

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.

```
options(digits=11)
pi
```

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

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

```
sum(1/(2^(0:102)))
```

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

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

```
#prod(1/(3*(1:37))) there's a better way
prod(1/seq(from=3,by=3,length.out=37))
```

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

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

```
prod(1/2^(0:386))
```

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

Is this answer *exactly* correct?

It’s not exactly correct because it is a very small positive number. The number was too small and we experienced numerical underflow so R defaulted to 0.

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

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

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

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

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

```
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.

As x approaches 0, $\log(x)$ approaches $-\text{Inf}$. So when $x = 0$ in this case, it shows that $\log(0) = -\text{Inf}$. $\log(0)$ technically does not exist but the answer is appropriate enough. As x approaches Inf , then $\log(x)$ approaches Inf so this is appropriate. Log does not exist for negative values of x , so R gives us a NaN , which is maybe not as appropriate as “NA” since $\log(-x)$ is not available/applicable rather than not a number.

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

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

- 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`.

```
which(!y) #finding the falses in y (non-reals)
```

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

```
# or which(y == FALSE)
```

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

```
which(is.infinite(x))
```

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

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

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

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

```
which.max(x)
```

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

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

```
length(unique(x))
```

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

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

```
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
```

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

```
as.integer(x) # INFs and NaN converted to NA
```

```
## 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  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 NA
```

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

```
y = x[(!is.nan(x) & is.finite(x) & x > 0)]
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 $1e-6$.

```
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.

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

```
## [1] 0.53
```

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

```
mean(sample(c(0,1),size=100,replace=TRUE,prob=c(0.1,0.9)))
```

```
## [1] 0.89
```

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

```
mean(rbinom(n=1000,size=1,prob=0.9))
```

```
## [1] 0.9
```

- 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.

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

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

```
x_3_bin = x_3 != "none"
x_3_bin
```

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

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

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

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

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

```
inf = as.numeric(x_3_ord == "infraction")
inf
```

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

```
mis = as.numeric(x_3_ord == "misdemeanor")
mis
```

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

```
fel = as.numeric(x_3_ord == "felony")
fel
```

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

```
X = matrix(data=NA,nrow=100,ncol=3)
colnames(X) = c("infraction", "misdemeanor", "felony")
X[, "infraction"] = inf
X[, "misdemeanor"] = mis
X[, "felony"] = fel
X
```

```
## infraction misdemeanor felony
```

##	[1,]	0	0	1
##	[2,]	0	0	0
##	[3,]	1	0	0
##	[4,]	0	0	0
##	[5,]	1	0	0
##	[6,]	1	0	0
##	[7,]	0	1	0
##	[8,]	0	1	0
##	[9,]	0	0	0
##	[10,]	0	0	1
##	[11,]	0	0	1
##	[12,]	0	0	1
##	[13,]	0	1	0
##	[14,]	0	0	0
##	[15,]	0	0	1
##	[16,]	0	1	0
##	[17,]	0	1	0
##	[18,]	0	1	0
##	[19,]	0	0	0
##	[20,]	1	0	0
##	[21,]	0	0	0
##	[22,]	0	0	1
##	[23,]	0	0	0
##	[24,]	1	0	0
##	[25,]	0	0	0
##	[26,]	0	0	1
##	[27,]	0	0	1
##	[28,]	0	0	1
##	[29,]	0	0	0
##	[30,]	0	0	1
##	[31,]	0	0	0
##	[32,]	0	0	1
##	[33,]	0	0	0
##	[34,]	0	0	0
##	[35,]	0	0	0
##	[36,]	0	0	0
##	[37,]	0	1	0
##	[38,]	0	1	0
##	[39,]	0	1	0
##	[40,]	0	0	1
##	[41,]	0	0	0
##	[42,]	0	0	1
##	[43,]	1	0	0
##	[44,]	0	1	0
##	[45,]	1	0	0
##	[46,]	0	0	1
##	[47,]	0	1	0
##	[48,]	0	0	1
##	[49,]	0	1	0
##	[50,]	0	0	1
##	[51,]	1	0	0
##	[52,]	0	0	0
##	[53,]	0	0	0
##	[54,]	0	1	0

##	[55,]	0	0	1
##	[56,]	0	0	0
##	[57,]	1	0	0
##	[58,]	0	1	0
##	[59,]	1	0	0
##	[60,]	0	0	1
##	[61,]	0	0	1
##	[62,]	0	0	0
##	[63,]	0	0	0
##	[64,]	0	0	0
##	[65,]	0	1	0
##	[66,]	0	0	0
##	[67,]	0	0	1
##	[68,]	1	0	0
##	[69,]	0	0	1
##	[70,]	0	1	0
##	[71,]	0	0	0
##	[72,]	0	0	1
##	[73,]	0	1	0
##	[74,]	0	0	0
##	[75,]	1	0	0
##	[76,]	0	1	0
##	[77,]	0	0	0
##	[78,]	0	1	0
##	[79,]	0	1	0
##	[80,]	0	0	1
##	[81,]	1	0	0
##	[82,]	1	0	0
##	[83,]	0	0	1
##	[84,]	0	0	0
##	[85,]	0	1	0
##	[86,]	0	1	0
##	[87,]	0	0	0
##	[88,]	0	0	0
##	[89,]	0	1	0
##	[90,]	1	0	0
##	[91,]	0	0	0
##	[92,]	0	0	0
##	[93,]	0	0	0
##	[94,]	1	0	0
##	[95,]	0	0	0
##	[96,]	0	0	1
##	[97,]	0	0	0
##	[98,]	0	1	0
##	[99,]	0	0	0
##	[100,]	0	1	0

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

The row represents a person and each of their columns represents if that was the highest crime that they committed. So the sum of the row can only be 1 or 0. This means that the sum of the row represents if an individual committed ANY crime whatsoever.

Verify that.


```
as.matrix(rowSums(X), nrow=100)
```

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

```

## [51,] 1
## [52,] 0
## [53,] 0
## [54,] 1
## [55,] 1
## [56,] 0
## [57,] 1
## [58,] 1
## [59,] 1
## [60,] 1
## [61,] 1
## [62,] 0
## [63,] 0
## [64,] 0
## [65,] 1
## [66,] 0
## [67,] 1
## [68,] 1
## [69,] 1
## [70,] 1
## [71,] 0
## [72,] 1
## [73,] 1
## [74,] 0
## [75,] 1
## [76,] 1
## [77,] 0
## [78,] 1
## [79,] 1
## [80,] 1
## [81,] 1
## [82,] 1
## [83,] 1
## [84,] 0
## [85,] 1
## [86,] 1
## [87,] 0
## [88,] 0
## [89,] 1
## [90,] 1
## [91,] 0
## [92,] 0
## [93,] 0
## [94,] 1
## [95,] 0
## [96,] 1
## [97,] 0
## [98,] 1
## [99,] 0
## [100,] 1

```

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

The column sum represents the total number of a certain crime that everyone in the data set has committed.

For example, if 20 people committed a felony, then the sum of the felony column is 20.

Verify that.

```
colSums(X)
```

```
##  infraction misdemeanor      felony
##           16           25           25
```

- 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"
)
```

```
Y = matrix(data=NA, nrow=100, ncol=6)
rownames(Y) = fake_first_names
?rnorm
```

```
## starting httpd help server ... done
```

```
Y[,1] = rnorm(n=100, mean=17, sd=sqrt(38))
?runif
Y[,2] = runif(n=100, min=-10, max=10)
?rpois
Y[,3] = rpois(n=100, lambda=6)
?rexp
Y[,4] = rexp(n=100, rate=9)
?rbinom
Y[,5] = rbinom(n=20, size=100, p=0.12)
Y[,6] = rbinom(n=100, size=1, p=0.24)
Y
```

```
##           [,1]           [,2] [,3]           [,4] [,5] [,6]
```

## Sophia	10.91861876543	-4.097394072451	6	0.01234750516920	14	0
## Emma	15.83154338879	-4.321016655304	4	0.01622077119019	12	1
## Olivia	15.91442099575	-5.472529665567	3	0.20993376687891	14	0
## Ava	27.24053754303	4.904534891248	6	0.32886607009819	8	0
## Mia	18.37069867801	7.861592834815	2	0.26157304125783	16	0
## Isabella	20.39793837183	-9.979295795783	6	0.81935421414145	13	0
## Riley	22.31304681125	2.353761158884	5	0.00097520683640	11	0
## Aria	14.08692403011	0.685578994453	4	0.23941259320870	13	1
## Zoe	21.48317001033	7.119872537442	6	0.13858579347064	9	0
## Charlotte	26.10421764337	-4.216666910797	12	0.03739220007426	8	0
## Lily	6.45400846640	-6.544662918895	8	0.08544390358392	11	0
## Layla	-0.80709892028	5.576190194115	7	0.07128832432338	11	0
## Amelia	19.29558821057	0.548814330250	6	0.04487050164284	11	0
## Emily	14.15304667879	6.000881744549	3	0.02567854358090	10	0
## Madelyn	12.81404936657	-3.863396327943	5	0.14354394675904	14	0
## Aubrey	21.62990376212	4.245483372360	7	0.03465824181007	12	0
## Adalyn	18.27366457527	2.851941566914	4	0.05172419411206	16	0
## Madison	12.53437973421	7.491714912467	3	0.03716211938101	8	1
## Chloe	24.56431343792	-1.629586699419	5	0.21608689198786	14	0
## Harper	11.59023615958	-1.476277317852	6	0.16243064701894	9	0
## Abigail	6.75414348257	5.908799632452	9	0.12885072806176	14	0
## Aaliyah	20.50419567831	-8.953183884732	5	0.00031601450886	12	0
## Avery	6.56302486164	-8.422682061791	8	0.05603115109393	14	0
## Evelyn	13.20481125051	8.421457801014	6	0.14256558960044	8	0
## Kaylee	13.39043612149	-6.077099931426	5	0.00829849816445	16	0
## Ella	24.56096653907	6.665602279827	7	0.03302398370579	13	1
## Ellie	18.99076507771	2.535851267166	4	0.05151304556057	11	1
## Scarlett	21.40655670907	-0.504435314797	6	0.48084990368469	13	0
## Arianna	24.25281726944	-2.192661357112	9	0.02368054352701	9	0
## Hailey	7.14977957083	9.512943918817	7	0.03488503603472	8	0
## Nora	14.46477593762	9.569652336650	7	0.06471871377693	11	1
## Addison	18.45072299369	1.996409213170	5	0.21152726870338	11	0
## Brooklyn	9.42283407256	4.304349203594	2	0.10718394494666	11	0
## Hannah	16.35465728807	5.227468637750	4	0.04702946740306	10	1
## Mila	16.24735606561	-8.421867601573	2	0.04247614617149	14	0
## Leah	23.69092478058	4.116982151754	4	0.03228555866852	12	0
## Elizabeth	12.19392780690	5.412375028245	7	0.00274754222482	16	0
## Sarah	18.00557872139	7.113266144879	3	0.00578148924162	8	1
## Eliana	18.95954997659	-9.999384502880	5	0.12210056621759	14	0
## Mackenzie	6.20819060692	-6.340586673468	7	0.08527980765068	9	0
## Peyton	17.36424865467	7.184893097728	7	0.25182350620055	14	0
## Maria	25.17838372839	8.152099400759	9	0.06083976699867	12	1
## Grace	17.63824421202	4.811713369563	3	0.12790883929698	14	1
## Adeline	6.75217432625	6.777169569395	4	0.12858806901869	8	0
## Elena	18.22405395450	-1.008109096438	4	0.02554333432474	16	0
## Anna	19.29324600138	-4.414599454030	4	0.03280237724797	13	0
## Victoria	18.73241535812	-8.356434949674	3	0.09329353644977	11	0
## Camilla	31.42337921064	5.004761335440	4	0.00369865840508	13	0
## Lillian	15.00611096845	-1.270415247418	7	0.04585436549006	9	0
## Natalie	19.60619309146	5.160495946184	6	0.06760437041521	8	1
## Jackson	14.64428130426	-1.893939487636	6	0.14666798337827	11	0
## Aiden	19.14421519870	8.636615863070	5	0.41373680079011	11	0
## Lucas	10.36430077822	-4.377955114469	6	0.14004885239267	11	0
## Liam	15.68045781048	2.717919591814	8	0.08878630885595	10	0

## Noah	19.48875918133	-8.591755125672	3	0.13767253979574	14	0
## Ethan	18.27429031769	-3.379811751656	4	0.13145331189397	12	0
## Mason	10.91525167552	0.869053024799	5	0.06717220693827	16	0
## Caden	11.72416568009	-2.957678493112	6	0.07567201673778	8	0
## Oliver	26.85378109997	6.385708604939	5	0.13450372398584	14	1
## Elijah	23.55184544769	-8.929673475213	5	0.19725006817838	9	0
## Grayson	27.86921766736	7.521594711579	9	0.03450234606862	14	0
## Jacob	13.38504670778	-6.187579929829	9	0.03921541732012	12	0
## Michael	8.99627498985	7.181904441677	6	0.23936242753688	14	0
## Benjamin	26.65274963166	5.410105343908	1	0.07010230085709	8	1
## Carter	31.69735378744	-7.117239637300	8	0.15254732945260	16	0
## James	17.11864828143	7.514688153751	1	0.03912136134693	13	0
## Jayden	6.81327736439	0.099926758558	9	0.16468768146508	11	0
## Logan	10.33088232434	3.078130716458	6	0.12357123123222	13	0
## Alexander	25.33791828663	-7.011408857070	5	0.09179956403405	9	0
## Caleb	19.34659512862	-8.805055189878	8	0.16477847802037	8	1
## Ryan	16.90438651634	1.699982136488	10	0.10335311644968	11	0
## Luke	2.59986726627	8.177500320598	5	0.03032431497963	11	1
## Daniel	22.40454797152	4.482135707512	8	0.30263913814648	11	0
## Jack	12.03560596211	-0.660762507468	2	0.36010579431839	10	0
## William	3.76983488360	3.439841615036	8	0.32720050805134	14	0
## Owen	21.15878699193	6.471642786637	8	0.08975977541103	12	1
## Gabriel	15.49329462354	6.489480631426	3	0.18194802932336	16	0
## Matthew	7.87417182900	-6.574119939469	5	0.10596404172427	8	0
## Connor	24.95496512144	-4.209469961934	6	0.09673158265184	14	0
## Jayce	14.95035341172	8.618910745718	6	0.12689958905541	9	0
## Isaac	9.01025742371	-9.398923846893	4	0.15450666281653	14	0
## Sebastian	14.34427320101	-5.192441097461	8	0.01265541652461	12	0
## Henry	12.10676658013	2.994423443452	6	0.04277192144137	14	0
## Muhammad	14.53271932656	6.665337597951	6	0.00950273284434	8	0
## Cameron	20.10938388170	8.401928213425	5	0.12988704432163	16	0
## Wyatt	29.45893479336	-1.227905107662	1	0.02449569178538	13	0
## Dylan	15.94941071677	9.614281305112	6	0.11154009394683	11	1
## Nathan	13.27879950546	-0.843189782463	10	0.00381051247112	13	0
## Nicholas	22.63344143031	9.032058115117	4	0.05121938211636	9	0
## Julian	17.01246781981	-3.148652738892	3	0.01673957379535	8	0
## Eli	27.56566710586	-7.942494899035	12	0.03769843978807	11	0
## Levi	14.58347265933	-5.371569073759	6	0.02647660030872	11	0
## Isaiah	7.68544084136	-7.090637353249	5	0.27198711884774	11	0
## Landon	22.44025724949	-7.464286964387	7	0.16852859137681	10	0
## David	6.99393462789	8.387943576090	6	0.45686142040773	14	0
## Christian	23.59389591992	-8.007079488598	8	0.21981266822974	12	1
## Andrew	18.08660121816	1.125044655055	7	0.16969588294520	16	1
## Brayden	8.65734128520	2.733864123002	9	0.09869872420805	8	0
## John	17.42536724215	-9.343861499801	8	0.06260052188817	14	0
## Lincoln	18.97768447955	-5.839329333976	7	0.06919418435751	9	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.

```
Y_frame = data.frame(Y)
Y_frame[,6] = ifelse(Y_frame[,6] == 1, "FOREIGN", "DOMESTIC")
View(Y_frame)
```

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

```
table(Y_frame[,6])
```

```
##
## DOMESTIC FOREIGN
##      81      19
```

```
table(Y_frame$X6, Y_frame$X6) / 100
```

```
##
##          DOMESTIC FOREIGN
## DOMESTIC      0.81    0.00
## FOREIGN       0.00    0.19
```

Print out a summary of the whole dataframe.

```
Y_frame$X6 = factor(Y_frame$X6, labels = c("DOMESTIC", "FOREIGN"))
summary(Y_frame)
```

```
##          X1          X2          X3
## Min.   :-0.80709892  Min.   :-9.99938450  Min.    : 1.00
## 1st Qu.:12.17213750  1st Qu.: -5.23722309  1st Qu.: 4.00
## Median :17.06555805  Median : 0.99704884  Median : 6.00
## Mean   :16.67938917  Mean   : 0.46137572  Mean    : 5.75
## 3rd Qu.:21.22072942  3rd Qu.: 6.09708846  3rd Qu.: 7.00
## Max.   :31.69735379  Max.    : 9.61428131  Max.    :12.00
##          X4          X5          X6
## Min.   :0.00031601451  Min.    : 8.00  DOMESTIC:81
## 1st Qu.:0.03733467990  1st Qu.: 9.75  FOREIGN :19
## Median :0.08927304213  Median :11.50
## Mean   :0.11972911324  Mean    :11.70
## 3rd Qu.:0.15303716279  3rd Qu.:14.00
## Max.   :0.81935421414  Max.    :16.00
```

- 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.

```
R = matrix(sample(
  c(0,1,2),
  size = 50,
  replace = TRUE,
  prob = c(.50, .25, .25)
), nrow = 50, ncol = 50)
table(R)
```

```
## R
##    0    1    2
## 1250  750  500
```

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

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

```
## R
##    0    1    2
## 876 525 349
```

```
R
```

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

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

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

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

```

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

```

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

```
?order # permutes indices
```

```
R[order(rowSums(R, na.rm = TRUE), decreasing = TRUE),] # (row manipulation) , (nothing in columns)
```

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

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

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

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

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

```
R # R was unchanged
```

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


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

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

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

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

```
## [20,] 2
## [21,] 0
## [22,] 0
## [23,] NA
## [24,] 1
## [25,] 1
## [26,] 2
## [27,] 0
## [28,] NA
## [29,] NA
## [30,] 0
## [31,] 0
## [32,] 0
## [33,] 1
## [34,] 0
## [35,] NA
## [36,] NA
## [37,] NA
## [38,] 2
## [39,] 0
## [40,] NA
## [41,] NA
## [42,] 1
## [43,] 0
## [44,] NA
## [45,] 1
## [46,] 0
## [47,] 1
## [48,] 1
## [49,] 1
## [50,] 0
```

```
R = R[order(rowSums(R, na.rm = TRUE), decreasing = TRUE),] # assigning
rowSums(R, na.rm = TRUE)
```

```
## [1] 82 74 74 74 70 70 68 66 62 58 46 40 39 37 37 35 35 35 34 33 33 32 31 31 27
## [26] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 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.

```
?apply
apply(R, MARGIN = 1, sd, na.rm = TRUE) # I don't know why this is all 0s
```

```
## [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, MARGIN = 2, sd, na.rm = TRUE)
```

```
## [1] 0.83219007599 0.78491525276 0.79301947772 0.75602419316 0.77459666924
```

```
## [6] 0.79599839534 0.78629127444 0.77390598995 0.78000215471 0.78857386432
## [11] 0.78532422798 0.80950789391 0.88006238638 0.75067174219 0.79282496717
## [16] 0.79831171061 0.81704218512 0.84091786587 0.78365433331 0.75996059566
## [21] 0.77755282397 0.82182530102 0.83591400764 0.81867681600 0.78532422798
## [26] 0.82227511432 0.83190353531 0.78000215471 0.83190353531 0.79884051447
## [31] 0.78288136126 0.80833723835 0.75337080350 0.79471941424 0.79301947772
## [36] 0.79705339699 0.74530297810 0.78000215471 0.75833704583 0.79042848102
## [41] 0.77390598995 0.75053323860 0.74238558959 0.81982893820 0.80229555709
## [46] 0.66713998349 0.78863883972 0.82060166754 0.70186240634 0.76477052086
```

```
# apply(R, MARGIN = c(1,2), sd, na.rm = TRUE) # all NAs
```

- 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.

```
?apply
vec = apply(R > 0, MARGIN = 2, sum, na.rm = TRUE)
vec
```

```
## [1] 17 16 20 14 15 17 18 16 19 18 21 16 17 19 17 16 14 18 18 18 18 17 16 18 21
## [26] 14 19 19 19 17 16 19 18 20 20 20 19 19 17 18 16 18 16 20 14 13 20 15 17 17
```

- 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`.

```
?split
split(R, col(R))
```

```
## $'1'
## [1] 2 2 2 2 2 NA 2 NA 2 2 1 NA 1 1 NA NA NA 1 1 1 NA 1 1 1 NA
## [26] 0 0 NA 0 NA 0 0 NA 0 NA 0 0 0 0 0 NA NA 0 NA NA NA 0 0 NA
##
## $'2'
## [1] 2 NA NA NA 2 2 NA 2 2 2 1 NA 1 1 1 1 1 1 NA NA NA 1 NA 1
## [26] 0 0 0 0 NA NA 0 0 0 0 NA NA 0 0 0 0 NA NA NA 0 NA 0 NA NA NA
##
## $'3'
## [1] 2 2 2 2 2 NA 2 2 2 NA 1 1 1 1 1 NA 1 1 1 NA NA 1 1 1 1
## [26] NA 0 0 0 0 0 0 0 0 NA 0 0 0 0 0 NA 0 NA NA 0 0 0 0 0 NA
##
## $'4'
## [1] NA 2 2 NA 2 2 NA NA NA 2 1 NA 1 1 1 NA 1 1 NA NA 1 1 NA 1 NA
## [26] 0 0 NA 0 0 0 NA 0 0 0 0 NA NA 0 0 0 0 0 0 NA NA NA 0 0 0
##
## $'5'
## [1] 2 NA NA 2 2 2 NA 2 2 NA 1 1 1 1 1 NA 1 NA NA 1 1 NA NA 1 NA
## [26] 0 0 0 0 0 0 0 0 0 0 0 NA 0 NA 0 0 NA 0 0 NA 0 0 NA 0 0
##
## $'6'
## [1] 2 NA 2 2 2 2 2 NA NA 2 1 1 1 1 1 NA NA 1 NA NA NA 1 1 1 1
## [26] 0 NA NA 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 NA NA NA NA NA 0
##
```

```

## $'7'
## [1] 2 2 NA NA NA 2 2 2 2 2 1 1 1 NA 1 1 NA 1 1 1 1 NA 1 NA 1
## [26] 0 0 NA 0 NA 0 0 0 0 0 0 0 0 0 NA NA 0 NA NA 0 0 0 0 NA
##
## $'8'
## [1] 2 2 2 NA 2 2 NA NA 2 NA 1 1 1 1 1 NA 1 NA 1 1 1 NA 1 NA NA
## [26] NA NA 0 0 0 NA 0 0 0 0 0 0 0 NA 0 0 NA 0 NA 0 0 0 NA 0 0
##
## $'9'
## [1] NA 2 2 2 NA NA 2 2 2 2 1 1 1 1 NA 1 1 1 1 NA 1 NA 1 1 1
## [26] 0 NA NA 0 NA 0 0 NA NA NA 0 0 0 0 NA NA 0 0 0 0 NA 0 0 0 0
##
## $'10'
## [1] NA NA 2 2 2 2 NA 2 2 2 1 1 NA 1 1 1 1 1 1 1 1 NA NA 1 NA
## [26] NA NA 0 NA 0 0 NA NA 0 0 0 0 0 0 NA NA 0 0 NA 0 0 0 0 0 0
##
## $'11'
## [1] 2 2 NA 2 2 2 2 2 NA 2 NA 1 1 NA 1 1 1 1 1 1 1 1 1 1 1
## [26] NA 0 0 0 0 0 NA NA NA NA NA 0 0 0 0 NA 0 0 0 0 0 0 0 0 0
##
## $'12'
## [1] 2 2 2 NA 2 NA NA 2 2 2 NA NA 1 1 1 1 1 NA NA 1 1 1 1 NA NA
## [26] 0 0 NA NA 0 NA 0 NA NA 0 0 0 NA 0 0 0 0 NA 0 0 0 NA 0 0 0
##
## $'13'
## [1] 2 2 2 2 2 2 2 2 2 2 1 NA 1 1 NA 1 1 NA NA NA NA 1 NA 1 NA
## [26] NA NA NA NA 0 0 0 0 0 0 0 0 0 0 0 0 NA 0 NA 0 NA 0 0 0 NA
##
## $'14'
## [1] NA NA NA 2 2 2 2 2 2 NA 1 1 1 1 1 1 1 1 1 1 1 1 NA 1 NA
## [26] NA NA 0 0 NA 0 NA NA NA 0 NA 0 0 NA NA 0 0 0 NA 0 0 0 NA 0 NA
##
## $'15'
## [1] 2 NA NA 2 2 2 2 NA 2 2 1 NA 1 1 NA 1 NA 1 1 NA 1 1 1 NA 1
## [26] NA 0 NA 0 0 0 0 0 0 0 0 0 0 0 0 0 0 NA 0 NA NA 0 0 0 NA
##
## $'16'
## [1] 2 2 2 2 NA NA 2 NA 2 2 1 NA NA 1 1 1 1 NA 1 NA NA 1 NA 1 1
## [26] 0 0 0 0 0 NA 0 0 NA 0 0 0 0 0 NA 0 NA 0 0 0 NA 0 0 0 0
##
## $'17'
## [1] NA 2 2 2 2 NA 2 2 2 NA 1 1 NA 1 1 1 1 1 NA NA NA NA NA NA NA
## [26] 0 0 0 0 NA 0 0 0 0 0 0 0 NA 0 NA NA 0 0 0 NA 0 0 0 0 0
##
## $'18'
## [1] 2 2 2 2 2 2 NA 2 2 2 1 1 NA 1 NA 1 1 1 1 NA NA 1 NA 1 NA
## [26] 0 NA NA 0 0 NA 0 0 NA 0 0 0 NA 0 0 0 0 0 NA 0 0 0 0 NA 0
##
## $'19'
## [1] 2 2 2 2 NA NA 2 2 2 NA 1 1 1 1 1 1 NA 1 NA 1 1 1 1 NA NA
## [26] 0 0 0 0 0 0 0 0 NA NA 0 0 NA 0 NA 0 NA 0 0 0 0 0 0 0 NA
##
## $'20'
## [1] NA NA 2 2 2 2 2 NA 2 NA 1 1 1 1 1 1 1 1 NA 1 1 NA 1 NA

```

```

## [26] NA 0 0 0 0 NA 0 0 0 0 NA NA 0 NA 0 NA 0 NA NA 0 0 0 0 0 NA
##
## $'21'
## [1] 2 2 2 2 NA 2 2 NA NA 2 1 1 1 NA 1 1 1 NA NA 1 NA 1 1 1 1
## [26] NA NA NA 0 0 0 0 0 0 NA 0 0 0 0 0 0 0 0 0 0 0 0 0 0
##
## $'22'
## [1] 2 2 2 2 NA NA 2 2 2 2 1 1 NA 1 1 1 NA NA 1 NA NA 1 1 NA 1
## [26] NA NA 0 0 0 0 NA 0 0 0 0 0 NA 0 0 0 0 NA 0 0 0 0 0 NA 0
##
## $'23'
## [1] 2 2 2 2 2 2 2 2 NA NA 1 NA NA 1 1 NA 1 NA 1 1 NA 1 1 NA NA
## [26] 0 NA NA 0 0 0 0 0 NA 0 0 0 0 NA NA 0 0 0 0 0 NA 0 0 NA 0
##
## $'24'
## [1] 2 2 2 NA 2 NA 2 2 2 2 NA 1 1 1 1 1 NA 1 NA 1 1 NA NA 1 1
## [26] 0 0 NA 0 0 0 0 0 NA 0 0 NA 0 0 NA NA NA 0 NA 0 NA NA 0 0 0
##
## $'25'
## [1] 2 2 NA 2 2 2 2 2 NA 2 1 1 1 1 1 NA 1 1 1 1 1 1 1 NA 1
## [26] 0 0 NA 0 0 0 0 0 NA NA 0 0 0 0 NA 0 NA 0 0 0 0 0 NA NA 0
##
## $'26'
## [1] 2 2 NA 2 NA 2 2 2 NA 2 1 1 1 NA NA 1 1 NA NA NA NA 1 NA 1 NA
## [26] 0 0 0 NA 0 0 0 0 0 0 0 NA NA 0 0 0 NA 0 0 0 NA 0 0 NA 0
##
## $'27'
## [1] 2 2 2 2 2 2 2 2 NA 2 1 1 1 1 NA NA NA 1 NA 1 1 1 1 NA 1
## [26] 0 NA NA NA NA 0 0 0 0 NA 0 0 0 0 NA 0 0 0 0 0 0 0 NA NA 0
##
## $'28'
## [1] 2 2 NA NA 2 2 NA 2 2 2 1 1 NA 1 NA 1 1 1 1 1 1 1 NA 1
## [26] 0 NA 0 0 NA 0 0 NA 0 0 NA 0 0 0 NA 0 0 0 NA 0 0 NA NA NA 0
##
## $'29'
## [1] NA 2 2 2 2 2 2 2 2 2 1 1 1 1 1 1 1 NA 1 1 NA NA NA 1 NA
## [26] 0 0 NA 0 0 0 0 0 NA NA NA 0 0 0 NA NA 0 0 0 0 NA 0 0 NA 0
##
## $'30'
## [1] 2 2 2 2 2 2 2 NA NA NA 1 NA 1 1 1 NA NA 1 1 1 1 1 NA NA
## [26] NA 0 0 0 NA 0 0 0 0 NA 0 0 NA NA 0 0 0 0 0 NA 0 NA 0 NA 0
##
## $'31'
## [1] 2 2 NA NA 2 2 2 NA 2 NA 1 1 NA NA 1 NA 1 NA 1 1 1 NA 1 1 1
## [26] 0 0 0 NA NA 0 NA 0 0 NA NA 0 0 NA NA 0 0 0 0 0 NA 0 NA NA 0
##
## $'32'
## [1] 2 2 2 2 2 2 NA NA 2 2 1 1 NA 1 1 1 1 1 1 1 NA NA NA 1 1
## [26] NA NA NA 0 NA NA 0 0 NA NA 0 NA 0 0 0 0 0 NA 0 0 0 NA 0 0 NA
##
## $'33'
## [1] 2 NA 2 2 2 NA 2 NA NA 2 1 1 1 1 1 1 1 NA 1 1 1 1 NA NA
## [26] 0 0 0 0 0 NA 0 0 0 NA 0 0 0 0 0 0 NA 0 NA 0 NA 0 0 NA 0
##
##

```



```

## $'34'
## [1] 2 2 2 2 2 2 NA 2 NA 2 1 1 1 NA 1 1 1 NA 1 1 NA 1 1 1 1
## [26] 0 0 0 0 NA 0 0 0 0 0 NA 0 0 NA 0 NA NA 0 0 NA 0 0 0 0 NA
##
## $'35'
## [1] 2 2 NA 2 NA 2 2 2 2 2 1 1 1 1 1 1 1 1 1 NA NA 1 NA 1
## [26] 0 0 0 0 NA 0 NA 0 0 0 0 0 0 0 0 NA 0 0 0 NA 0 0 NA NA
##
## $'36'
## [1] 2 2 2 2 NA 2 2 2 2 NA 1 1 1 1 1 1 NA 1 NA 1 1 NA 1 1 1
## [26] 0 0 0 0 NA 0 NA NA NA 0 0 0 0 NA NA 0 0 NA NA 0 0 NA 0 NA 0
##
## $'37'
## [1] 2 2 NA 2 NA 2 2 2 NA NA 1 1 1 NA 1 1 1 1 NA 1 1 1 1 1
## [26] 0 0 0 0 0 NA 0 0 NA 0 0 0 0 NA 0 0 0 0 NA 0 0 NA 0 NA 0
##
## $'38'
## [1] 2 2 2 2 2 NA 2 2 NA NA 1 1 1 1 NA NA 1 1 1 1 1 NA 1 1 1
## [26] 0 0 0 0 0 NA NA 0 NA 0 0 NA 0 0 0 NA NA 0 NA 0 0 0 NA NA 0
##
## $'39'
## [1] 2 NA 2 2 NA NA NA 2 2 2 1 1 1 NA 1 1 1 1 1 NA 1 NA NA 1 1
## [26] 0 0 0 0 0 0 0 0 0 0 0 0 0 NA NA 0 0 0 0 NA NA 0 0 0 0 NA
##
## $'40'
## [1] 2 2 NA NA 2 2 2 2 2 NA 1 1 1 NA NA 1 NA 1 1 1 1 1 1 NA
## [26] 0 NA NA 0 0 0 0 0 NA NA 0 NA 0 0 0 0 0 NA NA 0 NA 0 NA 0 0
##
## $'41'
## [1] 2 NA 2 2 2 2 2 NA NA NA 1 NA 1 NA 1 NA 1 NA 1 1 1 NA 1 1
## [26] 0 0 NA 0 NA 0 0 0 0 0 NA NA 0 0 NA NA 0 0 0 NA 0 0 0 0 0
##
## $'42'
## [1] 2 2 2 NA NA 2 NA 2 NA 2 1 1 1 1 1 1 1 1 1 1 NA 1 NA NA
## [26] 0 0 0 NA NA 0 0 0 0 0 0 0 0 0 0 0 NA 0 0 0 NA 0 NA 0 0
##
## $'43'
## [1] 2 NA 2 2 2 2 NA NA NA NA NA 1 1 1 1 1 1 1 1 1 NA NA NA
## [26] NA 0 0 0 NA 0 0 NA 0 0 NA 0 0 0 0 NA NA NA 0 0 0 0 NA 0
##
## $'44'
## [1] 2 2 2 2 2 2 2 NA 2 1 1 NA 1 1 1 1 NA 1 NA 1 1 1 NA 1
## [26] NA 0 0 0 0 0 NA 0 0 0 0 0 0 NA NA 0 0 0 NA 0 0 0 NA 0 NA
##
## $'45'
## [1] 2 NA 2 NA 2 NA 2 2 2 NA 1 1 1 NA NA NA 1 1 1 NA NA 1 NA 1 NA
## [26] 0 0 NA NA NA NA 0 NA 0 0 0 0 NA 0 0 0 NA NA 0 NA 0 0 0 0 0
##
## $'46'
## [1] NA 2 2 NA NA 2 NA NA NA NA 1 1 1 1 1 1 NA 1 1 NA 1 NA 1 NA NA
## [26] 0 0 NA 0 NA 0 0 0 NA 0 0 0 0 0 0 0 0 0 NA 0 NA 0 0 0 0
##
## $'47'
## [1] 2 2 2 2 2 NA 2 NA 2 2 1 1 NA 1 1 1 NA 1 1 1 1 NA 1 1 1

```

```
## [26] 0 0 0 0 0 0 0 0 0 0 NA 0 0 0 0 0 0 0 0 0 NA NA 0 NA 0
##
## $'48'
## [1] 2 2 2 2 NA 2 NA 2 2 NA 1 1 1 NA NA NA NA 1 NA 1 1 1 NA 1 NA
## [26] 0 0 0 NA NA 0 NA 0 0 0 0 0 0 NA 0 0 0 0 NA 0 NA NA NA 0
##
## $'49'
## [1] NA 2 2 NA 2 NA NA NA 2 NA 1 1 1 NA 1 1 1 1 1 1 1 NA 1 1
## [26] 0 NA 0 NA NA 0 0 NA NA NA NA 0 NA NA 0 0 0 NA 0 0 0 NA NA 0 NA
##
## $'50'
## [1] 2 NA 2 2 NA 2 2 2 NA NA 1 1 1 1 NA 1 NA NA NA 1 1 1 1 1 1
## [26] 0 NA 0 0 NA 0 0 0 0 0 0 0 NA NA 0 0 0 0 NA 0 NA NA 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.

```
?lapply
?split
lapply(split(R, col(R)), function(X) list(min = min(X, na.rm = TRUE), max = max(X, na.rm = TRUE), pct_m
```

```
## $'1'
## $'1'$min
## [1] 0
##
## $'1'$max
## [1] 2
##
## $'1'$pct_missing
## [1] 0.36
##
## $'1'$first_NA
## [1] 6
##
##
## $'2'
## $'2'$min
## [1] 0
##
## $'2'$max
## [1] 2
##
## $'2'$pct_missing
## [1] 0.4
##
## $'2'$first_NA
## [1] 2
##
##
## $'3'
## $'3'$min
```

```

## [1] 0
##
## $'3'$max
## [1] 2
##
## $'3'$pct_missing
## [1] 0.22
##
## $'3'$first_NA
## [1] 6
##
##
## $'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] 0.3
##
## $'5'$first_NA
## [1] 2
##
##
## $'6'
## $'6'$min
## [1] 0
##
## $'6'$max
## [1] 2
##
## $'6'$pct_missing
## [1] 0.3
##
## $'6'$first_NA
## [1] 2
##
##

```

```

## $'7'
## $'7'$min
## [1] 0
##
## $'7'$max
## [1] 2
##
## $'7'$pct_missing
## [1] 0.28
##
## $'7'$first_NA
## [1] 3
##
##
## $'8'
## $'8'$min
## [1] 0
##
## $'8'$max
## [1] 2
##
## $'8'$pct_missing
## [1] 0.32
##
## $'8'$first_NA
## [1] 4
##
##
## $'9'
## $'9'$min
## [1] 0
##
## $'9'$max
## [1] 2
##
## $'9'$pct_missing
## [1] 0.3
##
## $'9'$first_NA
## [1] 1
##
##
## $'10'
## $'10'$min
## [1] 0
##
## $'10'$max
## [1] 2
##
## $'10'$pct_missing
## [1] 0.3
##
## $'10'$first_NA
## [1] 1

```

```

##
##
## $'11'
## $'11'$min
## [1] 0
##
## $'11'$max
## [1] 2
##
## $'11'$pct_missing
## [1] 0.22
##
## $'11'$first_NA
## [1] 3
##
##
## $'12'
## $'12'$min
## [1] 0
##
## $'12'$max
## [1] 2
##
## $'12'$pct_missing
## [1] 0.34
##
## $'12'$first_NA
## [1] 4
##
##
## $'13'
## $'13'$min
## [1] 0
##
## $'13'$max
## [1] 2
##
## $'13'$pct_missing
## [1] 0.32
##
## $'13'$first_NA
## [1] 12
##
##
## $'14'
## $'14'$min
## [1] 0
##
## $'14'$max
## [1] 2
##
## $'14'$pct_missing
## [1] 0.36
##

```

```

## $'14'$first_NA
## [1] 1
##
##
## $'15'
## $'15'$min
## [1] 0
##
## $'15'$max
## [1] 2
##
## $'15'$pct_missing
## [1] 0.28
##
## $'15'$first_NA
## [1] 2
##
##
## $'16'
## $'16'$min
## [1] 0
##
## $'16'$max
## [1] 2
##
## $'16'$pct_missing
## [1] 0.28
##
## $'16'$first_NA
## [1] 5
##
##
## $'17'
## $'17'$min
## [1] 0
##
## $'17'$max
## [1] 2
##
## $'17'$pct_missing
## [1] 0.32
##
## $'17'$first_NA
## [1] 1
##
##
## $'18'
## $'18'$min
## [1] 0
##
## $'18'$max
## [1] 2
##
## $'18'$pct_missing

```

```

## [1] 0.28
##
## $'18'$first_NA
## [1] 7
##
##
## $'19'
## $'19'$min
## [1] 0
##
## $'19'$max
## [1] 2
##
## $'19'$pct_missing
## [1] 0.26
##
## $'19'$first_NA
## [1] 5
##
##
## $'20'
## $'20'$min
## [1] 0
##
## $'20'$max
## [1] 2
##
## $'20'$pct_missing
## [1] 0.32
##
## $'20'$first_NA
## [1] 1
##
##
## $'21'
## $'21'$min
## [1] 0
##
## $'21'$max
## [1] 2
##
## $'21'$pct_missing
## [1] 0.22
##
## $'21'$first_NA
## [1] 5
##
##
## $'22'
## $'22'$min
## [1] 0
##
## $'22'$max
## [1] 2

```

```

##
## $'22'$pct_missing
## [1] 0.28
##
## $'22'$first_NA
## [1] 5
##
##
## $'23'
## $'23'$min
## [1] 0
##
## $'23'$max
## [1] 2
##
## $'23'$pct_missing
## [1] 0.32
##
## $'23'$first_NA
## [1] 9
##
##
## $'24'
## $'24'$min
## [1] 0
##
## $'24'$max
## [1] 2
##
## $'24'$pct_missing
## [1] 0.32
##
## $'24'$first_NA
## [1] 4
##
##
## $'25'
## $'25'$min
## [1] 0
##
## $'25'$max
## [1] 2
##
## $'25'$pct_missing
## [1] 0.22
##
## $'25'$first_NA
## [1] 3
##
##
## $'26'
## $'26'$min
## [1] 0
##
##

```



```

## '$26'$max
## [1] 2
##
## '$26'$pct_missing
## [1] 0.34
##
## '$26'$first_NA
## [1] 3
##
##
## '$27'
## '$27'$min
## [1] 0
##
## '$27'$max
## [1] 2
##
## '$27'$pct_missing
## [1] 0.28
##
## '$27'$first_NA
## [1] 9
##
##
## '$28'
## '$28'$min
## [1] 0
##
## '$28'$max
## [1] 2
##
## '$28'$pct_missing
## [1] 0.3
##
## '$28'$first_NA
## [1] 3
##
##
## '$29'
## '$29'$min
## [1] 0
##
## '$29'$max
## [1] 2
##
## '$29'$pct_missing
## [1] 0.28
##
## '$29'$first_NA
## [1] 1
##
##
## '$30'
## '$30'$min

```

```

## [1] 0
##
## $'30'$max
## [1] 2
##
## $'30'$pct_missing
## [1] 0.32
##
## $'30'$first_NA
## [1] 8
##
##
## $'31'
## $'31'$min
## [1] 0
##
## $'31'$max
## [1] 2
##
## $'31'$pct_missing
## [1] 0.38
##
## $'31'$first_NA
## [1] 3
##
##
## $'32'
## $'32'$min
## [1] 0
##
## $'32'$max
## [1] 2
##
## $'32'$pct_missing
## [1] 0.34
##
## $'32'$first_NA
## [1] 7
##
##
## $'33'
## $'33'$min
## [1] 0
##
## $'33'$max
## [1] 2
##
## $'33'$pct_missing
## [1] 0.26
##
## $'33'$first_NA
## [1] 2
##
##

```

```

## $'34'
## $'34'$min
## [1] 0
##
## $'34'$max
## [1] 2
##
## $'34'$pct_missing
## [1] 0.24
##
## $'34'$first_NA
## [1] 7
##
##
## $'35'
## $'35'$min
## [1] 0
##
## $'35'$max
## [1] 2
##
## $'35'$pct_missing
## [1] 0.22
##
## $'35'$first_NA
## [1] 3
##
##
## $'36'
## $'36'$min
## [1] 0
##
## $'36'$max
## [1] 2
##
## $'36'$pct_missing
## [1] 0.3
##
## $'36'$first_NA
## [1] 5
##
##
## $'37'
## $'37'$min
## [1] 0
##
## $'37'$max
## [1] 2
##
## $'37'$pct_missing
## [1] 0.24
##
## $'37'$first_NA
## [1] 3

```

```

##
##
## $'38'
## $'38'$min
## [1] 0
##
## $'38'$max
## [1] 2
##
## $'38'$pct_missing
## [1] 0.3
##
## $'38'$first_NA
## [1] 6
##
##
## $'39'
## $'39'$min
## [1] 0
##
## $'39'$max
## [1] 2
##
## $'39'$pct_missing
## [1] 0.26
##
## $'39'$first_NA
## [1] 2
##
##
## $'40'
## $'40'$min
## [1] 0
##
## $'40'$max
## [1] 2
##
## $'40'$pct_missing
## [1] 0.32
##
## $'40'$first_NA
## [1] 3
##
##
## $'41'
## $'41'$min
## [1] 0
##
## $'41'$max
## [1] 2
##
## $'41'$pct_missing
## [1] 0.32
##

```

```

## $'41'$first_NA
## [1] 2
##
##
## $'42'
## $'42'$min
## [1] 0
##
## $'42'$max
## [1] 2
##
## $'42'$pct_missing
## [1] 0.24
##
## $'42'$first_NA
## [1] 4
##
##
## $'43'
## $'43'$min
## [1] 0
##
## $'43'$max
## [1] 2
##
## $'43'$pct_missing
## [1] 0.34
##
## $'43'$first_NA
## [1] 2
##
##
## $'44'
## $'44'$min
## [1] 0
##
## $'44'$max
## [1] 2
##
## $'44'$pct_missing
## [1] 0.24
##
## $'44'$first_NA
## [1] 9
##
##
## $'45'
## $'45'$min
## [1] 0
##
## $'45'$max
## [1] 2
##
## $'45'$pct_missing

```

```

## [1] 0.4
##
## $'45'$first_NA
## [1] 2
##
##
## $'46'
## $'46'$min
## [1] 0
##
## $'46'$max
## [1] 2
##
## $'46'$pct_missing
## [1] 0.34
##
## $'46'$first_NA
## [1] 1
##
##
## $'47'
## $'47'$min
## [1] 0
##
## $'47'$max
## [1] 2
##
## $'47'$pct_missing
## [1] 0.18
##
## $'47'$first_NA
## [1] 6
##
##
## $'48'
## $'48'$min
## [1] 0
##
## $'48'$max
## [1] 2
##
## $'48'$pct_missing
## [1] 0.36
##
## $'48'$first_NA
## [1] 5
##
##
## $'49'
## $'49'$min
## [1] 0
##
## $'49'$max
## [1] 2

```

```
##
## $'49'$pct_missing
## [1] 0.42
##
## $'49'$first_NA
## [1] 1
##
##
## $'50'
## $'50'$min
## [1] 0
##
## $'50'$max
## [1] 2
##
## $'50'$pct_missing
## [1] 0.3
##
## $'50'$first_NA
## [1] 2
```

- 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.

```
set.seed(1997)
?rnorm
v = rnorm(n=1000,mean=-10,sd=sqrt(100))
v
```

```
##      [1] -17.675075287345 -0.949106997727 -21.066080455948 -11.120659879294
##      [5] -27.375027862063 -7.704144076084  2.597498851215 -5.515257599821
##      [9] -24.460034119716 -22.183513749114 -12.172376580441 -19.932224927593
##     [13] -40.589574811965 -4.042791369789 -7.921791907704 -25.171271034845
##     [17] -7.154827257229 -16.242704003329  2.698337308058 -14.112945787479
##     [21] -19.005216872874 -19.468127109558 -24.795080119834 -14.565484554333
##     [25] -14.848788652614 -23.276613947575 -23.677226193297 -10.355930014706
##     [29] -12.986072061446  1.102600768017 -6.553384276259 -15.398435755252
##     [33] -7.097227711029 -4.257667013194 -13.818777098701 -10.428719959574
##     [37] -9.935950684218 -5.243923183966 -12.050187835554 -8.347434870727
##     [41] -17.695521882223 -10.968180101525 -21.473348771507 -23.133052728704
##     [45] -1.985455782487 -21.626807647293 -8.075617472219  3.366873499473
##     [49] -3.303425209237  2.425684631294  1.801978361841 -8.584232151446
##     [53] -9.314462577062 -22.547805356553 -12.035091979326 -10.950830893286
##     [57] -20.258361001872 -12.651441378184 -7.270835552875  4.405994575461
##     [61] -20.461940104114 -31.414553951163 -25.646675723423 -31.331316067967
##     [65] -7.578754505849 -18.151594301284 -10.930649006001 -31.168901261683
##     [69] -2.477994347714 -22.548255903827 -23.210422435126  11.777299512369
##     [73]  7.428032727033 -5.911275480957 -4.317293553459 -22.605811929479
##     [77] -8.099993583120 -2.186213991853 -11.672740794780 -15.936009458596
##     [81] -18.449909226976 -15.456585208946  14.169397203459 -19.468018594904
##     [85] -10.366055191468 -15.433842868361 -27.440233126389 -4.100313941819
##     [89] -2.966463692549 -14.492620488028 -12.701700545468 -17.541691505294
##     [93] -11.180618465129 -1.994373053461 -1.871776046599 -7.378958020688
```

```

## [97] -5.978624547935 -0.227992529838 -3.824920429153 -5.263561992652
## [101] -9.201825236459 -20.680259746570 -6.773769442336 -3.421813641457
## [105] 2.402168586646 -5.364094210864 -6.973390018061 -18.385767173802
## [109] -12.061227688453 3.149730197075 -16.061057180708 -2.257612039426
## [113] -9.936548168969 -12.214717137182 -12.646391042828 -15.476814365295
## [117] -10.719964382217 -4.831423449430 -26.226289884387 11.616078708203
## [121] -13.261104492088 -4.484189092450 -10.928835116863 -18.678733363087
## [125] 4.432487838495 7.326872658389 -3.453592472821 -17.509921130044
## [129] -20.131683878681 -9.600588083671 -15.056258017703 -13.086224561976
## [133] -8.617455313744 4.112372140495 -6.501328645238 -15.231188029610
## [137] -11.889499314849 -5.878917627878 8.063718289513 -12.826085935949
## [141] -9.572632577052 -28.915863828949 -17.153200677198 9.870065789418
## [145] -1.940388273824 4.702765243513 -17.468046163970 -6.004097269767
## [149] 11.808930687967 -12.547324728295 -22.409038918006 -9.845173737171
## [153] -19.243068174955 -24.848475317706 0.033457003406 -21.738261723065
## [157] -25.245306280145 -14.372955851173 -7.624926851233 -12.531633969231
## [161] -15.048875315416 -9.819212127515 -16.669332712485 -10.389585416116
## [165] -24.518493496738 -29.667647936582 -9.001201792480 18.699913183824
## [169] -11.523515208863 -17.025039467558 -10.190485663506 -1.964954170292
## [173] 10.577590264792 -13.362521187145 -18.038520820021 -9.770044051213
## [177] -2.497586390317 -11.279282118801 -25.689231809685 -17.734640601634
## [181] -20.479633767396 -4.313128204591 -0.816196578256 -3.137077767318
## [185] -18.315873095340 -27.045625650228 -12.006588214002 6.427404185808
## [189] -13.762627132292 -5.139469059477 -21.335230825650 -25.701437700320
## [193] -16.302337394572 -12.292421632107 -6.170152707879 -14.100263915475
## [197] -21.874545053831 -26.410526890184 -10.979108727875 1.785934892104
## [201] -14.204782004761 -18.688312446027 -2.977401078677 -3.287007872954
## [205] 4.650885604901 -4.852856029993 -14.431637615470 -20.005374895754
## [209] 0.790701783115 2.178876415095 -1.025521151893 -22.143975940735
## [213] -5.310478062384 -33.294901729148 -19.660011088052 -28.358201912067
## [217] -10.389592912381 -30.133521718314 -9.985158367923 -14.934985668312
## [221] 3.197142077887 -19.581111271523 9.751130885028 -12.962741220576
## [225] 16.609731115238 -19.538412669592 2.086703561310 -13.410858759493
## [229] 0.364268369458 -22.932200198355 -11.848197017461 -9.736149822799
## [233] -31.741954663254 4.202722956243 -33.994704404213 -9.226817710218
## [237] 9.890592798578 -3.972847793470 -22.254856962172 -9.280720115976
## [241] -14.738227349677 -7.964379417245 -26.592598337096 -0.677299560044
## [245] -18.364189340615 -4.701733461802 -18.706622566496 -12.105696633213
## [249] -17.123331894326 -15.392392614509 5.023418729435 -4.183555954247
## [253] -11.223875612457 -3.993167998937 -1.096992059817 -23.582418019742
## [257] -9.761800307751 -27.340710029202 -5.101081082792 -14.113802483831
## [261] 6.230270720496 -20.426100423141 3.074772452820 11.653107665237
## [265] -15.262380800897 -16.820845649763 -7.797938002474 -2.490138710000
## [269] -3.431481080231 -2.669263983490 -9.635902077450 -16.387862285020
## [273] -13.629913959958 -15.399706528673 -21.411677678622 -7.192973702671
## [277] -9.719796840692 -23.943799095410 -10.608644583268 -1.864279050982
## [281] -17.362904858532 -7.711483441580 -2.987507816457 -16.185621285070
## [285] -7.300760987886 -17.993267567723 -0.869820541584 -4.642587624481
## [289] -0.966277954573 -4.521689180411 0.274473021962 -14.045851845721
## [293] 8.685332385166 -6.394307376462 -15.895829683093 -16.098429697997
## [297] -15.617732041420 -1.665929600869 -12.939645629661 -10.149101071728
## [301] 2.632572155427 -13.760696656096 -2.662559305228 -12.690014907739
## [305] -19.135956878579 -18.220056773777 0.913472322452 -22.122930669266
## [309] -23.942725567812 -8.892440811686 -23.469067746007 -11.142992876375

```


##	[313]	2.965306046357	-4.409664088108	4.446731609640	17.563713724939
##	[317]	-9.784752606683	-9.368148757915	-24.211164541320	-35.702560240790
##	[321]	-7.939482013140	-6.516497619739	-20.030629940175	10.070250336529
##	[325]	-2.295733075421	-21.892024607116	-24.097162644068	-11.373080851947
##	[329]	-15.709581008943	-4.321873730397	-7.525743346105	5.723427405123
##	[333]	-5.804678081388	5.238354411043	1.458355619524	-9.044075696258
##	[337]	-9.525746487472	-16.791141888638	-48.773558171947	-10.806989413334
##	[341]	-0.893143291288	-15.194890291363	-20.853839009389	-0.514692059810
##	[345]	-21.584089465274	-11.425546879343	2.671230766599	-12.911662560195
##	[349]	-6.915935685304	-10.486961142163	3.090580306872	3.202106743289
##	[353]	-11.020154543166	-20.169191134749	-1.392838391696	-5.282976358578
##	[357]	-22.930325496718	-4.367569658851	-23.097951559090	-5.129010771743
##	[361]	-9.198866978781	-4.070163709157	-10.514481048732	-17.715207194223
##	[365]	-2.888227858856	-18.517251900259	-12.345561313218	-20.649390250901
##	[369]	-16.953279749864	-13.751822248678	-15.911455213490	-27.458170500670
##	[373]	-11.631700120767	-8.855348299840	-20.184380708685	-9.881159831317
##	[377]	-13.408893035642	-13.464154474975	-25.095494127423	-2.749464524350
##	[381]	-19.390047644923	-2.040358131737	-6.373167878764	-14.535554237514
##	[385]	-5.675464812310	-6.233932493987	-10.104283638124	-3.916170461888
##	[389]	-9.430213156515	-12.985485211286	-14.760361187738	-13.118356311670
##	[393]	-9.388084506682	1.916235917823	-7.228031503635	-7.727836275254
##	[397]	-5.237567610826	-10.748695424443	-21.879460534838	-2.472554464817
##	[401]	-5.298320775399	-13.877768994742	-4.753386575356	4.397443670378
##	[405]	-33.661510175126	-3.135526270782	-31.680559441996	-20.238193926398
##	[409]	-1.678197865810	-0.345224422496	-5.917970456579	-0.197095044759
##	[413]	-17.552539175191	-1.720355924099	2.666904697729	7.375745692462
##	[417]	-9.410704904291	-5.580161581670	-19.190156392236	-14.219405784947
##	[421]	-18.129578131008	4.074238025536	-3.760343990745	-22.713695847586
##	[425]	-6.944201733727	-11.980321420525	-8.508423411349	0.780020973064
##	[429]	9.297741882185	-18.189525060322	-36.408032897485	7.842591759951
##	[433]	11.123452727608	-10.591680971207	6.413797001708	-5.102562978557
##	[437]	0.375589857064	-1.300352090405	-16.008388758033	-21.828361822766
##	[441]	-0.607705090535	-31.420365744715	-9.935247652635	-9.942913254109
##	[445]	-7.016861010806	-8.141759051846	-11.934492579797	-36.470552225975
##	[449]	-10.893848630125	-9.917690778766	-4.355753192875	-16.048819036799
##	[453]	-6.830849138618	-2.672684887174	-8.830139775018	-17.117599726955
##	[457]	-2.202364016309	-2.089086441928	-3.951325198835	-11.930776473723
##	[461]	-17.238931034536	-21.221167194950	-26.208472080620	-23.222620828641
##	[465]	-4.187042585856	-5.614496110724	-12.664779383654	-9.473480522084
##	[469]	-1.045979601344	-11.900040100276	-4.148819535912	-21.358862727266
##	[473]	-9.678462945256	-17.378091725547	-15.907295462256	-7.779435099214
##	[477]	4.061347212525	-22.951846872984	9.961697274195	-7.300250018146
##	[481]	-23.090199720162	-26.771680331848	-4.581408529756	1.639515239534
##	[485]	-8.374657692890	0.871449340980	7.673536231225	2.327158357485
##	[489]	3.630915079441	-21.551601890939	-18.041495461964	-15.864346686774
##	[493]	-6.883881020770	-14.310892082815	-16.806143708846	-25.526722919195
##	[497]	-0.293820087089	-10.017211652994	-22.345471983688	-30.283548536234
##	[501]	-1.673187782356	-2.432260751940	-15.251677779876	-23.563177575553
##	[505]	-1.988680710518	-3.631460697105	-13.362260875068	-8.666116675617
##	[509]	-0.538693023692	-4.280943920390	5.049123311739	-5.603855094527
##	[513]	3.117641131978	-1.093182980144	0.521204958092	-2.094326954343
##	[517]	-12.200728673830	13.090781262719	-11.546973168533	-19.057108876867
##	[521]	-1.919964664388	-13.358382934053	-4.654595459388	-2.008022204125
##	[525]	-17.674384320864	-9.064215021469	-21.258128579029	-16.733052978268

```

## [529] -12.896008611531 -12.165351403338 -14.823393193427 -5.061417028605
## [533] -9.494772447063 4.096720756652 -23.046510519507 -18.297160176909
## [537] -13.475449507475 -14.443807141372 -5.847965862724 -11.928095056432
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## [565] -3.994936050779 -18.543325206961 -14.680186080536 17.658275723077
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```

```

## [745] 8.131623272931 0.627319782575 -9.817871260108 -23.338620790478
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## [781] -7.811488458099 -12.781261037037 -17.672245318062 -12.499218441881
## [785] -12.339325689676 2.721383820871 3.972734260381 -12.445966698272
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## [937] -3.531176173338 -8.633308074774 -20.458867605230 9.882671510279
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## [953] -26.143552739200 2.783335997745 1.301441145727 -11.383544876582
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```

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## [961] -12.949516069881 -5.885844667457 -12.861530029051 -11.685482842150
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## [973] -16.902457609334 -6.934206316057 -19.726258607731 2.922769588320
## [977] -12.206112040685 -0.397556937674 -14.266088631673 -14.723349180514
## [981] -5.599160138138 -1.852944660173 -4.083250181944 -10.845154790800
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## [997] -18.501539379958 -12.463851659622 -13.580793521121 -25.843965795372
```

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

```
set.seed(1997)
v = rnorm(n=1000,mean=-10,sd=sqrt(100))
v
```

```
## [1] -17.675075287345 -0.949106997727 -21.066080455948 -11.120659879294
## [5] -27.375027862063 -7.704144076084 2.597498851215 -5.515257599821
## [9] -24.460034119716 -22.183513749114 -12.172376580441 -19.932224927593
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## [29] -12.986072061446 1.102600768017 -6.553384276259 -15.398435755252
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## [45] -1.985455782487 -21.626807647293 -8.075617472219 3.366873499473
## [49] -3.303425209237 2.425684631294 1.801978361841 -8.584232151446
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## [69] -2.477994347714 -22.548255903827 -23.210422435126 11.777299512369
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## [145] -1.940388273824 4.702765243513 -17.468046163970 -6.004097269767
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```

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


```
mean(v)
```

```
## [1] -9.6941212672
```

```
sd(v)
```

```
## [1] 9.7639309287
```

- 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?

```
?quantile  
quantile(v, 0.05)
```

```
##           5%  
## -25.41669862
```

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

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

```
# The estimate is about the same
```

- 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?

```
inverse_quantile_obj = ecdf(v)  
inverse_quantile_obj(0)
```

```
## [1] 0.848
```

```
# The estimate is about the same when you take the CDF of 0 of this distribution 0.84134475
```