdemeanor", "felony")
X[, "infraction"] = as.numeric(x_3_ord == "infraction")
X[, "misdemeanor"] = as.numeric(x_3_ord == "misdemeanor")
X[, "felony"] = as.numeric(x_3_ord == "felony")
X
```

```
##      infraction misdemeanor felony
## [1,]          1           0      0
## [2,]          0           0      0
## [3,]          0           1      0
## [4,]          0           0      0
## [5,]          0           0      1
## [6,]          0           1      0
## [7,]          0           1      0
## [8,]          0           0      0
## [9,]          0           0      1
## [10,]         0           0      0
## [11,]         0           0      0
## [12,]         0           0      1
## [13,]         1           0      0
## [14,]         0           0      1
## [15,]         0           1      0
## [16,]         1           0      0
## [17,]         0           1      0
## [18,]         0           1      0
## [19,]         1           0      0
## [20,]         0           1      0
## [21,]         0           0      0
## [22,]         1           0      0
```

##	[23,]	1	0	0
##	[24,]	0	0	1
##	[25,]	0	0	0
##	[26,]	0	1	0
##	[27,]	0	1	0
##	[28,]	0	0	0
##	[29,]	1	0	0
##	[30,]	0	0	1
##	[31,]	1	0	0
##	[32,]	0	1	0
##	[33,]	0	0	0
##	[34,]	0	0	1
##	[35,]	1	0	0
##	[36,]	0	1	0
##	[37,]	0	0	0
##	[38,]	0	0	1
##	[39,]	0	0	0
##	[40,]	0	0	0
##	[41,]	0	0	1
##	[42,]	1	0	0
##	[43,]	0	1	0
##	[44,]	1	0	0
##	[45,]	1	0	0
##	[46,]	0	1	0
##	[47,]	1	0	0
##	[48,]	0	1	0
##	[49,]	0	0	1
##	[50,]	0	0	1
##	[51,]	0	0	0
##	[52,]	1	0	0
##	[53,]	1	0	0
##	[54,]	0	1	0
##	[55,]	0	1	0
##	[56,]	1	0	0
##	[57,]	0	0	0
##	[58,]	1	0	0
##	[59,]	0	0	0
##	[60,]	0	0	0
##	[61,]	0	0	0
##	[62,]	0	0	1
##	[63,]	1	0	0
##	[64,]	0	0	1
##	[65,]	0	1	0
##	[66,]	0	0	1
##	[67,]	1	0	0
##	[68,]	0	0	1
##	[69,]	0	0	1
##	[70,]	0	0	0
##	[71,]	0	1	0
##	[72,]	0	1	0
##	[73,]	0	0	0
##	[74,]	1	0	0
##	[75,]	1	0	0
##	[76,]	0	1	0


```
## [77,]      0      0      1
## [78,]      1      0      0
## [79,]      0      0      0
## [80,]      0      0      0
## [81,]      0      0      0
## [82,]      0      0      0
## [83,]      0      1      0
## [84,]      0      0      1
## [85,]      0      0      1
## [86,]      0      1      0
## [87,]      1      0      0
## [88,]      0      1      0
## [89,]      0      1      0
## [90,]      1      0      0
## [91,]      1      0      0
## [92,]      0      1      0
## [93,]      0      0      0
## [94,]      0      0      1
## [95,]      0      0      1
## [96,]      1      0      0
## [97,]      0      0      1
## [98,]      0      0      1
## [99,]      0      0      0
## [100,]     0      1      0
```

- What should the sum of each row be (in English)?

#TO-DO The sum of each row represents if a person has committed a crime or not because it can only be 1 or 0.

Verify that.

```
#TO-DO
as.matrix(rowSums(X), nrow = 100)
```

```
##      [,1]
## [1,]    1
## [2,]    0
## [3,]    1
## [4,]    0
## [5,]    1
## [6,]    1
## [7,]    1
## [8,]    0
## [9,]    1
## [10,]   0
## [11,]   0
## [12,]   1
## [13,]   1
## [14,]   1
## [15,]   1
## [16,]   1
## [17,]   1
## [18,]   1
## [19,]   1
```

##	[20,]	1
##	[21,]	0
##	[22,]	1
##	[23,]	1
##	[24,]	1
##	[25,]	0
##	[26,]	1
##	[27,]	1
##	[28,]	0
##	[29,]	1
##	[30,]	1
##	[31,]	1
##	[32,]	1
##	[33,]	0
##	[34,]	1
##	[35,]	1
##	[36,]	1
##	[37,]	0
##	[38,]	1
##	[39,]	0
##	[40,]	0
##	[41,]	1
##	[42,]	1
##	[43,]	1
##	[44,]	1
##	[45,]	1
##	[46,]	1
##	[47,]	1
##	[48,]	1
##	[49,]	1
##	[50,]	1
##	[51,]	0
##	[52,]	1
##	[53,]	1
##	[54,]	1
##	[55,]	1
##	[56,]	1
##	[57,]	0
##	[58,]	1
##	[59,]	0
##	[60,]	0
##	[61,]	0
##	[62,]	1
##	[63,]	1
##	[64,]	1
##	[65,]	1
##	[66,]	1
##	[67,]	1
##	[68,]	1
##	[69,]	1
##	[70,]	0
##	[71,]	1
##	[72,]	1
##	[73,]	0

```
## [74,] 1
## [75,] 1
## [76,] 1
## [77,] 1
## [78,] 1
## [79,] 0
## [80,] 0
## [81,] 0
## [82,] 0
## [83,] 1
## [84,] 1
## [85,] 1
## [86,] 1
## [87,] 1
## [88,] 1
## [89,] 1
## [90,] 1
## [91,] 1
## [92,] 1
## [93,] 0
## [94,] 1
## [95,] 1
## [96,] 1
## [97,] 1
## [98,] 1
## [99,] 0
## [100,] 1
```

- How should the column sum look (in English)?

#TO-DO The sum of each column represents the number of people who committed that level of crime. Verify that.

```
#TO-DO
colSums(X)
```

```
## infraction misdemeanor      felony
##          26           26          23
```

- Generate a matrix with 100 rows where the first column is realization from a normal with mean 17 and variance 38, the second column is uniform between -10 and 10, the third column is poisson with mean 6, the fourth column is exponential with lambda of 9, the fifth column is binomial with $n = 20$ and $p = 0.12$ and the sixth column is a binary variable with exactly 24% 1's dispersed randomly. Name the rows the entries of the `fake_first_names` vector.

```
fake_first_names = c(
  "Sophia", "Emma", "Olivia", "Ava", "Mia", "Isabella", "Riley",
  "Aria", "Zoe", "Charlotte", "Lily", "Layla", "Amelia", "Emily",
  "Madelyn", "Aubrey", "Adalyn", "Madison", "Chloe", "Harper",
  "Abigail", "Aaliyah", "Avery", "Evelyn", "Kaylee", "Ella", "Ellie",
  "Scarlett", "Arianna", "Hailey", "Nora", "Addison", "Brooklyn",
  "Hannah", "Mila", "Leah", "Elizabeth", "Sarah", "Eliana", "Mackenzie",
  "Peyton", "Maria", "Grace", "Adeline", "Elena", "Anna", "Victoria",
```

```

"Camilla", "Lillian", "Natalie", "Jackson", "Aiden", "Lucas",
"Liam", "Noah", "Ethan", "Mason", "Caden", "Oliver", "Elijah",
"Grayson", "Jacob", "Michael", "Benjamin", "Carter", "James",
"Jayden", "Logan", "Alexander", "Caleb", "Ryan", "Luke", "Daniel",
"Jack", "William", "Owen", "Gabriel", "Matthew", "Connor", "Jayce",
"Isaac", "Sebastian", "Henry", "Muhammad", "Cameron", "Wyatt",
"Dylan", "Nathan", "Nicholas", "Julian", "Eli", "Levi", "Isaiah",
"Landon", "David", "Christian", "Andrew", "Brayden", "John",
"Lincoln"
)
#T0-D0
B = matrix(NA, nrow = 100, ncol = 6)
B[,1] = rnorm(n = 100, mean = 17, sd = sqrt(38))
B[,2] = runif(n = 100, min = -10, max = 10)
B[,3] = rpois(n = 100, lambda = 6)
B[,4] = rexp(n = 100, rate = 9)
B[,5] = rbinom(n = 20, size = 100, prob = 0.12)
B[,6] = rbinom(n = 100, size = 1, prob = 0.24)
rownames(B) = fake_first_names
B

```

##		[,1]	[,2]	[,3]	[,4]	[,5]	[,6]
##	Sophia	18.6228834383	4.74800163414	5	0.0132472557533	12	0
##	Emma	18.8298736491	-5.57085520122	5	0.1189609084025	6	0
##	Olivia	23.9379543366	-3.92566817347	4	0.0281965606329	10	0
##	Ava	11.6484033451	3.22530474048	3	0.4362348920122	10	1
##	Mia	15.5756829445	1.37514353264	6	0.1287883490070	16	0
##	Isabella	6.1004372198	-5.35362662748	6	0.0406228563127	15	1
##	Riley	20.3614825687	7.04584285617	7	0.0327756617011	10	0
##	Aria	14.0116074987	-5.86304808035	2	0.0058654611413	7	0
##	Zoe	15.3496518420	-7.88703411352	6	0.0011110324413	11	0
##	Charlotte	18.8404561162	8.58094614930	5	0.0105378293084	16	0
##	Lily	19.3723937293	3.89607279096	6	0.0207917749261	6	0
##	Layla	13.1232810600	4.15119568817	10	0.3427819882643	5	0
##	Amelia	10.0935068496	2.81161554158	7	0.0052221149924	13	0
##	Emily	21.0252365852	5.79011213034	5	0.0021497264194	18	0
##	Madelyn	14.9542925101	1.17811095435	5	0.0834313085670	15	0
##	Aubrey	16.9078105644	-9.11678104661	3	0.2057503546598	8	0
##	Adalyn	13.8685503612	-0.62626692001	1	0.0307172613598	7	0
##	Madison	23.0661474916	8.74376271851	0	0.1122599767681	8	1
##	Chloe	18.8061082496	8.22164801415	6	0.1367407665738	13	0
##	Harper	12.4763607225	-6.45029041450	2	0.0797244403203	14	1
##	Abigail	24.8002239496	-5.33036083449	8	0.1243986696824	12	1
##	Aaliyah	5.9915745561	-2.41925588809	4	0.3754015308101	6	0
##	Avery	11.3853284663	-9.99301454518	6	0.3078334983298	10	0
##	Evelyn	19.6653256042	-3.66232550237	7	0.2458972366747	10	0
##	Kaylee	23.4054919265	-6.70826703776	3	0.0739060326790	16	0
##	Ella	21.7462281512	9.07042117324	4	0.0357666960169	15	0
##	Ellie	17.2771583902	-2.71060957573	6	0.0361864632104	10	1
##	Scarlett	24.9980549438	8.56886404566	7	0.0901238728889	7	0
##	Arianna	23.8507651030	1.10019125510	7	0.3817983062544	11	0
##	Hailey	22.0403362536	-5.60164245311	2	0.0330830377896	16	0
##	Nora	11.2515077530	-7.37068059854	7	0.0537659630386	6	1
##	Addison	26.8072418302	-1.32249599323	0	0.0014685968248	5	0

## Brooklyn	24.5802709058	-3.65267177578	8	0.4381621585305	13	0
## Hannah	15.6148818793	1.67949920520	4	0.0108772176784	18	0
## Mila	25.0611506232	-6.87863368075	3	0.0396486630456	15	1
## Leah	8.4983350637	-9.19793718494	9	0.0570866594919	8	0
## Elizabeth	13.8757788008	-7.72785416339	3	0.0593465916916	7	0
## Sarah	15.8635332033	5.14925116673	6	0.0463687714914	8	0
## Eliana	15.7664092812	-0.63597224653	7	0.0266307933877	13	0
## Mackenzie	9.7674766146	-4.65168361086	5	0.0329539233101	14	0
## Peyton	31.0090232896	2.30373036582	1	0.0481194968105	12	0
## Maria	21.6378404840	3.85253179353	7	0.0700154518191	6	0
## Grace	17.4843876835	3.79203496035	5	0.0275177827312	10	0
## Adeline	25.0751996865	4.37047226354	5	0.1260508971449	10	1
## Elena	12.0577532705	0.44495828450	8	0.3197752129514	16	0
## Anna	3.1734196599	2.80626317486	6	0.2094047619971	15	1
## Victoria	17.0891312203	-0.50511456560	8	0.0429283827026	10	0
## Camilla	6.8840369912	-1.64853038732	4	0.0505011312457	7	1
## Lillian	14.8106432431	8.16609966103	5	0.0339230611579	11	0
## Natalie	33.0723916577	-5.65234059002	6	0.0016547467705	16	1
## Jackson	25.5119972360	0.58562278282	7	0.0810991208954	6	0
## Aiden	14.6669396708	3.34315334447	8	0.0181596453208	5	0
## Lucas	19.3947680068	9.47722834535	9	0.0194291401551	13	0
## Liam	21.3351017282	-9.64136096649	5	0.1244929954363	18	0
## Noah	18.4508129867	7.21688559745	6	0.2217381490922	15	0
## Ethan	19.7494050390	0.65466662403	8	0.1129721446847	8	0
## Mason	13.4126607070	-2.64585227706	5	0.0449186008837	7	1
## Caden	8.2567763356	-3.58873907942	7	0.0624264858062	8	0
## Oliver	11.7071376814	-5.86080968846	5	0.0380528719785	13	0
## Elijah	17.4873782209	7.38203393295	5	0.0969229144929	14	0
## Grayson	18.7713196698	6.24293044675	3	0.0141618991767	12	0
## Jacob	10.6286021296	-9.00555715896	6	0.0028335570236	6	0
## Michael	14.3710287029	3.72824836522	7	0.1823769564324	10	0
## Benjamin	21.4650669587	-7.19378968235	4	0.0821617615780	10	1
## Carter	16.1637034205	4.34524910059	2	0.1568290307058	16	0
## James	17.8553488029	0.75122170150	3	0.0026623700331	15	0
## Jayden	25.7715289430	5.38260185625	4	0.0061331743168	10	0
## Logan	22.1406734354	-8.49813784938	4	0.1517520146398	7	0
## Alexander	17.7609769051	-8.20692520589	7	0.2081785404754	11	0
## Caleb	18.6127180311	-7.18326319940	2	0.0285360323679	16	0
## Ryan	13.2900892018	-6.04526637122	9	0.1849021243045	6	1
## Luke	8.6267558753	4.87544958945	7	0.0778996534520	5	0
## Daniel	29.4661509729	3.62408324610	3	0.1793979104645	13	1
## Jack	21.5806971156	-9.49536796194	3	0.0111779536431	18	0
## William	23.1351173838	-9.26139835734	4	0.2604691955393	15	0
## Owen	20.7532013377	-2.03549832571	1	0.0037969675226	8	0
## Gabriel	21.3446793704	9.88041357603	7	0.0411419001304	7	0
## Matthew	13.1291936552	3.09902855195	9	0.0954762795479	8	1
## Connor	17.1266766818	-0.47633072827	7	0.0813695052592	13	0
## Jayce	4.3058782573	7.44661027100	5	0.1225724248169	14	1
## Isaac	18.3333387664	3.77185912337	5	0.0386593721580	12	0
## Sebastian	15.3281494544	2.44326249696	5	0.0784757059642	6	0
## Henry	20.3408679849	-7.59907983709	9	0.0556485867128	10	0
## Muhammad	24.0109976793	-4.45470682345	6	0.1472150635755	10	0
## Cameron	18.8697326264	-3.28205777798	3	0.3394009934345	16	0
## Wyatt	19.0389970424	5.48303566873	8	0.1517773357484	15	1

```
## Dylan      17.1047564772  8.43593365978  10 0.0269819266784  10  0
## Nathan     13.1615373310  8.18152135238   7 0.0953216950236   7  0
## Nicholas   16.9942015861  2.88654346019   5 0.0160867286225  11  0
## Julian     15.8196383616 -1.33691873867   7 0.0355587206023  16  0
## Eli        18.8501243015 -8.66235929076   3 0.0263090582854   6  1
## Levi       12.3886816339  6.01220315788   7 0.0035919442647   5  0
## Isaiah     19.9950459342 -4.56238072366   3 0.0349746580933  13  1
## Landon     26.3671277822 -8.45756768249   3 0.0788924078307  18  1
## David      10.9198713436  6.17931347340   4 0.0073333413087  15  0
## Christian  18.1920633711  9.48672177270   7 0.0163135304625   8  0
## Andrew     27.5736140732  5.40155935567   7 0.4166652909738   7  0
## Brayden    13.7352610744  6.86891500372   9 0.0210745303064   8  0
## John       11.7096033948  8.52251090575   2 0.2652886346256  13  0
## Lincoln    17.7166450805 -5.86003556848   5 0.0444720029934  14  0
```

- Create a data frame of the same data as above except make the binary variable a factor “DOMESTIC” vs “FOREIGN” for 0 and 1 respectively. Use RStudio’s **View** function to ensure this worked as desired.

```
#TO-DO
B_dataframe = data.frame(B)
B_dataframe[,6] <- ifelse(B_dataframe[,6] == 0, "DOMESTIC", "FOREIGN")
View(B_dataframe)
```

- Print out a table of the binary variable. Then print out the proportions of “DOMESTIC” vs “FOREIGN”.

```
#TO-DO
table(B_dataframe$X6)
```

```
##
## DOMESTIC  FOREIGN
##          78      22
```

```
table(B_dataframe$X6) / 100
```

```
##
## DOMESTIC  FOREIGN
##    0.78    0.22
```

Print out a summary of the whole dataframe.

```
#TO-DO
B_dataframe$X6 = factor(B_dataframe$X6, labels = c("DOMESTIC", "FOREIGN"))
summary(B_dataframe)
```

```
##           X1                X2                X3
## Min.      : 3.1734197  Min.    :-9.993014545  Min.     : 0.00
## 1st Qu.:13.6546110  1st Qu.: -5.614316987  1st Qu.: 4.00
## Median :17.7388110  Median : 0.620144703  Median : 5.00
## Mean     :17.5423566  Mean    :-0.010354836  Mean     : 5.32
## 3rd Qu.:21.3747763  3rd Qu.: 4.943899984  3rd Qu.: 7.00
```

```
## Max. :33.0723917 Max. : 9.880413576 Max. :10.00
##      X4              X5              X6
## Min. :0.0011110324 Min. : 5.00    DOMESTIC:78
## 1st Qu.:0.0268941434 1st Qu.: 7.75    FOREIGN :22
## Median :0.0547072749 Median :10.50
## Mean   :0.0985058898 Mean   :11.00
## 3rd Qu.:0.1267352601 3rd Qu.:14.25
## Max.   :0.4381621585 Max.   :18.00
```

- Let $n = 50$. Create a $n \times n$ matrix R of exactly 50% entries 0's, 25% 1's 25% 2's. These values should be in random locations.

```
#TO-DO #####
R = matrix(sample(c(0,1,2), size=50 , replace=TRUE, p = c(0.5,0.25,0.25)), nrow = 50, ncol = 50)
View(R)
table(R)
```

```
## R
##      0      1      2
## 1400   550   550
```

- Randomly punch holes (i.e. NA) values in this matrix so that an each entry is missing with probability 30%.

```
#TO-DO #####
R[sample(1:length(R), length(R)*0.3)] <- NA
table(R)
```

```
## R
##      0      1      2
## 1006   370   374
```

```
R
```

```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12] [,13]
## [1,]  NA  NA   0   NA  NA  NA   0   0   0   0   0   NA  NA
## [2,]   2   2   2   2   2   2   2   2   2   2   NA   2   2
## [3,]   0   0   0   NA   0   0   0   0   0   0   0   0   NA
## [4,]   0   0   NA   0   0   NA  NA   0   0   0   0   0   NA
## [5,]  NA  NA  NA  NA   0   0   0   NA   0   0   0   0   NA
## [6,]   0   0   0   0   0   0   0   0   NA   0   0   NA   0
## [7,]  NA   0   0   0   0   0   NA  NA   0   NA  NA  NA   0
## [8,]   0   0   NA   0   0   NA   0   0   0   0   0   0   0
## [9,]   0   0   0   0   0   0   0   0   0   0   0   0   0
## [10,] NA  NA   2   2   2   NA   2   NA   2   2   NA   2   2
## [11,]   1  NA   1  NA   1   1   1   1   NA   1   NA   1   1
## [12,]   1   1  NA   1   1  NA  NA   1   1   NA  NA   1  NA
## [13,]   0   0  NA   0   0   0   0   0   NA   0   0   NA   0
## [14,]   0   0   0   0   0   0   0   0   0   0   0   0   0
## [15,]   0   0   0  NA   0   0   0   0   0   NA  NA  NA   0
## [16,]   0   0   0   0   0  NA  NA  NA  NA   0  NA  NA   0
## [17,]   2   2  NA   2   2   2   2   2   2   2   2   NA   2
```

## [18,]	2	NA	2	NA	2	2	NA	2	2	2	2	2	2
## [19,]	NA	1	NA	1	1	1	1	1	1	1	1	NA	1
## [20,]	NA	NA	NA	1	1	1	1	1	1	NA	1	NA	1
## [21,]	1	NA	1	1	NA	1	NA	NA	1	1	1	1	1
## [22,]	2	NA	2	2	2	NA	2	2	2	2	2	NA	2
## [23,]	1	1	1	NA	1	1	NA	1	1	1	1	NA	NA
## [24,]	0	0	NA	0	0	0	0	0	0	0	0	0	NA
## [25,]	0	0	0	0	NA	0	NA	0	NA	NA	0	0	NA
## [26,]	0	0	NA	NA	0	NA	0	NA	0	0	NA	0	NA
## [27,]	1	1	1	1	1	1	1	1	NA	NA	NA	NA	1
## [28,]	2	2	2	NA	NA	NA	2	NA	2	2	NA	2	NA
## [29,]	0	0	NA	0	0	0	NA	0	NA	0	NA	0	0
## [30,]	2	NA	NA	NA	NA	2	2	2	2	2	2	2	2
## [31,]	0	0	0	0	0	0	0	0	0	0	0	NA	0
## [32,]	NA	NA	NA	1	1	1	1	1	1	1	1	1	1
## [33,]	2	NA	2	2	NA	NA	NA	2	NA	2	2	2	NA
## [34,]	2	2	2	2	NA	NA	2	2	2	2	2	NA	NA
## [35,]	0	0	0	NA	0	NA	0	0	0	0	0	0	0
## [36,]	2	2	2	NA	2	2	2	2	2	2	2	2	NA
## [37,]	0	0	0	0	NA	NA	0	NA	0	0	0	0	0
## [38,]	1	NA	1	NA	NA	1	NA	1	NA	1	1	1	1
## [39,]	0	0	NA	NA	NA	0	NA	NA	NA	0	0	0	0
## [40,]	NA	1	1	NA	NA	1	NA	NA	1	1	NA	NA	NA
## [41,]	NA	NA	NA	NA	2	NA	2	2	2	2	2	2	NA
## [42,]	NA	0	0	0	0	0	0	0	NA	0	0	0	0
## [43,]	1	1	NA	1	1	NA	1	1	NA	NA	1	1	1
## [44,]	NA	0	0	NA	NA	NA	0	0	0	0	0	0	0
## [45,]	NA	NA	0	0	NA	0	0	0	NA	0	NA	NA	0
## [46,]	0	0	0	0	0	NA	0	0	0	0	NA	0	0
## [47,]	NA	NA	0	0	NA	NA	0	NA	0	0	0	0	NA
## [48,]	NA	0	0	0	0	0	0	0	0	0	NA	0	0
## [49,]	NA	0	0	NA	0	0	0	NA	0	0	NA	NA	0
## [50,]	0	0	0	0	0	0	0	0	0	0	0	0	0
##	[,14]	[,15]	[,16]	[,17]	[,18]	[,19]	[,20]	[,21]	[,22]	[,23]	[,24]	[,25]	
## [1,]	0	0	0	0	0	NA	0	NA	NA	0	0	NA	
## [2,]	2	2	2	2	2	2	2	NA	NA	2	NA	2	
## [3,]	NA	0	0	0	0	NA	0	0	NA	NA	NA	0	
## [4,]	0	NA	0	0	0	0	0	0	NA	0	NA	NA	
## [5,]	NA	0	0	NA	0	0	0	0	NA	0	0	0	
## [6,]	0	0	0	0	NA	0	NA	0	0	0	0	0	
## [7,]	0	0	0	0	0	0	0	0	0	0	NA	0	
## [8,]	NA	0	0	0	0	NA	0	0	0	0	0	0	
## [9,]	0	0	NA	0	0	NA	0	0	NA	0	0	0	
## [10,]	2	2	NA	NA	NA	2	2	2	2	NA	NA	2	
## [11,]	1	NA	NA	NA	1	NA	1	NA	1	1	NA	NA	
## [12,]	1	1	NA	1	1	NA	NA	1	1	NA	NA	1	
## [13,]	0	0	0	0	NA	0	NA	0	0	0	NA	NA	
## [14,]	0	0	0	0	0	NA	NA	0	NA	0	0	NA	
## [15,]	0	NA	NA	0	NA	0	0	NA	0	NA	0	NA	
## [16,]	NA	0	0	0	0	0	0	0	0	0	0	0	
## [17,]	2	NA	NA	2	2	NA	NA	NA	2	2	2	NA	
## [18,]	2	2	2	2	NA	2	NA	NA	2	2	2	2	
## [19,]	1	NA	NA	1	NA	1	1	NA	1	1	NA	1	
## [20,]	1	1	NA	1	1	1	NA	1	1	1	NA	1	

## [21,]	1	NA	NA	NA	1	NA	1	1	1	NA	NA	1
## [22,]	2	NA	2	2	NA	NA	2	2	2	NA	2	2
## [23,]	NA	1	1	NA	NA	1	1	NA	NA	1	1	1
## [24,]	0	NA	NA	NA	0	NA	0	NA	0	NA	0	NA
## [25,]	NA	NA	0	0	NA	0	0	0	0	0	0	0
## [26,]	0	NA	0	0	0	0	NA	0	NA	0	0	0
## [27,]	1	1	1	1	1	NA	1	1	1	1	1	NA
## [28,]	NA	2	2	2	NA	NA	2	2	NA	2	2	2
## [29,]	0	0	0	NA	0	0	0	0	0	NA	0	0
## [30,]	NA	2	NA	2	NA	NA	2	2	2	NA	2	2
## [31,]	0	NA	0	NA	0	0	NA	NA	0	0	NA	NA
## [32,]	1	NA	NA	1	NA	1	NA	1	NA	1	1	1
## [33,]	NA	2	2	NA	NA	NA	2	2	2	2	2	2
## [34,]	2	NA	2	2	2	2	NA	NA	2	NA	2	2
## [35,]	NA	0	0	0	0	NA	NA	0	0	0	0	0
## [36,]	NA	NA	2	2	2	NA	2	2	2	2	2	2
## [37,]	0	NA	0	NA	0	0	0	0	0	0	0	0
## [38,]	NA	1	NA	1	NA	1	NA	NA	1	1	1	NA
## [39,]	0	0	0	0	NA	NA	NA	NA	NA	NA	0	NA
## [40,]	NA	1	NA	NA	NA	1	1	1	1	NA	NA	NA
## [41,]	2	2	2	2	NA	2	2	2	NA	2	NA	2
## [42,]	NA	0	0	0	NA	0	0	0	0	NA	NA	0
## [43,]	1	NA	1	1	NA	NA	1	1	1	1	1	1
## [44,]	0	NA	0	0	0	0	NA	0	0	0	0	0
## [45,]	0	NA	0	0	0	0	0	0	0	0	0	NA
## [46,]	0	0	0	0	0	0	0	0	0	0	NA	0
## [47,]	0	NA	0	NA	NA	0	0	NA	NA	NA	0	0
## [48,]	NA	0	0	0	0	0	0	NA	NA	NA	NA	0
## [49,]	0	0	0	NA	0	0	0	NA	0	0	0	0
## [50,]	0	0	0	NA	0	NA	0	0	NA	0	0	NA
##	[,26]	[,27]	[,28]	[,29]	[,30]	[,31]	[,32]	[,33]	[,34]	[,35]	[,36]	[,37]
## [1,]	0	0	0	0	0	0	0	0	NA	NA	0	0
## [2,]	2	2	NA	2	2	2	NA	2	NA	2	2	NA
## [3,]	0	0	NA	0	0	NA	0	0	0	0	0	NA
## [4,]	0	NA	NA	0	0	NA	0	0	0	NA	0	0
## [5,]	0	0	0	0	NA	NA	NA	NA	0	0	0	0
## [6,]	0	NA	0	NA	NA	0	0	0	0	0	0	0
## [7,]	NA	NA	0	0	0	0	0	0	NA	NA	NA	0
## [8,]	NA	0	0	0	0	0	0	NA	0	0	0	0
## [9,]	0	0	NA	0	0	0	NA	NA	NA	NA	0	0
## [10,]	2	NA	2	2	2	2	2	2	NA	2	2	2
## [11,]	NA	1	NA	1	1	1	1	1	1	1	1	1
## [12,]	1	1	1	1	1	1	1	1	1	1	1	1
## [13,]	0	NA	0	0	NA	0	0	NA	0	0	0	0
## [14,]	0	NA	0	0	NA	NA	NA	0	0	0	NA	0
## [15,]	NA	NA	0	0	0	NA	0	0	0	0	NA	0
## [16,]	0	NA	0	0	0	0	0	NA	0	0	0	0
## [17,]	NA	2	2	2	2	2	2	2	NA	NA	NA	2
## [18,]	NA	NA	NA	NA	2	NA	2	2	NA	NA	NA	NA
## [19,]	1	NA	1	1	1	1	1	1	1	1	1	1
## [20,]	1	1	1	NA	1	1	1	1	1	1	1	1
## [21,]	NA	1	NA	1	1	1	1	1	1	1	1	1
## [22,]	2	NA	NA	2	2	2	2	2	2	NA	2	2
## [23,]	1	1	NA	NA	NA	NA	NA	1	1	1	1	NA

## [24,]	0	NA	0	NA	0	0	0	NA	0	0	0	0
## [25,]	0	NA	NA	0	0	0	0	0	0	0	0	0
## [26,]	NA	NA	NA	0	NA	0	0	0	0	0	0	0
## [27,]	1	1	NA	1	1	1	1	NA	1	1	1	1
## [28,]	NA	NA	2	NA	2	2	2	NA	NA	2	2	2
## [29,]	0	NA	0	NA	0	NA	NA	0	0	0	0	0
## [30,]	2	2	NA	NA	2	2	2	2	2	2	2	NA
## [31,]	NA	0	0	NA	0	0	0	NA	NA	NA	NA	0
## [32,]	NA	1	NA	1	1	1	1	1	1	1	1	1
## [33,]	2	2	2	NA	2	NA	NA	2	2	NA	2	NA
## [34,]	2	2	NA	2	2	2	NA	2	2	NA	NA	NA
## [35,]	0	0	0	0	0	0	0	NA	0	0	NA	0
## [36,]	2	2	2	2	2	2	NA	NA	2	2	2	2
## [37,]	0	0	0	0	0	NA	0	NA	NA	0	NA	0
## [38,]	NA	1	1	1	NA	1	NA	1	1	1	NA	NA
## [39,]	0	0	0	0	0	0	NA	0	0	NA	NA	0
## [40,]	1	1	1	1	1	1	1	1	1	1	1	1
## [41,]	2	NA	2	2	2	2	2	NA	2	2	2	2
## [42,]	0	NA	NA	0	0	0	0	0	0	NA	0	0
## [43,]	1	1	1	1	NA	1	NA	NA	1	1	1	1
## [44,]	0	0	0	NA	NA	0	0	NA	0	0	NA	0
## [45,]	0	0	0	0	0	NA	NA	0	0	0	0	0
## [46,]	0	0	0	0	0	0	0	NA	0	0	NA	NA
## [47,]	0	0	0	0	0	0	0	NA	NA	NA	0	0
## [48,]	0	0	0	0	NA	0	0	0	0	NA	0	NA
## [49,]	NA	0	0	0	0	0	NA	0	0	0	NA	NA
## [50,]	0	0	0	0	0	0	0	0	0	0	NA	0
##	[,38]	[,39]	[,40]	[,41]	[,42]	[,43]	[,44]	[,45]	[,46]	[,47]	[,48]	[,49]
## [1,]	0	0	NA	NA	0	0	0	0	0	NA	NA	0
## [2,]	2	2	2	2	2	2	2	NA	2	NA	NA	2
## [3,]	0	0	0	0	0	NA	0	0	0	NA	0	0
## [4,]	0	0	0	0	NA	0	0	NA	0	NA	0	0
## [5,]	0	0	0	NA	0	NA	0	0	0	0	0	0
## [6,]	0	NA	0	NA	NA	NA	0	0	0	0	0	NA
## [7,]	NA	NA	0	NA	NA	0	0	0	0	NA	0	0
## [8,]	0	0	NA	0	NA	0	0	0	0	0	0	NA
## [9,]	NA	0	NA	0	0	0	NA	NA	0	0	0	0
## [10,]	NA	2	NA	NA	NA	2	2	2	NA	2	2	2
## [11,]	1	1	1	NA	1	NA	NA	1	1	NA	1	1
## [12,]	1	1	NA	1	NA	1	1	NA	NA	1	1	NA
## [13,]	NA	0	0	0	NA	0	0	NA	NA	NA	0	0
## [14,]	0	0	0	0	0	0	NA	NA	0	0	0	0
## [15,]	0	NA	0	0	NA	0	0	0	NA	0	NA	0
## [16,]	0	0	NA	NA	0	0	0	0	NA	0	0	0
## [17,]	2	2	NA	2	2	NA	2	2	2	2	NA	2
## [18,]	2	NA	2	NA	NA	2	2	NA	2	2	2	2
## [19,]	1	NA	NA	NA	NA	1	NA	1	1	1	1	NA
## [20,]	1	NA	NA	1	1	1	NA	NA	1	NA	1	NA
## [21,]	NA	1	1	1	1	1	NA	1	1	1	NA	1
## [22,]	2	NA	2	2	2	2	2	2	2	2	2	2
## [23,]	1	NA	1	NA	NA	1	1	1	1	1	1	1
## [24,]	NA	0	0	NA	NA	NA	0	NA	0	0	0	0
## [25,]	0	0	0	0	0	0	0	0	0	0	0	0
## [26,]	NA	0	0	NA	0	0	0	0	0	0	0	NA

## [27,]	1	1	1	1	NA	NA	1	NA	1	NA	1	1
## [28,]	2	2	2	NA	2	2	NA	2	2	NA	NA	2
## [29,]	NA	0	0	NA	0	NA	0	0	0	0	0	NA
## [30,]	2	2	2	NA	NA	2	NA	NA	2	NA	NA	NA
## [31,]	0	0	NA	NA	0	0	0	0	0	NA	0	NA
## [32,]	1	1	1	NA	1	NA	1	1	1	1	1	NA
## [33,]	NA	NA	NA	2	NA	2	2	2	2	NA	2	2
## [34,]	2	2	2	2	2	2	2	NA	2	2	NA	2
## [35,]	0	0	0	0	0	NA	0	NA	NA	0	0	NA
## [36,]	2	2	2	NA	2	NA	2	2	NA	2	NA	2
## [37,]	NA	0	NA	NA	0	0	0	NA	0	0	NA	NA
## [38,]	NA	1	NA	NA	NA	NA	NA	1	1	1	1	NA
## [39,]	0	0	0	NA	0	0	0	NA	0	0	NA	NA
## [40,]	1	1	1	1	NA	NA	1	NA	NA	1	NA	1
## [41,]	2	2	2	2	2	2	NA	NA	NA	NA	2	NA
## [42,]	0	0	0	0	NA	NA	0	0	NA	0	0	0
## [43,]	1	1	1	1	NA	1	1	NA	NA	1	1	1
## [44,]	NA	0	0	0	0	0	0	0	NA	0	NA	0
## [45,]	0	0	0	0	0	0	0	0	0	0	0	0
## [46,]	0	0	0	NA	0	0	0	NA	NA	NA	0	NA
## [47,]	0	NA	NA	NA	0	0	NA	NA	0	0	0	0
## [48,]	0	0	0	NA	0	0	NA	NA	0	0	0	0
## [49,]	0	NA	NA	0	0	NA	0	0	0	0	0	NA
## [50,]	0	0	0	0	NA	0	NA	NA	0	NA	0	0
##	[,50]											
## [1,]	0											
## [2,]	2											
## [3,]	0											
## [4,]	0											
## [5,]	0											
## [6,]	0											
## [7,]	0											
## [8,]	0											
## [9,]	NA											
## [10,]	NA											
## [11,]	1											
## [12,]	1											
## [13,]	0											
## [14,]	0											
## [15,]	NA											
## [16,]	0											
## [17,]	2											
## [18,]	NA											
## [19,]	1											
## [20,]	1											
## [21,]	NA											
## [22,]	NA											
## [23,]	NA											
## [24,]	NA											
## [25,]	0											
## [26,]	0											
## [27,]	1											
## [28,]	2											
## [29,]	NA											

```
## [30,]      2
## [31,]     NA
## [32,]     NA
## [33,]      2
## [34,]      2
## [35,]     NA
## [36,]      2
## [37,]      0
## [38,]      1
## [39,]      0
## [40,]      1
## [41,]      2
## [42,]     NA
## [43,]      1
## [44,]      0
## [45,]      0
## [46,]      0
## [47,]      0
## [48,]      0
## [49,]      0
## [50,]      0
```

- Sort the rows in matrix R by the largest row sum to lowest. Be careful about the NA's!

```
#TO-DO
sorted_rowSum <- R[order(rowSums(R[,], na.rm = TRUE), decreasing=TRUE),]
#sanity check
#rowSums(sorted_rowSum, na.rm = TRUE)
sorted_rowSum
```

```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12] [,13]
## [1,]    2    2    2    2    2    2    2    2    2    2    NA    2    2
## [2,]    2    2    2   NA    2    2    2    2    2    2    2    2   NA
## [3,]    2   NA    2    2    2   NA    2    2    2    2    2    NA    2
## [4,]    2    2   NA    2    2    2    2    2    2    2    2    NA    2
## [5,]    2    2    2    2   NA   NA    2    2    2    2    2    NA   NA
## [6,]   NA   NA   NA   NA    2   NA    2    2    2    2    2    2   NA
## [7,]   NA   NA    2    2    2   NA    2   NA    2    2    NA    2    2
## [8,]    2    2    2   NA   NA   NA    2   NA    2    2    NA    2   NA
## [9,]    2   NA   NA   NA   NA    2    2    2    2    2    2    2    2
## [10,]   2   NA    2   NA    2    2   NA    2    2    2    2    2    2
## [11,]   2   NA    2    2   NA   NA   NA    2   NA    2    2    2   NA
## [12,]    1    1    1    1    1    1    1    1   NA   NA   NA   NA    1
## [13,]    1    1   NA    1    1   NA    1    1   NA   NA    1    1    1
## [14,]   NA   NA   NA    1    1    1    1    1    1    1    1    1    1
## [15,]   NA    1   NA    1    1    1    1    1    1    1    1   NA    1
## [16,]   NA   NA   NA    1    1    1    1    1    1   NA    1   NA    1
## [17,]    1    1   NA    1    1   NA   NA    1    1   NA   NA    1   NA
## [18,]    1   NA    1    1   NA    1   NA   NA    1    1    1    1    1
## [19,]    1   NA    1   NA    1    1    1    1   NA    1   NA    1    1
## [20,]    1    1    1   NA    1    1   NA    1    1    1    1   NA   NA
## [21,]   NA    1    1   NA   NA    1   NA   NA    1    1   NA   NA   NA
## [22,]    1   NA    1   NA   NA    1   NA    1   NA    1    1    1    1
```

## [23,]	NA	NA	0	NA	NA	NA	0	0	0	0	0	NA	NA
## [24,]	0	0	0	NA	0	0	0	0	0	0	0	0	NA
## [25,]	0	0	NA	0	0	NA	NA	0	0	0	0	0	NA
## [26,]	NA	NA	NA	NA	0	0	0	NA	0	0	0	0	NA
## [27,]	0	0	0	0	0	0	0	0	NA	0	0	NA	0
## [28,]	NA	0	0	0	0	0	NA	NA	0	NA	NA	0	0
## [29,]	0	0	NA	0	0	NA	0	0	0	0	0	0	0
## [30,]	0	0	0	0	0	0	0	0	0	0	0	0	0
## [31,]	0	0	NA	0	0	0	0	0	NA	0	0	NA	0
## [32,]	0	0	0	0	0	0	0	0	0	0	0	0	0
## [33,]	0	0	0	NA	0	0	0	0	0	NA	NA	NA	0
## [34,]	0	0	0	0	0	NA	NA	NA	NA	0	NA	NA	0
## [35,]	0	0	NA	0	0	0	0	0	0	0	0	0	NA
## [36,]	0	0	0	0	NA	0	NA	0	NA	NA	0	0	NA
## [37,]	0	0	NA	NA	0	NA	0	NA	0	0	NA	0	NA
## [38,]	0	0	NA	0	0	0	NA	0	NA	0	NA	0	0
## [39,]	0	0	0	0	0	0	0	0	0	0	0	NA	0
## [40,]	0	0	0	NA	0	NA	0	0	0	0	0	0	0
## [41,]	0	0	0	0	NA	NA	0	NA	0	0	0	0	0
## [42,]	0	0	NA	NA	NA	0	NA	NA	NA	0	0	0	0
## [43,]	NA	0	0	0	0	0	0	0	NA	0	0	0	0
## [44,]	NA	0	0	NA	NA	NA	0	0	0	0	0	0	0
## [45,]	NA	NA	0	0	NA	0	0	0	NA	0	NA	NA	0
## [46,]	0	0	0	0	0	NA	0	0	0	0	NA	0	0
## [47,]	NA	NA	0	0	NA	NA	0	NA	0	0	0	0	NA
## [48,]	NA	0	0	0	0	0	0	0	0	0	NA	0	0
## [49,]	NA	0	0	NA	0	0	0	NA	0	0	NA	NA	0
## [50,]	0	0	0	0	0	0	0	0	0	0	0	0	0
##	[,14]	[,15]	[,16]	[,17]	[,18]	[,19]	[,20]	[,21]	[,22]	[,23]	[,24]	[,25]	
## [1,]	2	2	2	2	2	2	2	NA	NA	2	NA	2	
## [2,]	NA	NA	2	2	2	NA	2	2	2	2	2	2	
## [3,]	2	NA	2	2	NA	NA	2	2	2	NA	2	2	
## [4,]	2	NA	NA	2	2	NA	NA	NA	2	2	2	NA	
## [5,]	2	NA	2	2	2	2	NA	NA	2	NA	2	2	
## [6,]	2	2	2	2	NA	2	2	2	NA	2	NA	2	
## [7,]	2	2	NA	NA	NA	2	2	2	2	NA	NA	2	
## [8,]	NA	2	2	2	NA	NA	2	2	NA	2	2	2	
## [9,]	NA	2	NA	2	NA	NA	2	2	2	NA	2	2	
## [10,]	2	2	2	2	NA	2	NA	NA	2	2	2	2	
## [11,]	NA	2	2	NA	NA	NA	2	2	2	2	2	2	
## [12,]	1	1	1	1	1	NA	1	1	1	1	1	NA	
## [13,]	1	NA	1	1	NA	NA	1	1	1	1	1	1	
## [14,]	1	NA	NA	1	NA	1	NA	1	NA	1	1	1	
## [15,]	1	NA	NA	1	NA	1	1	NA	1	1	NA	1	
## [16,]	1	1	NA	1	1	1	NA	1	1	1	NA	1	
## [17,]	1	1	NA	1	1	NA	NA	1	1	NA	NA	1	
## [18,]	1	NA	NA	NA	1	NA	1	1	1	NA	NA	1	
## [19,]	1	NA	NA	NA	1	NA	1	NA	1	1	NA	NA	
## [20,]	NA	1	1	NA	NA	1	1	NA	NA	1	1	1	
## [21,]	NA	1	NA	NA	NA	1	1	1	1	NA	NA	NA	
## [22,]	NA	1	NA	1	NA	1	NA	NA	1	1	1	NA	
## [23,]	0	0	0	0	0	NA	0	NA	NA	0	0	NA	
## [24,]	NA	0	0	0	0	NA	0	0	NA	NA	NA	0	
## [25,]	0	NA	0	0	0	0	0	0	NA	0	NA	NA	

## [26,]	NA	0	0	NA	0	0	0	0	NA	0	0	0
## [27,]	0	0	0	0	NA	0	NA	0	0	0	0	0
## [28,]	0	0	0	0	0	0	0	0	0	0	NA	0
## [29,]	NA	0	0	0	0	NA	0	0	0	0	0	0
## [30,]	0	0	NA	0	0	NA	0	0	NA	0	0	0
## [31,]	0	0	0	0	NA	0	NA	0	0	0	NA	NA
## [32,]	0	0	0	0	0	NA	NA	0	NA	0	0	NA
## [33,]	0	NA	NA	0	NA	0	0	NA	0	NA	0	NA
## [34,]	NA	0	0	0	0	0	0	0	0	0	0	0
## [35,]	0	NA	NA	NA	0	NA	0	NA	0	NA	0	NA
## [36,]	NA	NA	0	0	NA	0	0	0	0	0	0	0
## [37,]	0	NA	0	0	0	0	NA	0	NA	0	0	0
## [38,]	0	0	0	NA	0	0	0	0	0	NA	0	0
## [39,]	0	NA	0	NA	0	0	NA	NA	0	0	NA	NA
## [40,]	NA	0	0	0	0	NA	NA	0	0	0	0	0
## [41,]	0	NA	0	NA	0	0	0	0	0	0	0	0
## [42,]	0	0	0	0	NA	NA	NA	NA	NA	NA	0	NA
## [43,]	NA	0	0	0	NA	0	0	0	0	NA	NA	0
## [44,]	0	NA	0	0	0	0	NA	0	0	0	0	0
## [45,]	0	NA	0	0	0	0	0	0	0	0	0	NA
## [46,]	0	0	0	0	0	0	0	0	0	0	NA	0
## [47,]	0	NA	0	NA	NA	0	0	NA	NA	NA	0	0
## [48,]	NA	0	0	0	0	0	0	NA	NA	NA	NA	0
## [49,]	0	0	0	NA	0	0	0	NA	0	0	0	0
## [50,]	0	0	0	NA	0	NA	0	0	NA	0	0	NA
##	[,26]	[,27]	[,28]	[,29]	[,30]	[,31]	[,32]	[,33]	[,34]	[,35]	[,36]	[,37]
## [1,]	2	2	NA	2	2	2	NA	2	NA	2	2	NA
## [2,]	2	2	2	2	2	2	NA	NA	2	2	2	2
## [3,]	2	NA	NA	2	2	2	2	2	2	NA	2	2
## [4,]	NA	2	2	2	2	2	2	2	NA	NA	NA	2
## [5,]	2	2	NA	2	2	2	NA	2	2	NA	NA	NA
## [6,]	2	NA	2	2	2	2	2	NA	2	2	2	2
## [7,]	2	NA	2	2	2	2	2	2	NA	2	2	2
## [8,]	NA	NA	2	NA	2	2	2	NA	NA	2	2	2
## [9,]	2	2	NA	NA	2	2	2	2	2	2	2	NA
## [10,]	NA	NA	NA	NA	2	NA	2	2	NA	NA	NA	NA
## [11,]	2	2	2	NA	2	NA	NA	2	2	NA	2	NA
## [12,]	1	1	NA	1	1	1	1	NA	1	1	1	1
## [13,]	1	1	1	1	NA	1	NA	NA	1	1	1	1
## [14,]	NA	1	NA	1	1	1	1	1	1	1	1	1
## [15,]	1	NA	1	1	1	1	1	1	1	1	1	1
## [16,]	1	1	1	NA	1	1	1	1	1	1	1	1
## [17,]	1	1	1	1	1	1	1	1	1	1	1	1
## [18,]	NA	1	NA	1	1	1	1	1	1	1	1	1
## [19,]	NA	1	NA	1	1	1	1	1	1	1	1	1
## [20,]	1	1	NA	NA	NA	NA	NA	1	1	1	1	NA
## [21,]	1	1	1	1	1	1	1	1	1	1	1	1
## [22,]	NA	1	1	1	NA	1	NA	1	1	1	NA	NA
## [23,]	0	0	0	0	0	0	0	0	NA	NA	0	0
## [24,]	0	0	NA	0	0	NA	0	0	0	0	0	NA
## [25,]	0	NA	NA	0	0	NA	0	0	0	NA	0	0
## [26,]	0	0	0	0	NA	NA	NA	NA	0	0	0	0
## [27,]	0	NA	0	NA	NA	0	0	0	0	0	0	0
## [28,]	NA	NA	0	0	0	0	0	0	NA	NA	NA	0

## [29,]	NA	0	0	0	0	0	0	NA	0	0	0	0
## [30,]	0	0	NA	0	0	0	NA	NA	NA	NA	0	0
## [31,]	0	NA	0	0	NA	0	0	NA	0	0	0	0
## [32,]	0	NA	0	0	NA	NA	NA	0	0	0	NA	0
## [33,]	NA	NA	0	0	0	NA	0	0	0	0	NA	0
## [34,]	0	NA	0	0	0	0	0	NA	0	0	0	0
## [35,]	0	NA	0	NA	0	0	0	NA	0	0	0	0
## [36,]	0	NA	NA	0	0	0	0	0	0	0	0	0
## [37,]	NA	NA	NA	0	NA	0	0	0	0	0	0	0
## [38,]	0	NA	0	NA	0	NA	NA	0	0	0	0	0
## [39,]	NA	0	0	NA	0	0	0	NA	NA	NA	NA	0
## [40,]	0	0	0	0	0	0	0	NA	0	0	NA	0
## [41,]	0	0	0	0	0	0	NA	0	NA	NA	0	NA
## [42,]	0	0	0	0	0	0	0	NA	0	0	NA	NA
## [43,]	0	NA	NA	0	0	0	0	0	0	0	NA	0
## [44,]	0	0	0	NA	NA	0	0	NA	0	0	NA	0
## [45,]	0	0	0	0	0	NA	NA	0	0	0	0	0
## [46,]	0	0	0	0	0	0	0	NA	0	0	NA	NA
## [47,]	0	0	0	0	0	0	0	NA	NA	NA	0	0
## [48,]	0	0	0	0	NA	0	0	0	0	NA	0	NA
## [49,]	NA	0	0	0	0	0	NA	0	0	0	NA	NA
## [50,]	0	0	0	0	0	0	0	0	0	0	NA	0
##	[,38]	[,39]	[,40]	[,41]	[,42]	[,43]	[,44]	[,45]	[,46]	[,47]	[,48]	[,49]
## [1,]	2	2	2	2	2	2	2	NA	2	NA	NA	2
## [2,]	2	2	2	NA	2	NA	2	2	NA	2	NA	2
## [3,]	2	NA	2	2	2	2	2	2	2	2	2	2
## [4,]	2	2	NA	2	2	NA	2	2	2	2	NA	2
## [5,]	2	2	2	2	2	2	2	NA	2	2	NA	2
## [6,]	2	2	2	2	2	2	NA	NA	NA	NA	2	NA
## [7,]	NA	2	NA	NA	NA	2	2	2	NA	2	2	2
## [8,]	2	2	2	NA	2	2	NA	2	2	NA	NA	2
## [9,]	2	2	2	NA	NA	2	NA	NA	2	NA	NA	NA
## [10,]	2	NA	2	NA	NA	2	2	NA	2	2	2	2
## [11,]	NA	NA	NA	2	NA	2	2	2	2	NA	2	2
## [12,]	1	1	1	1	NA	NA	1	NA	1	NA	1	1
## [13,]	1	1	1	1	NA	1	1	NA	NA	1	1	1
## [14,]	1	1	1	NA	1	NA	1	1	1	1	1	NA
## [15,]	1	NA	NA	NA	NA	1	NA	1	1	1	1	NA
## [16,]	1	NA	NA	1	1	1	NA	NA	1	NA	1	NA
## [17,]	1	1	NA	1	NA	1	1	NA	NA	1	1	NA
## [18,]	NA	1	1	1	1	1	NA	1	1	1	NA	1
## [19,]	1	1	1	NA	1	NA	NA	1	1	NA	1	1
## [20,]	1	NA	1	NA	NA	1	1	1	1	1	1	1
## [21,]	1	1	1	1	NA	NA	1	NA	NA	1	NA	1
## [22,]	NA	1	NA	NA	NA	NA	NA	1	1	1	1	NA
## [23,]	0	0	NA	NA	0	0	0	0	0	NA	NA	0
## [24,]	0	0	0	0	0	NA	0	0	0	NA	0	0
## [25,]	0	0	0	0	NA	0	0	NA	0	NA	0	0
## [26,]	0	0	0	NA	0	NA	0	0	0	0	0	0
## [27,]	0	NA	0	NA	NA	NA	0	0	0	0	0	NA
## [28,]	NA	NA	0	NA	NA	0	0	0	0	NA	0	0
## [29,]	0	0	NA	0	NA	0	0	0	0	0	0	NA
## [30,]	NA	0	NA	0	0	0	NA	NA	0	0	0	0
## [31,]	NA	0	0	0	NA	0	0	NA	NA	NA	0	0

## [32,]	0	0	0	0	0	0	NA	NA	0	0	0	0
## [33,]	0	NA	0	0	NA	0	0	0	NA	0	NA	0
## [34,]	0	0	NA	NA	0	0	0	0	NA	0	0	0
## [35,]	NA	0	0	NA	NA	NA	0	NA	0	0	0	0
## [36,]	0	0	0	0	0	0	0	0	0	0	0	0
## [37,]	NA	0	0	NA	0	0	0	0	0	0	0	NA
## [38,]	NA	0	0	NA	0	NA	0	0	0	0	0	NA
## [39,]	0	0	NA	NA	0	0	0	0	0	NA	0	NA
## [40,]	0	0	0	0	0	NA	0	NA	NA	0	0	NA
## [41,]	NA	0	NA	NA	0	0	0	NA	0	0	NA	NA
## [42,]	0	0	0	NA	0	0	0	NA	0	0	NA	NA
## [43,]	0	0	0	0	NA	NA	0	0	NA	0	0	0
## [44,]	NA	0	0	0	0	0	0	0	NA	0	NA	0
## [45,]	0	0	0	0	0	0	0	0	0	0	0	0
## [46,]	0	0	0	NA	0	0	0	NA	NA	NA	0	NA
## [47,]	0	NA	NA	NA	0	0	NA	NA	0	0	0	0
## [48,]	0	0	0	NA	0	0	NA	NA	0	0	0	0
## [49,]	0	NA	NA	0	0	NA	0	0	0	0	0	NA
## [50,]	0	0	0	0	NA	0	NA	NA	0	NA	0	0
## [,50]												
## [1,]	2											
## [2,]	2											
## [3,]	NA											
## [4,]	2											
## [5,]	2											
## [6,]	2											
## [7,]	NA											
## [8,]	2											
## [9,]	2											
## [10,]	NA											
## [11,]	2											
## [12,]	1											
## [13,]	1											
## [14,]	NA											
## [15,]	1											
## [16,]	1											
## [17,]	1											
## [18,]	NA											
## [19,]	1											
## [20,]	NA											
## [21,]	1											
## [22,]	1											
## [23,]	0											
## [24,]	0											
## [25,]	0											
## [26,]	0											
## [27,]	0											
## [28,]	0											
## [29,]	0											
## [30,]	NA											
## [31,]	0											
## [32,]	0											
## [33,]	NA											
## [34,]	0											


```
## [35,] NA
## [36,] 0
## [37,] 0
## [38,] NA
## [39,] NA
## [40,] NA
## [41,] 0
## [42,] 0
## [43,] NA
## [44,] 0
## [45,] 0
## [46,] 0
## [47,] 0
## [48,] 0
## [49,] 0
## [50,] 0
```

- We will now learn the `apply` function. This is a handy function that saves writing for loops which should be eschewed in R. Use the `apply` function to compute a vector whose entries are the standard deviation of each row. Use the `apply` function to compute a vector whose entries are the standard deviation of each column. Be careful about the NA's! This should be one line.

```
#TO-DO
apply(R,1,sd, na.rm=TRUE)
```

```
## [1] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## [39] 0 0 0 0 0 0 0 0 0 0 0 0
```

```
apply(R,2,sd, na.rm=TRUE)
```

```
## [1] 0.85993941549 0.74133651733 0.84861216259 0.79755169718 0.80277297192
## [6] 0.75602419316 0.85687468993 0.83529877279 0.87078025831 0.86522582333
## [11] 0.84281592351 0.84861216259 0.78306495953 0.80752760964 0.83858559876
## [16] 0.84468459409 0.85588532090 0.72793204179 0.77607915226 0.83816526318
## [21] 0.81704218512 0.82787876178 0.80752760964 0.85943956369 0.87735277919
## [26] 0.82836355919 0.78030184399 0.78760450457 0.78532422798 0.86971849262
## [31] 0.82553708032 0.80277297192 0.83029750053 0.75106761620 0.76168151491
## [36] 0.81683957468 0.75554629403 0.83529877279 0.81484207754 0.83816526318
## [41] 0.83757892854 0.85500554545 0.86675285070 0.83198088451 0.82615959871
## [46] 0.82381956682 0.78306495953 0.73111868704 0.87581131218 0.82381956682
```

- Use the `apply` function to compute a vector whose entries are the count of entries that are 1 or 2 in each column. This should be one line.

```
#TO-DO
apply(R != 0 ,2,sum, na.rm=TRUE)
```

```
## [1] 16 11 14 13 15 14 15 18 17 18 15 14 14 15 13 11 16 9 11 15 14 17 15 13 17
## [26] 15 16 12 16 19 19 15 17 17 17 18 15 18 16 15 12 11 15 14 12 16 14 14 15 16
```

- Use the `split` function to create a list whose keys are the column number and values are the vector of the columns. Look at the last example in the documentation `?split`.

```
#TO-DO
split(R, col(R))
```

```
## $'1'
## [1] NA 2 0 0 NA 0 NA 0 0 NA 1 1 0 0 0 0 2 2 NA NA 1 2 1 0 0
## [26] 0 1 2 0 2 0 NA 2 2 0 2 0 1 0 NA NA NA 1 NA NA 0 NA NA NA 0
##
## $'2'
## [1] NA 2 0 0 NA 0 0 0 0 NA NA 1 0 0 0 0 2 NA 1 NA NA NA 1 0 0
## [26] 0 1 2 0 NA 0 NA NA 2 0 2 0 NA 0 1 NA 0 1 0 NA 0 NA 0 0 0
##
## $'3'
## [1] 0 2 0 NA NA 0 0 NA 0 2 1 NA NA 0 0 0 NA 2 NA NA 1 2 1 NA 0
## [26] NA 1 2 NA NA 0 NA 2 2 0 2 0 1 NA 1 NA 0 NA 0 0 0 0 0 0
##
## $'4'
## [1] NA 2 NA 0 NA 0 0 0 0 2 NA 1 0 0 NA 0 2 NA 1 1 1 2 NA 0 0
## [26] NA 1 NA 0 NA 0 1 2 2 NA NA 0 NA NA NA NA 0 1 NA 0 0 0 0 NA 0
##
## $'5'
## [1] NA 2 0 0 0 0 0 0 0 2 1 1 0 0 0 0 2 2 1 1 NA 2 1 0 NA
## [26] 0 1 NA 0 NA 0 1 NA NA 0 2 NA NA NA NA 2 0 1 NA NA 0 NA 0 0 0
##
## $'6'
## [1] NA 2 0 NA 0 0 0 NA 0 NA 1 NA 0 0 0 NA 2 2 1 1 1 NA 1 0 0
## [26] NA 1 NA 0 2 0 1 NA NA NA 2 NA 1 0 1 NA 0 NA NA 0 NA NA 0 0 0
##
## $'7'
## [1] 0 2 0 NA 0 0 NA 0 0 2 1 NA 0 0 0 NA 2 NA 1 1 NA 2 NA 0 NA
## [26] 0 1 2 NA 2 0 1 NA 2 0 2 0 NA NA NA 2 0 1 0 0 0 0 0 0
##
## $'8'
## [1] 0 2 0 0 NA 0 NA 0 0 NA 1 1 0 0 0 NA 2 2 1 1 NA 2 1 0 0
## [26] NA 1 NA 0 2 0 1 2 2 0 2 NA 1 NA NA 2 0 1 0 0 0 NA 0 NA 0
##
## $'9'
## [1] 0 2 0 0 0 NA 0 0 0 2 NA 1 NA 0 0 NA 2 2 1 1 1 2 1 0 NA
## [26] 0 NA 2 NA 2 0 1 NA 2 0 2 0 NA NA 1 2 NA NA 0 NA 0 0 0 0
##
## $'10'
## [1] 0 2 0 0 0 0 NA 0 0 2 1 NA 0 0 NA 0 2 2 1 NA 1 2 1 0 NA
## [26] 0 NA 2 0 2 0 1 2 2 0 2 0 1 0 1 2 0 NA 0 0 0 0 0 0
##
## $'11'
## [1] 0 NA 0 0 0 0 NA 0 0 NA NA NA 0 0 NA NA 2 2 1 1 1 2 1 0 0
## [26] NA NA NA NA 2 0 1 2 2 0 2 0 1 0 NA 2 0 1 0 NA NA 0 NA NA 0
##
## $'12'
## [1] NA 2 0 0 0 NA 0 0 0 2 1 1 NA 0 NA NA NA 2 NA NA 1 NA NA 0 0
## [26] 0 NA 2 0 2 NA 1 2 NA 0 2 0 1 0 NA 2 0 1 0 NA 0 0 0 NA 0
##
## $'13'
## [1] NA 2 NA NA NA 0 0 0 0 2 1 NA 0 0 0 0 2 2 1 1 1 2 NA NA NA
```

```

## [26] NA 1 NA 0 2 0 1 NA NA 0 NA 0 1 0 NA NA 0 1 0 0 0 NA 0 0 0
##
## $'14'
## [1] 0 2 NA 0 NA 0 0 NA 0 2 1 1 0 0 0 NA 2 2 1 1 1 2 NA 0 NA
## [26] 0 1 NA 0 NA 0 1 NA 2 NA NA 0 NA 0 NA 2 NA 1 0 0 0 0 NA 0 0
##
## $'15'
## [1] 0 2 0 NA 0 0 0 0 0 2 NA 1 0 0 NA 0 NA 2 NA 1 NA NA 1 NA NA
## [26] NA 1 2 0 2 NA NA 2 NA 0 NA NA 1 0 1 2 0 NA NA NA 0 NA 0 0 0
##
## $'16'
## [1] 0 2 0 0 0 0 0 0 NA NA NA NA 0 0 NA 0 NA 2 NA NA NA 2 1 NA 0
## [26] 0 1 2 0 NA 0 NA 2 2 0 2 0 NA 0 NA 2 0 1 0 0 0 0 0 0 0
##
## $'17'
## [1] 0 2 0 0 NA 0 0 0 0 NA NA 1 0 0 0 0 2 2 1 1 NA 2 NA NA 0
## [26] 0 1 2 NA 2 NA 1 NA 2 0 2 NA 1 0 NA 2 0 1 0 0 0 NA 0 NA NA
##
## $'18'
## [1] 0 2 0 0 0 NA 0 0 0 NA 1 1 NA 0 NA 0 2 NA NA 1 1 NA NA 0 NA
## [26] 0 1 NA 0 NA 0 NA NA 2 0 2 0 NA NA NA NA NA NA 0 0 0 NA 0 0 0
##
## $'19'
## [1] NA 2 NA 0 0 0 0 NA NA 2 NA NA 0 NA 0 0 NA 2 1 1 NA NA 1 NA 0
## [26] 0 NA NA 0 NA 0 1 NA 2 NA NA 0 1 NA 1 2 0 NA 0 0 0 0 0 0 NA
##
## $'20'
## [1] 0 2 0 0 0 NA 0 0 0 2 1 NA NA NA 0 0 NA NA 1 NA 1 2 1 0 0
## [26] NA 1 2 0 2 NA NA 2 NA NA 2 0 NA NA 1 2 0 1 NA 0 0 0 0 0 0
##
## $'21'
## [1] NA NA 0 0 0 0 0 0 0 2 NA 1 0 0 NA 0 NA NA NA 1 1 2 NA NA 0
## [26] 0 1 2 0 2 NA 1 2 NA 0 2 0 NA NA 1 2 0 1 0 0 0 NA NA NA 0
##
## $'22'
## [1] NA NA NA NA NA 0 0 0 NA 2 1 1 0 NA 0 0 2 2 1 1 1 2 NA 0 0
## [26] NA 1 NA 0 2 0 NA 2 2 0 2 0 1 NA 1 NA 0 1 0 0 0 NA NA 0 NA
##
## $'23'
## [1] 0 2 NA 0 0 0 0 0 0 NA 1 NA 0 0 NA 0 2 2 1 1 NA NA 1 NA 0
## [26] 0 1 2 NA NA 0 1 2 NA 0 2 0 1 NA NA 2 NA 1 0 0 0 NA NA 0 0
##
## $'24'
## [1] 0 NA NA NA 0 0 NA 0 0 NA NA NA NA 0 0 0 2 2 NA NA NA 2 1 0 0
## [26] 0 1 2 0 2 NA 1 2 2 0 2 0 1 0 NA NA NA 1 0 0 NA 0 NA 0 0
##
## $'25'
## [1] NA 2 0 NA 0 0 0 0 0 2 NA 1 NA NA NA 0 NA 2 1 1 1 2 1 NA 0
## [26] 0 NA 2 0 2 NA 1 2 2 0 2 0 NA NA NA 2 0 1 0 NA 0 0 0 0 NA
##
## $'26'
## [1] 0 2 0 0 0 0 NA NA 0 2 NA 1 0 0 NA 0 NA NA 1 1 NA 2 1 0 0
## [26] NA 1 NA 0 2 NA NA 2 2 0 2 0 NA 0 1 2 0 1 0 0 0 0 0 NA 0
##

```

```

## $'27'
## [1] 0 2 0 NA 0 NA NA 0 0 NA 1 1 NA NA NA NA 2 NA NA 1 1 NA 1 NA NA
## [26] NA 1 NA NA 2 0 1 2 2 0 2 0 1 0 1 NA NA 1 0 0 0 0 0 0 0
##
## $'28'
## [1] 0 NA NA NA 0 0 0 0 NA 2 NA 1 0 0 0 0 2 NA 1 1 NA NA NA 0 NA
## [26] NA NA 2 0 NA 0 NA 2 NA 0 2 0 1 0 1 2 NA 1 0 0 0 0 0 0
##
## $'29'
## [1] 0 2 0 0 0 NA 0 0 0 2 1 1 0 0 0 0 2 NA 1 NA 1 2 NA NA 0
## [26] 0 1 NA NA NA NA 1 NA 2 0 2 0 1 0 1 2 0 1 NA 0 0 0 0 0
##
## $'30'
## [1] 0 2 0 0 NA NA 0 0 0 2 1 1 NA NA 0 0 2 2 1 1 1 2 NA 0 0
## [26] NA 1 2 0 2 0 1 2 2 0 2 0 NA 0 1 2 0 NA NA 0 0 0 NA 0 0
##
## $'31'
## [1] 0 2 NA NA NA 0 0 0 0 2 1 1 0 NA NA 0 2 NA 1 1 1 2 NA 0 0
## [26] 0 1 2 NA 2 0 1 NA 2 0 2 NA 1 0 1 2 0 1 0 NA 0 0 0 0
##
## $'32'
## [1] 0 NA 0 0 NA 0 0 0 NA 2 1 1 0 NA 0 0 2 2 1 1 1 2 NA 0 0
## [26] 0 1 2 NA 2 0 1 NA NA 0 NA 0 NA NA 1 2 0 NA 0 NA 0 0 0 NA 0
##
## $'33'
## [1] 0 2 0 0 NA 0 0 NA NA 2 1 1 NA 0 0 NA 2 2 1 1 1 2 1 NA 0
## [26] 0 NA NA 0 2 NA 1 2 2 NA NA NA 1 0 1 NA 0 NA NA 0 NA NA 0 0 0
##
## $'34'
## [1] NA NA 0 0 0 0 NA 0 NA NA 1 1 0 0 0 0 NA NA 1 1 1 2 1 0 0
## [26] 0 1 NA 0 2 NA 1 2 2 0 2 NA 1 0 1 2 0 1 0 0 0 NA 0 0 0
##
## $'35'
## [1] NA 2 0 NA 0 0 NA 0 NA 2 1 1 0 0 0 0 NA NA 1 1 1 NA 1 0 0
## [26] 0 1 2 0 2 NA 1 NA NA 0 2 0 1 NA 1 2 NA 1 0 0 0 NA NA 0 0
##
## $'36'
## [1] 0 2 0 0 0 0 NA 0 0 2 1 1 0 NA NA 0 NA NA 1 1 1 2 1 0 0
## [26] 0 1 2 0 2 NA 1 2 NA NA 2 NA NA NA 1 2 0 1 NA 0 NA 0 0 NA NA
##
## $'37'
## [1] 0 NA NA 0 0 0 0 0 0 2 1 1 0 0 0 0 2 NA 1 1 1 2 NA 0 0
## [26] 0 1 2 0 NA 0 1 NA NA 0 2 0 NA 0 1 2 0 1 0 0 NA 0 NA NA 0
##
## $'38'
## [1] 0 2 0 0 0 0 NA 0 NA NA 1 1 NA 0 0 0 2 2 1 1 NA 2 1 NA 0
## [26] NA 1 2 NA 2 0 1 NA 2 0 2 NA NA 0 1 2 0 1 NA 0 0 0 0 0 0
##
## $'39'
## [1] 0 2 0 0 0 NA NA 0 0 2 1 1 0 0 NA 0 2 NA NA NA 1 NA NA 0 0
## [26] 0 1 2 0 2 0 1 NA 2 0 2 0 1 0 1 2 0 1 0 0 0 NA 0 NA 0
##
## $'40'
## [1] NA 2 0 0 0 0 0 NA NA NA 1 NA 0 0 0 NA NA 2 NA NA 1 2 1 0 0

```

```
## [26] 0 1 2 0 2 NA 1 NA 2 0 2 NA NA 0 1 2 0 1 0 0 0 NA 0 NA 0
##
## $'41'
## [1] NA 2 0 0 NA NA NA 0 0 NA NA 1 0 0 0 NA 2 NA NA 1 1 2 NA NA 0
## [26] NA 1 NA NA NA NA NA 2 2 0 NA NA NA NA 1 2 0 1 0 0 NA NA NA 0 0
##
## $'42'
## [1] 0 2 0 NA 0 NA NA NA 0 NA 1 NA NA 0 NA 0 2 NA NA 1 1 2 NA NA 0
## [26] 0 NA 2 0 NA 0 1 NA 2 0 2 0 NA 0 NA 2 NA NA 0 0 0 0 0 0 NA
##
## $'43'
## [1] 0 2 NA 0 NA NA 0 0 0 2 NA 1 0 0 0 0 NA 2 1 1 1 2 1 NA 0
## [26] 0 NA 2 NA 2 0 NA 2 2 NA NA 0 NA 0 NA 2 NA 1 0 0 0 0 0 NA 0
##
## $'44'
## [1] 0 2 0 0 0 0 0 0 NA 2 NA 1 0 NA 0 0 2 2 NA NA NA 2 1 0 0
## [26] 0 1 NA 0 NA 0 1 2 2 0 2 0 NA 0 1 NA 0 1 0 0 0 NA NA 0 NA
##
## $'45'
## [1] 0 NA 0 NA 0 0 0 0 NA 2 1 NA NA NA 0 0 2 NA 1 NA 1 2 1 NA 0
## [26] 0 NA 2 0 NA 0 1 2 NA NA 2 NA 1 NA NA NA 0 NA 0 0 NA NA NA 0 NA
##
## $'46'
## [1] 0 2 0 0 0 0 0 0 0 NA 1 NA NA 0 NA NA 2 2 1 1 1 2 1 0 0
## [26] 0 1 2 0 2 0 1 2 2 NA NA 0 1 0 NA NA NA NA NA 0 NA 0 0 0 0
##
## $'47'
## [1] NA NA NA NA 0 0 NA 0 0 2 NA 1 NA 0 0 0 2 2 1 NA 1 2 1 0 0
## [26] 0 NA NA 0 NA NA 1 NA 2 0 2 0 1 0 1 NA 0 1 0 0 NA 0 0 0 NA
##
## $'48'
## [1] NA NA 0 0 0 0 0 0 0 2 1 1 0 0 NA 0 NA 2 1 1 NA 2 1 0 0
## [26] 0 1 NA 0 NA 0 1 2 NA 0 NA NA 1 NA NA 2 0 1 NA 0 0 0 0 0 0
##
## $'49'
## [1] 0 2 0 0 0 NA 0 NA 0 2 1 NA 0 0 0 0 2 2 NA NA 1 2 1 0 0
## [26] NA 1 2 NA NA NA NA 2 2 NA 2 NA NA NA 1 NA 0 1 0 0 NA 0 0 NA 0
##
## $'50'
## [1] 0 2 0 0 0 0 0 0 NA NA 1 1 0 0 NA 0 2 NA 1 1 NA NA NA NA 0
## [26] 0 1 2 NA 2 NA NA 2 2 NA 2 0 1 0 1 2 NA 1 0 0 0 0 0 0 0
```

- In one statement, use the `lapply` function to create a list whose keys are the column number and values are themselves a list with keys: “min” whose value is the minimum of the column, “max” whose value is the maximum of the column, “pct_missing” is the proportion of missingness in the column and “first_NA” whose value is the row number of the first time the NA appears.

```
#T0-D0
```

```
lapply(split(R,col(R)), function(x) list(min =min(x,na.rm=TRUE), max =max(x,na.rm=TRUE), pct_missing =
```

```
## $'1'
## $'1'$min
## [1] 0
```

```

##
## $'1'$max
## [1] 2
##
## $'1'$pct_missing
## [1] 0.3
##
## $'1'$first_NA
## [1] 1
##
##
## $'2'
## $'2'$min
## [1] 0
##
## $'2'$max
## [1] 2
##
## $'2'$pct_missing
## [1] 0.3
##
## $'2'$first_NA
## [1] 1
##
##
## $'3'
## $'3'$min
## [1] 0
##
## $'3'$max
## [1] 2
##
## $'3'$pct_missing
## [1] 0.32
##
## $'3'$first_NA
## [1] 4
##
##
## $'4'
## $'4'$min
## [1] 0
##
## $'4'$max
## [1] 2
##
## $'4'$pct_missing
## [1] 0.36
##
## $'4'$first_NA
## [1] 1
##
##
## $'5'

```

```

## $'5'$min
## [1] 0
##
## $'5'$max
## [1] 2
##
## $'5'$pct_missing
## [1] 0.28
##
## $'5'$first_NA
## [1] 1
##
##
## $'6'
## $'6'$min
## [1] 0
##
## $'6'$max
## [1] 2
##
## $'6'$pct_missing
## [1] 0.36
##
## $'6'$first_NA
## [1] 1
##
##
## $'7'
## $'7'$min
## [1] 0
##
## $'7'$max
## [1] 2
##
## $'7'$pct_missing
## [1] 0.26
##
## $'7'$first_NA
## [1] 4
##
##
## $'8'
## $'8'$min
## [1] 0
##
## $'8'$max
## [1] 2
##
## $'8'$pct_missing
## [1] 0.24
##
## $'8'$first_NA
## [1] 5
##

```

```

##
## $'9'
## $'9'$min
## [1] 0
##
## $'9'$max
## [1] 2
##
## $'9'$pct_missing
## [1] 0.26
##
## $'9'$first_NA
## [1] 6
##
##
## $'10'
## $'10'$min
## [1] 0
##
## $'10'$max
## [1] 2
##
## $'10'$pct_missing
## [1] 0.14
##
## $'10'$first_NA
## [1] 7
##
##
## $'11'
## $'11'$min
## [1] 0
##
## $'11'$max
## [1] 2
##
## $'11'$pct_missing
## [1] 0.32
##
## $'11'$first_NA
## [1] 2
##
##
## $'12'
## $'12'$min
## [1] 0
##
## $'12'$max
## [1] 2
##
## $'12'$pct_missing
## [1] 0.32
##
## $'12'$first_NA

```



```

## [1] 1
##
##
## $'13'
## $'13'$min
## [1] 0
##
## $'13'$max
## [1] 2
##
## $'13'$pct_missing
## [1] 0.32
##
## $'13'$first_NA
## [1] 1
##
##
## $'14'
## $'14'$min
## [1] 0
##
## $'14'$max
## [1] 2
##
## $'14'$pct_missing
## [1] 0.3
##
## $'14'$first_NA
## [1] 3
##
##
## $'15'
## $'15'$min
## [1] 0
##
## $'15'$max
## [1] 2
##
## $'15'$pct_missing
## [1] 0.38
##
## $'15'$first_NA
## [1] 4
##
##
## $'16'
## $'16'$min
## [1] 0
##
## $'16'$max
## [1] 2
##
## $'16'$pct_missing
## [1] 0.28

```

```

##
## $'16'$first_NA
## [1] 9
##
##
## $'17'
## $'17'$min
## [1] 0
##
## $'17'$max
## [1] 2
##
## $'17'$pct_missing
## [1] 0.28
##
## $'17'$first_NA
## [1] 5
##
##
## $'18'
## $'18'$min
## [1] 0
##
## $'18'$max
## [1] 2
##
## $'18'$pct_missing
## [1] 0.4
##
## $'18'$first_NA
## [1] 6
##
##
## $'19'
## $'19'$min
## [1] 0
##
## $'19'$max
## [1] 2
##
## $'19'$pct_missing
## [1] 0.4
##
## $'19'$first_NA
## [1] 1
##
##
## $'20'
## $'20'$min
## [1] 0
##
## $'20'$max
## [1] 2
##

```

```

## $'20'$pct_missing
## [1] 0.3
##
## $'20'$first_NA
## [1] 6
##
##
## $'21'
## $'21'$min
## [1] 0
##
## $'21'$max
## [1] 2
##
## $'21'$pct_missing
## [1] 0.32
##
## $'21'$first_NA
## [1] 1
##
##
## $'22'
## $'22'$min
## [1] 0
##
## $'22'$max
## [1] 2
##
## $'22'$pct_missing
## [1] 0.32
##
## $'22'$first_NA
## [1] 1
##
##
## $'23'
## $'23'$min
## [1] 0
##
## $'23'$max
## [1] 2
##
## $'23'$pct_missing
## [1] 0.3
##
## $'23'$first_NA
## [1] 3
##
##
## $'24'
## $'24'$min
## [1] 0
##
## $'24'$max

```

```

## [1] 2
##
## $'24'$pct_missing
## [1] 0.34
##
## $'24'$first_NA
## [1] 2
##
##
## $'25'
## $'25'$min
## [1] 0
##
## $'25'$max
## [1] 2
##
## $'25'$pct_missing
## [1] 0.3
##
## $'25'$first_NA
## [1] 1
##
##
## $'26'
## $'26'$min
## [1] 0
##
## $'26'$max
## [1] 2
##
## $'26'$pct_missing
## [1] 0.26
##
## $'26'$first_NA
## [1] 7
##
##
## $'27'
## $'27'$min
## [1] 0
##
## $'27'$max
## [1] 2
##
## $'27'$pct_missing
## [1] 0.36
##
## $'27'$first_NA
## [1] 4
##
##
## $'28'
## $'28'$min
## [1] 0

```

```

##
## $'28'$max
## [1] 2
##
## $'28'$pct_missing
## [1] 0.32
##
## $'28'$first_NA
## [1] 2
##
##
## $'29'
## $'29'$min
## [1] 0
##
## $'29'$max
## [1] 2
##
## $'29'$pct_missing
## [1] 0.22
##
## $'29'$first_NA
## [1] 6
##
##
## $'30'
## $'30'$min
## [1] 0
##
## $'30'$max
## [1] 2
##
## $'30'$pct_missing
## [1] 0.2
##
## $'30'$first_NA
## [1] 5
##
##
## $'31'
## $'31'$min
## [1] 0
##
## $'31'$max
## [1] 2
##
## $'31'$pct_missing
## [1] 0.22
##
## $'31'$first_NA
## [1] 3
##
##
## $'32'

```

```

## $'32'$min
## [1] 0
##
## $'32'$max
## [1] 2
##
## $'32'$pct_missing
## [1] 0.28
##
## $'32'$first_NA
## [1] 2
##
##
## $'33'
## $'33'$min
## [1] 0
##
## $'33'$max
## [1] 2
##
## $'33'$pct_missing
## [1] 0.34
##
## $'33'$first_NA
## [1] 5
##
##
## $'34'
## $'34'$min
## [1] 0
##
## $'34'$max
## [1] 2
##
## $'34'$pct_missing
## [1] 0.22
##
## $'34'$first_NA
## [1] 1
##
##
## $'35'
## $'35'$min
## [1] 0
##
## $'35'$max
## [1] 2
##
## $'35'$pct_missing
## [1] 0.28
##
## $'35'$first_NA
## [1] 1
##
##

```

```

##
## $'36'
## $'36'$min
## [1] 0
##
## $'36'$max
## [1] 2
##
## $'36'$pct_missing
## [1] 0.3
##
## $'36'$first_NA
## [1] 7
##
##
## $'37'
## $'37'$min
## [1] 0
##
## $'37'$max
## [1] 2
##
## $'37'$pct_missing
## [1] 0.22
##
## $'37'$first_NA
## [1] 2
##
##
## $'38'
## $'38'$min
## [1] 0
##
## $'38'$max
## [1] 2
##
## $'38'$pct_missing
## [1] 0.24
##
## $'38'$first_NA
## [1] 7
##
##
## $'39'
## $'39'$min
## [1] 0
##
## $'39'$max
## [1] 2
##
## $'39'$pct_missing
## [1] 0.22
##
## $'39'$first_NA

```

```

## [1] 6
##
##
## $'40'
## $'40'$min
## [1] 0
##
## $'40'$max
## [1] 2
##
## $'40'$pct_missing
## [1] 0.3
##
## $'40'$first_NA
## [1] 1
##
##
## $'41'
## $'41'$min
## [1] 0
##
## $'41'$max
## [1] 2
##
## $'41'$pct_missing
## [1] 0.48
##
## $'41'$first_NA
## [1] 1
##
##
## $'42'
## $'42'$min
## [1] 0
##
## $'42'$max
## [1] 2
##
## $'42'$pct_missing
## [1] 0.4
##
## $'42'$first_NA
## [1] 4
##
##
## $'43'
## $'43'$min
## [1] 0
##
## $'43'$max
## [1] 2
##
## $'43'$pct_missing
## [1] 0.3

```



```

##
## $'43'$first_NA
## [1] 3
##
##
## $'44'
## $'44'$min
## [1] 0
##
## $'44'$max
## [1] 2
##
## $'44'$pct_missing
## [1] 0.26
##
## $'44'$first_NA
## [1] 9
##
##
## $'45'
## $'45'$min
## [1] 0
##
## $'45'$max
## [1] 2
##
## $'45'$pct_missing
## [1] 0.44
##
## $'45'$first_NA
## [1] 2
##
##
## $'46'
## $'46'$min
## [1] 0
##
## $'46'$max
## [1] 2
##
## $'46'$pct_missing
## [1] 0.26
##
## $'46'$first_NA
## [1] 10
##
##
## $'47'
## $'47'$min
## [1] 0
##
## $'47'$max
## [1] 2
##

```

```
## $'47'$pct_missing
## [1] 0.32
##
## $'47'$first_NA
## [1] 1
##
##
## $'48'
## $'48'$min
## [1] 0
##
## $'48'$max
## [1] 2
##
## $'48'$pct_missing
## [1] 0.26
##
## $'48'$first_NA
## [1] 1
##
##
## $'49'
## $'49'$min
## [1] 0
##
## $'49'$max
## [1] 2
##
## $'49'$pct_missing
## [1] 0.34
##
## $'49'$first_NA
## [1] 6
##
##
## $'50'
## $'50'$min
## [1] 0
##
## $'50'$max
## [1] 2
##
## $'50'$pct_missing
## [1] 0.26
##
## $'50'$first_NA
## [1] 9
```

- Set a seed and then create a vector `v` consisting of a sample of 1,000 iid normal realizations with mean -10 and variance 100.

```
#TO-DO
set.seed(2021)
```

```
v <- rnorm(n = 1000, mean = -10, sd = sqrt(100))
v
```

```
## [1] -11.2245998474947 -4.4754337174479 -6.5135049816145 -6.4036775590290
## [5] -1.0194631116780 -29.2256952111871 -7.3825563573923 -0.8443362881166
## [9] -9.8622806171177 7.2996316322577 -20.8220485386316 -12.7282518009668
## [13] -8.1800460062068 5.0854178691830 6.0447010524183 -28.4147561348120
## [17] 6.2331020617074 -8.6861098237369 4.8112247062764 5.1331828743875
## [21] -19.4244327383662 -11.8568501039204 -21.0112463866814 2.0811525320309
## [25] -26.2493854359929 -8.9462166597737 -24.5544334709541 -13.5401613654317
## [29] -10.9370004041569 1.0066862759491 -29.6382510899846 -24.4794438611301
## [33] 0.1944342034465 -24.2141707866824 -16.0453211718271 -25.8347389898921
## [37] -22.8593234958170 -24.5468488246031 -10.8707111836358 -4.9526355664617
## [41] -8.8361129189649 7.6021373200640 -13.4511646302783 11.2000015741514
## [45] -10.3437749107311 -17.9215405139377 4.7551521287709 -17.2555720865797
## [49] -6.8762095799969 -3.0803589050635 -15.0029079730589 -32.5586935180264
## [53] -9.5625867294120 -13.6881808673278 -19.6022240475323 -8.9623369181198
## [57] -5.7271086517218 -11.7048153946404 -25.4914029807068 -25.0559994343871
## [61] -9.8395646500481 -11.8536431340817 -6.0806674363467 -17.5671092211044
## [65] -7.6858239208413 -19.8361341017888 -4.3491918054561 6.1675189275509
## [69] -12.5196414007787 -20.5587860998667 -13.4823175759727 -10.4298997400425
## [73] -23.9755395563640 4.9021632987122 -20.3938712057354 -12.3694504653676
## [77] -19.9914145024687 -23.9254258975396 -0.1799474951175 -6.3905906478441
## [81] -13.3750921578395 -16.4338759473511 -31.6688527689601 -3.6671100500969
## [85] -11.4491414852162 -22.4002710255816 -4.6604067705811 -25.8826479655864
## [89] -19.9096453284471 -5.1673916725577 -1.8938162757618 -12.9366456553298
## [93] -10.5345831900956 -2.6481550435792 -9.8501500646186 -11.2200184981521
## [97] -16.4677369359611 -18.6785832746536 -15.0870030321820 -30.7758435556680
## [101] -12.6033646934845 -5.4966001949240 -11.4288162402178 -14.8672146693182
## [105] -21.9577316505865 -9.5305901420509 -11.2653168467927 -37.0071503815057
## [109] -15.7081332751361 -4.0840228504761 -5.1302329824534 -11.2679989330900
## [113] -22.5919986571775 -7.9870801905385 -29.1690444975283 6.7273912357611
## [117] -5.2921037954624 4.1411485120909 -9.1570142358503 -28.0230354008703
## [121] -2.4625635806089 -13.1194309449974 -27.3256029863391 -31.3856253016294
## [125] 13.6579840962528 -5.1524340028241 0.9323764306589 -6.9709159488577
## [129] 0.1529943636837 14.5359292676654 -12.4562082436702 -4.5848066058135
## [133] -8.0312339410259 -30.7116232239222 -4.8741646170323 -14.0576187909405
## [137] -6.4380198973516 -13.3157087144216 -9.1940886159225 -12.6153249043408
## [141] -18.7745023911664 -2.5869119161025 -36.8296318718774 -19.4947848280734
## [145] -5.5373800282307 -22.8882946164421 -11.5780545636953 -6.5218439767272
## [149] -10.5962246845670 4.7672877923358 -16.5416466923871 -12.5681482679838
## [153] -22.5403793237680 -2.2895683106426 -19.1135193860969 -16.9330537084302
## [157] -16.1766836869911 -2.3787681526235 -20.8715836335082 -13.9979952601623
## [161] -1.7220353799784 -6.4458032074431 -8.4086121538816 -0.4460481054803
## [165] -13.3964229197775 -17.2738146701573 -26.9780623551506 9.5413838551499
## [169] 16.6673789759452 10.6337942289087 -1.8121662079286 -10.7965010899760
## [173] -14.8944943403659 -1.5228125383433 -19.5904477157196 -0.7131265815139
## [177] -6.1903499079712 4.9460378771554 -14.6770437186324 -7.3884270760645
## [181] -19.9260864341981 -20.6338100397911 -7.2571534001850 -0.5465744934794
## [185] -2.7381091984732 -12.5451267132867 4.8518016806535 -7.6971383660440
## [189] -7.2199735346373 -8.5295924675552 -21.9628937691984 -9.0986373281509
## [193] 2.1926977596306 -15.6149256600551 -6.6311824179951 -25.3680015637564
## [197] -12.4012970707402 -4.8513452267829 -12.3885522302029 -4.1818142703563
```

```

## [201] -7.2980472880289 -23.4325021974245 -18.4888893457069 -14.0760793103598
## [205] -16.6615045427712 -11.0323738021861 -19.2405112406428 -5.6140054114580
## [209] -10.1210000865645 -16.4591073957797 3.4414679015825 -6.6539852487062
## [213] -9.9710630630520 0.9695312954456 1.6327065802330 -8.9921365777612
## [217] -13.9175248848570 -14.1106933875927 -19.1358128188262 -15.4039309095167
## [221] -8.7863769983859 7.2773770570006 -10.4419155566199 -4.5515760669857
## [225] 9.1735174690329 -12.3657011585441 5.7162334833505 -5.1914992500272
## [229] -9.5740284833565 -5.6017637290029 -28.8056482998063 -27.2406994449654
## [233] 8.8316832162681 -10.3128735464783 -0.0095604090437 -6.9968071991697
## [237] -10.0519360946768 -12.4030429413523 -27.7098327430981 -11.5619926646092
## [241] 9.1536655001506 1.1011961445373 -29.8570883996274 -1.8563413261420
## [245] 0.9825138563043 -24.4069403754828 2.1523765423303 -17.8288501742009
## [249] -30.6708605115165 -6.6564557984435 -7.3906169471628 -14.3434213501311
## [253] -28.7300754005099 -18.0304452577060 -6.6767790763258 -9.8788735864855
## [257] -1.4989363529076 -25.3086781445721 -10.3155826935799 4.2763990744683
## [261] -19.2703039225169 0.0560868978609 -10.8595745358085 -0.6197513833026
## [265] -15.1829571679973 -19.3451645414484 2.3158546127539 -12.3959188920404
## [269] -7.2681075170767 4.3082511070128 -21.4101745520861 -1.0399334157352
## [273] -9.1716209095553 -6.4992712855048 -22.5829101120597 -1.6031384425159
## [277] -22.5842050923103 -8.4688629878782 -14.8370102107416 12.1085415730556
## [281] -9.1917555479331 -2.8389353560968 0.5445573440960 -7.2383031563242
## [285] -14.2026316447383 15.2250236021869 -9.9798347860640 -25.6224281762859
## [289] -29.8778394995942 -24.9205383822414 -7.4475858431993 -18.1449715989352
## [293] -1.6613006917371 -21.5249841035781 -11.4044969405555 1.7607768553349
## [297] -8.1305471132095 -16.9477421258093 -14.5944301429896 -14.7500551091276
## [301] 2.0605715822122 -0.0588976571093 5.3915767836658 -7.0815305988817
## [305] -4.8945168424369 -15.4091496623364 -16.7391385441803 -3.1984882625773
## [309] -8.1328520198869 -23.8553154756495 -20.5729423383868 -6.2576137503047
## [313] -20.0251693914880 -10.4266426147005 -10.0574302719883 -20.4159436495614
## [317] -13.2523143249921 -16.0856295224924 5.1726561425823 -7.0353448043622
## [321] -6.0030453670879 -2.5150016249545 -10.8807237686635 -20.8558911071576
## [325] -10.8528732173071 -5.3449810124031 -10.0002890257224 -3.8368592926497
## [329] -16.5205019930073 -5.5275836544067 -11.8258195429911 -18.0644072549375
## [333] -28.0955074369479 -17.7945472602999 -29.8832736896554 -0.0276443170774
## [337] -20.4212151325722 -7.9523666860634 -7.1769438978699 -8.4001506889171
## [341] -25.8628551817296 -4.5467373180232 -23.6653670611225 -21.1604803881585
## [345] -8.3752765553403 5.1164944775964 -13.4908145113984 -29.7024195921958
## [349] -18.4739944206898 -27.7034181797573 0.8967147680224 -24.0243299534487
## [353] -0.6476894160812 -10.1199263181585 -7.3991275823646 1.5089489407104
## [357] 1.6755393869468 -21.8831978714660 -7.7945396133931 1.3430170146380
## [361] -4.8902965574014 -24.9715421361813 -21.1755525646795 -17.5785499253972
## [365] -17.7643315251859 -12.6359771296979 -21.9883863611448 -23.5236873363715
## [369] -6.5471591907812 -19.1440176519419 -6.1830541997665 -15.5191816534554
## [373] -9.6529786415668 -15.3270084448360 -0.4655063533931 -3.0402549000385
## [377] -16.7225237882016 3.2299458623335 -13.4742942117732 -15.3083403643356
## [381] -2.6597688089836 -8.4548133129316 -3.4137157581051 -19.3598337635162
## [385] -29.4178308421042 -9.6631396421094 -14.4529830483691 1.7744192609410
## [389] -10.7715815653350 -4.4885387158253 -14.5197780778026 -23.7510502317013
## [393] -9.9508959391802 -0.9803863416184 -19.3253598392739 -4.3914959998422
## [397] -6.8857686135038 3.9203075372815 14.3984314193058 -11.8447454498955
## [401] -16.7455623672925 -7.6187338927140 -4.5491409480479 -14.4885150177411
## [405] -0.2875326685827 -25.4716385697591 -8.0300270899282 -1.6126145193682
## [409] -5.0409336691740 -9.2057695212550 -20.5715545287030 -17.0779949396806
## [413] -23.6354536319635 -3.7440764955495 -15.7706092023743 7.2029055672712

```

```

## [417] 6.3659881828158 -11.9936011781733 -4.7028487682952 -19.8448069075485
## [421] 2.4470895731057 -5.5113567597185 -7.9208280511736 -25.8134056010462
## [425] -1.3777435596548 3.0930243892024 -1.1156866952636 2.0496738324515
## [429] 11.0842726130995 8.1913955465052 8.9668121500470 -0.4508029195042
## [433] -20.6311770744916 8.2425491088999 -13.7780485928826 4.8634677857576
## [437] -14.1582704025770 -13.2917152266926 -10.4907630624181 11.1735212890837
## [441] -8.4622041334904 0.7180294452910 -21.0945793155562 -9.2864254255776
## [445] -7.8874750234540 -4.5293710477886 -5.9728674106091 -3.0147033673789
## [449] -8.1677037414109 9.7458058013288 1.9278093445413 -18.8937916879492
## [453] -14.0013592830159 -10.4300787992105 -10.1818999173100 -18.9343648358377
## [457] -20.4964219664919 -6.3793916046777 -1.2343193232652 12.3182006155592
## [461] 5.8887704222249 -4.1756619425355 -17.5371215820263 -8.2222536093213
## [465] -21.0058297241676 -10.5167911107499 4.5005081233264 -2.2768987986310
## [469] -2.7345393884983 5.4722831038679 -8.7475607568213 -8.8967993409421
## [473] 8.2657184541316 -12.0842300430922 -12.2320016808144 -29.7335229473313
## [477] -5.9555521070941 -17.7551142289662 -12.3581756690479 9.0738062456931
## [481] -7.8557653638588 -18.1760741356473 -23.0258441496384 -14.0708275281041
## [485] 20.2160171501379 -8.5801887442940 -17.5340445529216 1.6516127175527
## [489] -4.1724637984675 -20.5157086079004 -15.1781884177628 -20.7752159566779
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##	[721]	-8.4584829454495	-4.8280876300148	-11.1720170119416	-9.8511212168548
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##	[729]	2.1141165724295	-22.4345484724731	-13.8300503145464	-4.7381015868522
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##	[809]	-16.2378389579849	4.4879758438642	-23.3168056539773	-0.3087377010230
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## [997] 0.5049681997010 1.5702115888722 -12.3741822689372 -3.5678392611568
```

- Repeat this exercise by resetting the seed to ensure you obtain the same results.

```
#TO-DO
set.seed(2021)
x <- rnorm(n = 1000, mean = -10, sd = sqrt(100))
x
```

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## [1] -11.2245998474947 -4.4754337174479 -6.5135049816145 -6.4036775590290
## [5] -1.0194631116780 -29.2256952111871 -7.3825563573923 -0.8443362881166
## [9] -9.8622806171177 7.2996316322577 -20.8220485386316 -12.7282518009668
## [13] -8.1800460062068 5.0854178691830 6.0447010524183 -28.4147561348120
## [17] 6.2331020617074 -8.6861098237369 4.8112247062764 5.1331828743875
## [21] -19.4244327383662 -11.8568501039204 -21.0112463866814 2.0811525320309
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```

- Find the average of `v` and the standard error of `v`.

```
#TO-DO
mean(v)
```

```
## [1] -9.8724804176
```

```
sd(v)
```

```
## [1] 10.192282335
```

- Find the 5%ile of `v` and use the `qnorm` function to compute what it theoretically should be. Is the estimate about what is expected by theory?

```
#TO-DO
quantile(v, probs = 0.05)
```

```
##          5%
## -25.8863422
```

```
qnorm( p = 0.05, mean = -10, sd = sqrt(100))
```

```
## [1] -26.44853627
```

#Yes it is expected

- What is the percentile of v that corresponds to the value 0? What should it be theoretically? Is the estimate about what is expected by theory?

#TO-DO

```
inverse_quantile_object = ecdf(v)  
inverse_quantile_object(0)
```

```
## [1] 0.831
```

#The theoretical value of 0 should be 0.84134475. The empirical value is close to the theoretical value