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. Most of this will be a pure programming assignment but there are some questions that instead ask you to "write a few sentences". This is a W class! The tools for the solutions to these problems can be found in the class practice lectures. I prefer you to use the methods I taught you. If you google and find esoteric code you don't understand, this doesn't do you too much good.

To "hand in" the homework, you should first download this file. The best way to do this is by cloning the class repository then copying this file from the folder of that clone into the folder that is your personal class repository. Then do the assignment by filling in the TO-DO's. After you're done, compile this file into a PDF (use the "knit to PDF" button on the submenu above). This PDF will include output of your code. Then push the PDF and this Rmd file by the deadline to your github repository in a directory called "labs".

Basic R Skills

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

```
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 + . . .

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

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

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

```
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 *` . . .

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

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

Is this answer *exactly* correct?

No, because it only takes into account integer values, where it is closer to 0, so the answe complies at 0.

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

```
sum(log(1/(2^(0:386))))
```

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

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

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

- Create the sequence `x = [Inf, 20, 18, ..., -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(Inf), log_3(100), log_3(98), ... log_3(-20)]`.

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

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

```
log(100, 3)
```

```
## [1] 4.1918065486
```

Comment on the appropriateness of the non-numeric values.

NAN occurs because you cannot take the log of a negative number. -Inf occurs when you take the log of 0.

- 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
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 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`.

```
?which
which(!y)
```

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

```
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.

```
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)
  ```

  ```
  ## 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  3
  ## [26]  3  3  3  3  3  3  3  3  3  3  3  3  3  2  2  2  2  2  2  2  2  2  1  1  1
  ## [51]  0 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)]
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 xˆ2 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.

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

```
## [1] 0.59
```

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

```
sum(sample(c(0,1), size=500, replace=TRUE, prob=c(0.1, 0.9)))/500
```

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

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

```
?rbinom
rbinom(n=1000, size=1, p=0.9)
```

```
##    [1] 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 0 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1
##   [38] 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
##   [75] 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 0
##  [112] 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1
##  [149] 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1
##  [186] 1 1 1 1 0 1 1 1 1 1 1 1 1 0 1 1 1 1 1 0 1 1 1 1 0 1 0 1 0 1 1 1 0 1 1 1 1
##  [223] 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
##  [260] 1 1 1 1 0 1 1 1 0 1 0 1 1 1 1 1 1 1 0 1 0 1 1 1 1 0 0 1 1 1 1 1 1 1 1 0 1
##  [297] 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 0 1 1 1 1 0 1 1 1 0 1 1 1 1 1 1 1 1 0
##  [334] 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
##  [371] 1 0 1 1 1 1 1 1 1 1 1 1 0 1 1 0 1 1 1 1 1 0 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1
##  [408] 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
##  [445] 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1
##  [482] 1 1 0 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1
##  [519] 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1
##  [556] 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1
##  [593] 1 1 1 1 0 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1
##  [630] 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 0 1 1 1 1 0 1 1 1 1 1 0 1 1 1 1 1 1 1 1
##  [667] 1 1 1 0 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
##  [704] 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1
##  [741] 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
##  [778] 1 1 1 1 0 1 1 1 1 1 1 1 1 0 1 1 0 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1
##  [815] 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 0 1 1 1 0 1 1 0 1 1 1
##  [852] 1 1 1 1 0 1 1 1 1 1 1 1 0 1 0 1 1 1 1 1 1 1 1 1 1 1 0 1 0 1 1 1 1 1 1 1 1
##  [889] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 0 1 1 0 1 0 1
##  [926] 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1
##  [963] 1 1 1 1 0 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 0 1 1
## [1000] 0
```

- In class we considered a variable `x_3` which measured “criminality”. We imagined L = 4 levels “none”, “infraction”, “misdimeanor” 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", "misdimeanor", "felony"), size=100, replace=TRUE))
x_3
```

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

- 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", "misdimeanor", "felony"), order=TRUE)
x_3_ord
```

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

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

```
#converted into four binary variables due to there being 4 levels

bin_1 = as.numeric(x_3_ord=="infraction") ; bin_1
```

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

```
bin_2 = as.numeric(x_3_ord=="misdimeanor") ; bin_2
```

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

```
bin_3 = as.numeric(x_3_ord=="felony") ; bin_3
```

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

```
bin_matrix = matrix(NA, nrow = 100, ncol = 3)
bin_matrix[ ,1] = bin_1
bin_matrix[ ,2] = bin_2
bin_matrix[ ,3] = bin_3
colnames(bin_matrix) = c("infraction", "misdimeanor", "felony")
bin_matrix
```

```
##        infraction misdimeanor felony
##   [1,]          0           0      0
##   [2,]          1           0      0
##   [3,]          0           0      0
##   [4,]          0           1      0
##   [5,]          0           0      0
##   [6,]          0           0      0
##   [7,]          0           1      0
##   [8,]          0           0      0
##   [9,]          1           0      0
##  [10,]          1           0      0
## [11,]        0         1     0
## [12,]        1         0     0
## [13,]        0         0     1
## [14,]        1         0     0
## [15,]        0         0     1
## [16,]        1         0     0
## [17,]        0         0     0
## [18,]        0         0     0
## [19,]        1         0     0
## [20,]        0         0     0
## [21,]        0         0     0
## [22,]        0         0     0
## [23,]        0         1     0
## [24,]        0         1     0
## [25,]        0         0     1
## [26,]        0         1     0
## [27,]        1         0     0
## [28,]        0         0     0
## [29,]        0         0     1
## [30,]        0         0     1
## [31,]        0         1     0
## [32,]        0         1     0
## [33,]        0         0     0
## [34,]        1         0     0
## [35,]        0         1     0
## [36,]        0         0     0
## [37,]        1         0     0
## [38,]        0         0     1
## [39,]        0         0     0
## [40,]        0         0     1
## [41,]        0         1     0
## [42,]        1         0     0
## [43,]        0         0     0
## [44,]        0         0     1
## [45,]        1         0     0
## [46,]        0         0     0
## [47,]        0         0     0
## [48,]        1         0     0
## [49,]        0         1     0
## [50,]        0         1     0
## [51,]        1         0     0
## [52,]        0         0     1
## [53,]        0         0     0
## [54,]        1         0     0
## [55,]        0         0     0
## [56,]        0         1     0
## [57,]        0         1     0
## [58,]        0         0     0
## [59,]        0         1     0
## [60,]        0         0     1
## [61,]        0         0     1
## [62,]        0         1     0
## [63,]        1         0     0
## [64,]        0         1     0
##  [65,]          1            0       0
##  [66,]          1            0       0
##  [67,]          0            0       0
##  [68,]          0            1       0
##  [69,]          0            0       0
##  [70,]          0            0       0
##  [71,]          0            1       0
##  [72,]          0            0       0
##  [73,]          0            0       0
##  [74,]          0            1       0
##  [75,]          1            0       0
##  [76,]          0            0       1
##  [77,]          0            0       1
##  [78,]          1            0       0
##  [79,]          0            0       0
##  [80,]          0            1       0
##  [81,]          1            0       0
##  [82,]          0            0       0
##  [83,]          0            0       0
##  [84,]          1            0       0
##  [85,]          0            0       0
##  [86,]          1            0       0
##  [87,]          0            0       1
##  [88,]          1            0       0
##  [89,]          0            1       0
##  [90,]          1            0       0
##  [91,]          0            1       0
##  [92,]          1            0       0
##  [93,]          0            0       0
##  [94,]          1            0       0
##  [95,]          0            0       0
##  [96,]          0            0       0
##  [97,]          0            0       0
##  [98,]          0            0       0
##  [99,]          0            1       0
## [100,]          0            0       0
```

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

Each row sum should range from 0:3 since it is binary (0 or 1). What is being added is if a “infraction”, “misdimeanor”, “felony” occured in which the lowest value,0, would reflect no crime, and a sum of 3 would refelct all three crimes occuring.

Verify that.

```
rowSums(bin_matrix)
```

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

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

The sum should range from 0:100, however, lower values are to be expected more because of each matrix having more 0's than 1's for each respective binary variable. This means, although each crime type can have up to 100 crimes commited for each it is likely to have a lot less.

Verify that.

```
colSums(bin_matrix)
```

```
##   infraction misdimeanor      felony
##           27          24          14
```

- 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 in 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"
)

name_matrix = matrix(data = NA, nrow = 100, ncol = 6)
name_matrix[, 1] = rnorm(n = 100, mean = 17, sd = sqrt(38))
name_matrix[, 2] = runif(n = 100, min = -10, max = 10)
name_matrix[, 3] = rpois(100, lambda = 6)
name_matrix[, 4] = rexp(100, rate = 9)
name_matrix[, 5] = rbinom(100, size = 20, prob = 0.12)
name_matrix[, 6] = sample(c(rep(1, 100 * 0.24), rep(0, 100 * 0.76)))
rownames(name_matrix) = fake_first_names
name_matrix
```

```
##                     [,1]            [,2] [,3]            [,4] [,5] [,6]
## Sophia     9.7411578465 -9.657750572078   11 0.2275976281934    3    1
## Emma      30.1772573649  2.492402046919    5 0.0033036790167    0    1
## Olivia    24.8733997796  1.351683512330    1 0.1455153906671    4    0
## Ava       17.4791165412 -1.869113477878    5 0.0382722384400    5    1
## Mia       21.6717834721  2.484921053983   10 0.2193557994554    4    0
## Isabella  13.9421003595 -7.961470219307    4 0.2382543506996    4    0
## Riley     17.4364517965 -8.652742169797   10 0.1417020370930    1    0
## Aria      17.7723926084  9.713944951072    7 0.1149875745131    1    0
## Zoe       20.1076965093  1.971025676467    5 0.0433307589653    3    0
## Charlotte  0.6585954385  8.527604429983    9 0.0021590428079    3    0
## Lily      14.5992764090 -3.530530035496    7 0.3231440469538    1    0
## Layla      9.6131386963 -6.486847912893    6 0.0189764247973    2    0
## Amelia    11.5266123125 -6.031661746092    5 0.0768737828152    2    0
## Emily     18.7316068257  4.177767080255    4 0.0597264467118    2    0
## Madelyn   18.1965949184  8.107114378363    8 0.0227308249515    3    1
## Aubrey    35.8711755165  7.982615078799    6 0.2456170943322    1    1
## Adalyn    10.1002451240  8.244261345826   10 0.1908310717044    0    1
## Madison   21.5085718487  1.360237477347    6 0.3169715925864    2    0
## Chloe     23.8706357304 -2.124452176504    4 0.0781273210671    1    0
## Harper    10.4323672043  7.176078991033    3 0.0346710057929    4    1
## Abigail   16.8804881914  1.573015674949    7 0.0809750669063    3    0
## Aaliyah   23.2170037305 -5.572772175074    4 0.2506614053386    2    1
## Avery      5.7345545288  5.975631480105    4 0.1416562378567    2    1
## Evelyn    14.3896042252 -4.161609257571    6 0.0811998800638    0    1
## Kaylee     8.2308881905  0.076620727777    2 0.0550497863442    2    0
## Ella      22.2505022440 -8.021842362359    3 0.0302354007338    1    1
## Ellie     16.7731978160 -8.475745609030    6 0.3717245525597    3    0
## Scarlett  23.6941652683  7.526455046609    2 0.1020477103681    1    0
## Arianna   18.8265019942  2.941162623465    5 0.0053300304471    1    0
## Hailey    14.0277387421  2.832401595078    7 0.0742263087175    2    0
## Nora      23.2030466705 -4.118102020584    7 0.0704477685504    0    0
## Addison   15.3114780469 -9.298354960047    4 0.1434703877977    2    0
## Brooklyn  21.9491272668 -6.122297290713    7 0.0747460240705    2    0
## Hannah    17.6136240519 -4.644839772955    7 0.0370393692930    6    0
## Mila      19.5434533364  7.450763126835    5 0.0611784164794    2    0
## Leah      23.3910676040 -4.141135513783    7 0.0420538846714    3    0
## Elizabeth 16.2300019907 -9.605703777634    6 0.0809251366717    2    1
## Sarah      5.7984977464  3.856029617600    7 0.0115107844273    2    0
## Eliana    10.9184467060  5.542397638783    9 0.2078058562252    4    0
## Mackenzie 22.4356552133 -2.045461931266    5 0.0162646668633    2    0
## Peyton    12.3210950664  1.008528517559    4 0.1098565087710    3    0
## Maria     18.1621057624 -7.201613914222    8 0.4258477478572    1    0
## Grace     25.8975912575  0.838561081327   12 0.1345855102103    1    0
## Adeline   21.9328916014 -5.535035505891    5 0.0714285872980    4    0
## Elena     16.5964221442 -8.729584664106    6 0.0029307710938    4    0
## Anna      10.1821606187 -2.599527747370    7 0.1697755145437    1    0
## Victoria   9.6276961300 -4.123722403310    3 0.1204905082082    4    0
## Camilla   19.1108173383 -5.805842368864    7 0.0229730024002    3    1
## Lillian    9.4604483071  2.641435419209    5 0.0100567237888    2    0
## Natalie   19.4393961498  5.084659690037    8 0.0974106405712    2    0
## Jackson   19.1627506440  8.383950716816    4 0.0263000874677    1    0
## Aiden     24.7877960894  2.237461102195    6 0.0409960850763    0    0
## Lucas     18.7350963090  2.745157862082   12 0.3418099739299    2    1
## Liam      10.0268852295 -9.320227871649    6 0.0623645272830    6    0
## Noah      21.9475832519 -2.626964533702    7 0.1205237952739    0    0
## Ethan     23.4059186740  7.442669253796    5 0.0880737217835    3    1
## Mason     16.5348721571 -7.111708507873    6 0.0470295773037    2    1
## Caden     18.5927817586  3.155714389868    7 0.0425190971647    2    0
## Oliver    12.5727814751 -3.483911473304    4 0.3344453331546    1    0
## Elijah     7.7428248874 -1.971619441174    8 0.1589910715976    0    1
## Grayson   12.8744802675  8.859429601580    7 0.3601602423335    2    0
## Jacob     18.4884719631  8.230329328217    3 0.2750311839358    3    0
## Michael   22.4765066443 -9.571499167942    4 0.0542418898290    2    1
## Benjamin  10.3771448525  7.605855911970    5 0.0949815895263    3    0
## Carter    14.8720486738  2.374365353025    8 0.0040764163570    2    1
## James     21.1214761820  9.243583870120    6 0.2771113131883    0    0
## Jayden    21.1292739775  2.145524178632    4 0.1049233187564    2    0
## Logan     25.5951712509  4.034032416530    9 0.3236520364694    2    0
## Alexander 15.9129013236  4.539113459177    4 0.0364949610602    3    0
## Caleb     34.9153402081  4.868223741651   12 0.0470581924439    3    0
## Ryan      21.5754528612  3.905578614213    8 0.0489343509890    4    0
## Luke      18.0239964514 -9.945122520439    8 0.0438587091242    2    0
## Daniel    17.2457280738 -5.287397480570    4 0.0324807380223    4    0
## Jack      12.7140809842  4.756384692155    4 0.0258280101385    4    1
## William   20.5870322987 -7.946362243965    4 0.2662140443367    3    0
## Owen      30.8278374817  7.977810469456    7 0.0389263825491    0    0
## Gabriel   20.5590453548 -5.350091848522    5 0.3337376856417    1    0
## Matthew   10.7972153553  8.383616674691    2 0.2777787490297    3    0
## Connor    20.1579709569  5.787285934202    8 0.2172755526492    4    0
## Jayce     20.3084839604 -8.303870647214    1 0.0909892328865    3    0
## Isaac     24.5409157211 -5.932625704445    8 0.0131992191697    2    0
## Sebastian 12.3753851761 -2.018182105385    7 0.1959982940072    1    0
## Henry     15.2601831975 -3.779665036127    3 0.0326549553105    5    0
## Muhammad  29.3911853430 -7.704685633071    4 0.0306738893915    2    0
## Cameron   16.5037274690  1.273665344343    9 0.3588408844152    0    0
## Wyatt     17.2042610586 -2.528996705078    5 0.0502938273644    2    1
## Dylan     21.0781698500  1.842415137216    5 0.0749319654682    5    0
## Nathan    12.0139716656 -2.871800167486    5 0.1129587998360    3    0
## Nicholas  18.0951701219 -3.560533225536    5 0.3917849295582    1    0
## Julian    16.7626934389 -1.456719357520    8 0.3628922626189    3    0
## Eli       15.0247898805  0.881367628463    7 0.0174842552997    2    0
## Levi      11.3662819016 -0.383577104658    6 0.0095196202294    2    1
## Isaiah    19.9375590437 -7.542522768490    5 0.1360572819737    2    1
## Landon    21.7213509771  9.841776713729    8 0.0789986042216    3    0
## David     15.3464180500 -5.646805111319   13 0.0078711025963    5    0
## Christian 24.8273568584 -1.148336799815    5 0.3397785019357    1    0
## Andrew    14.7995263577  4.315268886276    7 0.0545056628374    1    0
## Brayden   22.7496872964  0.131656965241    6 0.0049665165134    2    1
## John      19.3621883878  0.321555705741    6 0.1283366610767    0    0
## Lincoln   15.7342736835 -7.814885578118    4 0.1519061634270    1    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.

```
name_frame = data.frame(name_matrix)
name_frame[,6]= factor(name_frame[,6], levels=c(0,1), labels= c("DOMESTIC", "FOREIGN"))
name_frame
```

```
##                      X1              X2 X3              X4 X5       X6
## Sophia     9.7411578465 -9.657750572078 11 0.2275976281934  3  FOREIGN
## Emma      30.1772573649  2.492402046919  5 0.0033036790167  0  FOREIGN
## Olivia    24.8733997796  1.351683512330  1 0.1455153906671  4 DOMESTIC
## Ava       17.4791165412 -1.869113477878  5 0.0382722384400  5  FOREIGN
## Mia       21.6717834721  2.484921053983 10 0.2193557994554  4 DOMESTIC
## Isabella  13.9421003595 -7.961470219307  4 0.2382543506996  4 DOMESTIC
## Riley     17.4364517965 -8.652742169797 10 0.1417020370930  1 DOMESTIC
## Aria      17.7723926084  9.713944951072  7 0.1149875745131  1 DOMESTIC
## Zoe       20.1076965093  1.971025676467  5 0.0433307589653  3 DOMESTIC
## Charlotte  0.6585954385  8.527604429983  9 0.0021590428079  3 DOMESTIC
## Lily      14.5992764090 -3.530530035496  7 0.3231440469538  1 DOMESTIC
## Layla      9.6131386963 -6.486847912893  6 0.0189764247973  2 DOMESTIC
## Amelia    11.5266123125 -6.031661746092  5 0.0768737828152  2 DOMESTIC
## Emily     18.7316068257  4.177767080255  4 0.0597264467118  2 DOMESTIC
## Madelyn   18.1965949184  8.107114378363  8 0.0227308249515  3  FOREIGN
## Aubrey    35.8711755165  7.982615078799  6 0.2456170943322  1  FOREIGN
## Adalyn    10.1002451240  8.244261345826 10 0.1908310717044  0  FOREIGN
## Madison   21.5085718487  1.360237477347  6 0.3169715925864  2 DOMESTIC
## Chloe     23.8706357304 -2.124452176504  4 0.0781273210671  1 DOMESTIC
## Harper    10.4323672043  7.176078991033  3 0.0346710057929  4  FOREIGN
## Abigail   16.8804881914  1.573015674949  7 0.0809750669063  3 DOMESTIC
## Aaliyah   23.2170037305 -5.572772175074  4 0.2506614053386  2  FOREIGN
## Avery      5.7345545288  5.975631480105  4 0.1416562378567  2  FOREIGN
## Evelyn    14.3896042252 -4.161609257571  6 0.0811998800638  0  FOREIGN
## Kaylee     8.2308881905  0.076620727777  2 0.0550497863442  2 DOMESTIC
## Ella      22.2505022440 -8.021842362359  3 0.0302354007338  1  FOREIGN
## Ellie     16.7731978160 -8.475745609030  6 0.3717245525597  3 DOMESTIC
## Scarlett  23.6941652683  7.526455046609  2 0.1020477103681  1 DOMESTIC
## Arianna   18.8265019942  2.941162623465  5 0.0053300304471  1 DOMESTIC
## Hailey    14.0277387421  2.832401595078  7 0.0742263087175  2 DOMESTIC
## Nora      23.2030466705 -4.118102020584  7 0.0704477685504  0 DOMESTIC
## Addison   15.3114780469 -9.298354960047  4 0.1434703877977  2 DOMESTIC
## Brooklyn  21.9491272668 -6.122297290713  7 0.0747460240705  2 DOMESTIC
## Hannah    17.6136240519 -4.644839772955  7 0.0370393692930  6 DOMESTIC
## Mila      19.5434533364  7.450763126835  5 0.0611784164794  2 DOMESTIC
## Leah      23.3910676040 -4.141135513783  7 0.0420538846714  3 DOMESTIC
## Elizabeth 16.2300019907 -9.605703777634  6 0.0809251366717  2  FOREIGN
## Sarah      5.7984977464  3.856029617600  7 0.0115107844273  2 DOMESTIC
## Eliana    10.9184467060  5.542397638783  9 0.2078058562252  4 DOMESTIC
## Mackenzie 22.4356552133 -2.045461931266  5 0.0162646668633  2 DOMESTIC
## Peyton    12.3210950664  1.008528517559  4 0.1098565087710  3 DOMESTIC
## Maria     18.1621057624 -7.201613914222  8 0.4258477478572  1 DOMESTIC
## Grace     25.8975912575  0.838561081327 12 0.1345855102103  1 DOMESTIC
## Adeline   21.9328916014 -5.535035505891  5 0.0714285872980  4 DOMESTIC
## Elena     16.5964221442 -8.729584664106  6 0.0029307710938  4 DOMESTIC
## Anna      10.1821606187 -2.599527747370  7 0.1697755145437  1 DOMESTIC
## Victoria   9.6276961300 -4.123722403310  3 0.1204905082082  4 DOMESTIC
## Camilla   19.1108173383 -5.805842368864  7 0.0229730024002  3  FOREIGN
## Lillian    9.4604483071  2.641435419209  5 0.0100567237888  2 DOMESTIC
## Natalie   19.4393961498  5.084659690037  8 0.0974106405712  2 DOMESTIC
## Jackson   19.1627506440  8.383950716816  4 0.0263000874677  1 DOMESTIC
## Aiden     24.7877960894  2.237461102195  6 0.0409960850763  0 DOMESTIC
## Lucas     18.7350963090  2.745157862082 12 0.3418099739299  2  FOREIGN
## Liam      10.0268852295 -9.320227871649  6 0.0623645272830  6 DOMESTIC
## Noah      21.9475832519 -2.626964533702  7 0.1205237952739  0 DOMESTIC
## Ethan     23.4059186740  7.442669253796  5 0.0880737217835  3  FOREIGN
## Mason     16.5348721571 -7.111708507873  6 0.0470295773037  2  FOREIGN
## Caden     18.5927817586  3.155714389868  7 0.0425190971647  2 DOMESTIC
## Oliver    12.5727814751 -3.483911473304  4 0.3344453331546  1 DOMESTIC
## Elijah     7.7428248874 -1.971619441174  8 0.1589910715976  0  FOREIGN
## Grayson   12.8744802675  8.859429601580  7 0.3601602423335  2 DOMESTIC
## Jacob     18.4884719631  8.230329328217  3 0.2750311839358  3 DOMESTIC
## Michael   22.4765066443 -9.571499167942  4 0.0542418898290  2  FOREIGN
## Benjamin  10.3771448525  7.605855911970  5 0.0949815895263  3 DOMESTIC
## Carter    14.8720486738  2.374365353025  8 0.0040764163570  2  FOREIGN
## James     21.1214761820  9.243583870120  6 0.2771113131883  0 DOMESTIC
## Jayden    21.1292739775  2.145524178632  4 0.1049233187564  2 DOMESTIC
## Logan     25.5951712509  4.034032416530  9 0.3236520364694  2 DOMESTIC
## Alexander 15.9129013236  4.539113459177  4 0.0364949610602  3 DOMESTIC
## Caleb     34.9153402081  4.868223741651 12 0.0470581924439  3 DOMESTIC
## Ryan      21.5754528612  3.905578614213  8 0.0489343509890  4 DOMESTIC
## Luke      18.0239964514 -9.945122520439  8 0.0438587091242  2 DOMESTIC
## Daniel    17.2457280738 -5.287397480570  4 0.0324807380223  4 DOMESTIC
## Jack      12.7140809842  4.756384692155  4 0.0258280101385  4  FOREIGN
## William   20.5870322987 -7.946362243965  4 0.2662140443367  3 DOMESTIC
## Owen      30.8278374817  7.977810469456  7 0.0389263825491  0 DOMESTIC
## Gabriel   20.5590453548 -5.350091848522  5 0.3337376856417  1 DOMESTIC
## Matthew   10.7972153553  8.383616674691  2 0.2777787490297  3 DOMESTIC
## Connor    20.1579709569  5.787285934202  8 0.2172755526492  4 DOMESTIC
## Jayce     20.3084839604 -8.303870647214  1 0.0909892328865  3 DOMESTIC
## Isaac     24.5409157211 -5.932625704445  8 0.0131992191697  2 DOMESTIC
## Sebastian 12.3753851761 -2.018182105385  7 0.1959982940072  1 DOMESTIC
## Henry     15.2601831975 -3.779665036127  3 0.0326549553105  5 DOMESTIC
## Muhammad  29.3911853430 -7.704685633071  4 0.0306738893915  2 DOMESTIC
## Cameron   16.5037274690  1.273665344343  9 0.3588408844152  0 DOMESTIC
## Wyatt     17.2042610586 -2.528996705078  5 0.0502938273644  2  FOREIGN
## Dylan     21.0781698500  1.842415137216  5 0.0749319654682  5 DOMESTIC
## Nathan    12.0139716656 -2.871800167486  5 0.1129587998360  3 DOMESTIC
## Nicholas  18.0951701219 -3.560533225536  5 0.3917849295582  1 DOMESTIC
## Julian    16.7626934389 -1.456719357520  8 0.3628922626189  3 DOMESTIC
## Eli       15.0247898805  0.881367628463  7 0.0174842552997  2 DOMESTIC
## Levi      11.3662819016 -0.383577104658  6 0.0095196202294  2  FOREIGN
## Isaiah    19.9375590437 -7.542522768490  5 0.1360572819737  2  FOREIGN
## Landon    21.7213509771  9.841776713729  8 0.0789986042216  3 DOMESTIC
## David     15.3464180500 -5.646805111319 13 0.0078711025963  5 DOMESTIC
## Christian 24.8273568584 -1.148336799815  5 0.3397785019357  1 DOMESTIC
## Andrew    14.7995263577  4.315268886276  7 0.0545056628374  1 DOMESTIC
## Brayden   22.7496872964  0.131656965241  6 0.0049665165134  2  FOREIGN
## John      19.3621883878  0.321555705741  6 0.1283366610767  0 DOMESTIC
## Lincoln   15.7342736835 -7.814885578118  4 0.1519061634270  1 DOMESTIC
```

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

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

```
## 
## DOMESTIC  FOREIGN 
##       76       24
```

```
n = 100
table(name_frame[,6])/n
```

```
##
## DOMESTIC  FOREIGN
##     0.76     0.24
```

Print out a summary of the whole dataframe.

```
summary(name_frame)
```

```
##        X1                    X2                    X3
##  Min.   : 0.65859544   Min.   :-9.94512252   Min.   : 1.00
##  1st Qu.:14.00632915   1st Qu.:-5.54446967   1st Qu.: 4.00
##  Median :18.05958329   Median : 0.10413885   Median : 6.00
##  Mean   :17.79623889   Mean   :-0.33604758   Mean   : 6.05
##  3rd Qu.:21.68417535   3rd Qu.: 4.21214253   3rd Qu.: 7.00
##  Max.   :35.87117552   Max.   : 9.84177671   Max.   :13.00
##        X4                     X5               X6
##  Min.   :0.0021590428   Min.   :0.00   DOMESTIC:76
##  1st Qu.:0.0379640211   1st Qu.:1.00   FOREIGN :24
##  Median :0.0799618704   Median :2.00
##  Mean   :0.1241651357   Mean   :2.23
##  3rd Qu.:0.1921228773   3rd Qu.:3.00
##  Max.   :0.4258477479   Max.   :6.00
```

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

```
n = 50
R = matrix(sample(c(rep(0, (n^2)*.5), rep(1, (n^2)*.25), rep(2, (n^2)*.25))), nrow = n, ncol = n)
R
```

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

- 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)* 0.30)] = NA
R
```

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

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

```
?sort
?rowSums

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

```
##  [1] 40 37 36 35 34 34 33 33 32 31 31 31 30 30 30 30 30 29 29 29 29 28 28 27 27
## [26] 27 27 26 26 26 25 25 25 25 24 23 23 23 23 23 23 23 22 22 21 20 20 19 18 17
```

- 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 # MARGIN = c(1,2) gives NA… had to use 'apply' function on row and column separately. apply(R, MARGIN=1, sd, na.rm=TRUE) apply(R, MARGIN=2, sd, na.rm=TRUE)

```
* Use the ‘apply‘ function to compute a vector whose entries are the count of entries that are 1 or 2 i


‘‘‘r
v = apply(R==1 | R==2, MARGIN = 2, sum, na.rm = TRUE)
v
```

```
##  [1] 17 13 12 17 22 18 18 19 16 12 17 20 16 20 16 26 22 26 14 17 18 18 15 23 17
## [26] 11 17 17 28 21 21 12 21 26 18 21 18 23 19 18 19 14  9 15 11 18 22 19 16 24
```

- 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 NA NA  0  2  0  1  2  2  0  0 NA  1  2 NA  0 NA NA  0  0  2 NA  1 NA  2
## [26] NA NA  1  0  0  2 NA  1 NA  0  1 NA NA NA NA  2  0  1 NA  0  0  1 NA NA NA
##
## $‘2‘
##  [1]  2 NA NA  1 NA  0  0 NA  2  0  0  0 NA NA NA NA  0  0  1 NA  0  0  2  0  1
## [26] NA  0  0  1  0  1 NA NA  0  2  0 NA  1  1 NA NA  0  0  2 NA  2  0 NA  0 NA
##
## $‘3‘
##  [1]  0  0  2  0  2  0 NA  2  0  2  1  0  1 NA  0  0  0 NA  2 NA NA  0 NA NA  1
## [26]  0  0  0 NA  1 NA  0  1  0 NA NA  2  0  0  0  0  0  2 NA  0 NA NA  0  0 NA
##
## $‘4‘
##  [1]  1 NA  0  2 NA  1 NA NA NA  2  2  0  0  0 NA NA  0 NA  0  2  0  1  0 NA  1
## [26] NA  1 NA  2  1 NA NA NA  1 NA  2  0  0 NA NA NA  0  2  0  2 NA  2  1 NA  0
##
## $‘5‘
##  [1]  0  1  2  2 NA  0 NA  1 NA  2  2  2  0  2 NA  2  2  1 NA  0  1 NA  2 NA  0
## [26]  0  2  1  0  0 NA NA  0  0 NA  0  1  2 NA  1  1  0  2  1 NA  0  2  0  0  0
##
## $‘6‘
##  [1]  2  2 NA NA NA  1 NA NA  1  0 NA  1 NA  2 NA  0 NA  0  0  0  0  0 NA  2  1
## [26] NA  2  0 NA  2  0  0 NA  2 NA  2 NA  1  2 NA  1 NA  0  0  0  2  1  2 NA NA
##
## $‘7‘
##  [1]  0 NA NA  1  2 NA  1  1  0 NA  2 NA  0 NA  0  0 NA  1  0 NA  1  1  2  0  0
## [26] NA  2 NA  0  0  1  1 NA  1  0  1  0 NA NA NA  2  2 NA  1  0 NA  0  2 NA NA
##
## $‘8‘
##  [1] NA  1 NA  1  2  0  2  2  2  0  1  2  0 NA  1 NA NA  1  1  0  0  0  2  0  0
## [26]  2  2  1  0  0 NA  0 NA NA  2  0  1  0  1  0  0 NA  2  0  0  0 NA NA  0  0
##
## $‘9‘
##  [1]  0  0  0 NA  0  2 NA NA  0  1 NA  2 NA  0  1  0  2  2  1  2 NA  0  0 NA  2
## [26]  0  0  2  0 NA  0  0  2  0  0  0  2  0  2  0  2 NA  0  2  0  0 NA  0  0  2
##
## $‘10‘
##  [1] NA  0 NA  1  2  0  1  0  1  1  0 NA  0 NA  0  0  0  0 NA NA  0  2  0  0 NA
## [26]  2 NA NA NA NA  0 NA  0  1  0 NA  0  0 NA  2  0 NA  0  1  2  0 NA  0  1  0
##
## $‘11‘
##  [1]  2  0  2  0  0  0  1  0  0  0  0  0  1 NA  2 NA  0  0  2 NA  0  2  2  0  0
## [26] NA NA  2  2  0  2  1  2  0  2  0 NA NA NA NA NA  2 NA  0  1  0 NA NA NA  2
##
## $‘12‘
##  [1]  2  0 NA  0  0  0  2  1 NA  2  0  2 NA  2  1  0 NA  2  0 NA  2  1 NA  1  0
## [26]  2 NA  2 NA NA NA NA  1 NA NA  1  0  0 NA NA  1  2 NA  0  1  0 NA  1 NA  2
##
## $‘13‘
##  [1]  2  1  1  2 NA  2 NA NA  2 NA  2 NA  2 NA NA  2  0  0  1  0  0  0 NA  0 NA
## [26]  0  0  0 NA  1  1 NA  0  0 NA  0 NA  0 NA  0 NA  1  0 NA  0  1  1 NA  2  0
##
## $‘14‘
##  [1]  1 NA  1  2  2  2  1  0  0  2  2  0  1 NA  2  0  1  0  0 NA  1  0  1  0  0
## [26] NA  0  0  0 NA  2 NA  1 NA  1  1  1  0 NA  0  2  0  0  0 NA NA  2 NA  0 NA
##
```

```
## $`15`
##  [1]  0  2  1  0 NA  1  2  2 NA  0  2  0  0 NA  1 NA  0  0  2  1  0  0 NA NA  1
## [26] NA  1 NA  2 NA  0 NA  2  2  0 NA  0  0  0  0 NA  0 NA  2  2 NA NA NA NA NA
## 
## $`16`
##  [1]  0  2  1  1  1  2  1  1  1  0  2 NA NA  2 NA  0  0 NA  1  0  1  2  0  1  1
## [26]  0  0 NA  2  1  2 NA NA NA  2  0  2  1  1  1  0  0  0  0 NA  1  2 NA NA  1
## 
## $`17`
##  [1] NA NA  2  0  2  2  2  1  1 NA NA  2  0 NA  1  2  1  0  0  2  0 NA NA  1  2
## [26]  2  1  1  2 NA NA NA  0  0 NA NA  1  0  0  1  0  2 NA  0 NA  2  0 NA NA  1
## 
## $`18`
##  [1]  2  1 NA  2  0  0  0 NA  2  2  1  0  2  0  1  1  1  0  0  2  2  2  2 NA  0
## [26] NA  2  2 NA  1  0 NA  0  0  0  1  0  2  2  2  1  0 NA NA  2  0  0  2  1  2
## 
## $`19`
##  [1]  2  1  0  2 NA  1 NA  2 NA NA NA NA  2  0  0  0  0  1  0  0  1  0  0  2 NA
## [26]  0 NA  0 NA  1  1  0 NA NA NA  0  0 NA  0  1 NA NA NA  0  0  2 NA  0  0  1
## 
## $`20`
##  [1] NA  2  1  0 NA  2 NA NA  1 NA  0  0  0  0  2  1  0  0  2 NA  2  2 NA NA NA
## [26]  2 NA  0 NA NA  0  0 NA  1  0  0  2  0  2  1  0  0  2  2  0  0  2 NA  0 NA
## 
## $`21`
##  [1]  2  2  0  0  0  2 NA  0  1  0  1  2  0  1 NA  2  2  2  0 NA  0  0  2  2 NA
## [26]  1 NA  0  0 NA  0  1  2 NA  1  0  0  0 NA NA NA  0  2 NA  1 NA  0 NA  0  0
## 
## $`22`
##  [1]  2  2  0  2  2 NA  1  0  2  0 NA  0  2  0  0  1 NA NA  0  2  0  2  1  0  1
## [26]  0 NA  0  1 NA NA NA  2 NA NA  1 NA  2  0  0 NA NA NA NA  2  1  0 NA NA NA
## 
## $`23`
##  [1]  0  0  0  0  1 NA  0  0  0 NA NA  1  2  2  2  0  2 NA NA  0  2  0  0 NA NA
## [26] NA  0  0  0  1  0 NA  2  2  0  1  2  1  1 NA NA  0  0  0  0  0  1 NA  0  0
## 
## $`24`
##  [1] NA  2  1 NA  1  0  1 NA  1  1  1  1  1  1  1 NA  0  2  0  0  1 NA NA  0  1
## [26]  0  0  2  1 NA  0  2  1  0 NA  1 NA NA  2  0  0  0  2 NA  0  0  0  2  1 NA
## 
## $`25`
##  [1]  0 NA  1  0  1 NA  2 NA  1  2  0  0  0 NA  1 NA  0  0  1  0 NA  2  0  2  2
## [26] NA NA NA  0  0  0  2  0  1  2 NA NA  0  0  1  2  1  1  0 NA  0  0  0 NA NA
## 
## $`26`
##  [1]  0 NA  0 NA  2 NA NA  0 NA NA  2  0  2 NA  2  1  0 NA  0 NA NA  2  0 NA  0
## [26] NA NA  2 NA  0 NA NA NA  0  1  1  0  2 NA NA NA  1  0 NA NA  0 NA  0 NA NA
## 
## $`27`
##  [1]  1  2  2  0 NA  1  0 NA  0  0  2  0  1  2  1  0 NA  2  0  0  1  0 NA  0  1
## [26]  0  0  2  0  2  2 NA NA  0  1  0  0 NA  2 NA NA  0 NA NA  0 NA  0  0  0  1
## 
## $`28`
##  [1]  1  1  1  1  0  0  0  2  0  1  1 NA  1  0  2 NA  0  1  0  1  0 NA  1 NA  0
## [26] NA  0  2 NA NA NA  1  1 NA NA  1  0  1  0 NA  0 NA  0  0  0  0 NA  0  0  0
##
## $`29`
##  [1]  1  1  1  2  0  0 NA NA  1  1  0  2  0 NA NA  2  2  1  1  2  2  0 NA NA  1
## [26]  1  2  1  0  2  2  2  2  2  2  1  0  0 NA  0 NA  2  0  2  2  0 NA  0  1 NA
##
## $`30`
##  [1] NA NA NA NA  1  0  1 NA  1  1 NA  1 NA  2  2  1  1  1  0  1  2  0  0  0  0
## [26]  0  0 NA  1 NA  1  2 NA  2  1 NA  0 NA  1  0  1 NA  1 NA NA NA  0  0  1  0
##
## $`31`
##  [1] NA  2 NA  2  0  2  2  1  0  2 NA  1  0  1 NA  1  2  0  0 NA NA  1 NA  1  1
## [26]  0  0 NA  2  2  0  1  0  2  0  1 NA NA  1  2 NA NA  0 NA  0 NA  0  1 NA NA
##
## $`32`
##  [1]  1 NA  2 NA  0 NA  2  0  1 NA NA  1  1  0  0  1  0  1  0  2 NA NA  0  0  0
## [26] NA  0 NA  0  0 NA NA  0 NA NA  2  0  2 NA  0  0  0  0 NA NA  0  0 NA  1 NA
##
## $`33`
##  [1]  0  1 NA NA  1  2  1 NA  1  2  2 NA  2  2 NA NA  2 NA  0  1  0  0  0  1  0
## [26]  2  1  0  0  1 NA NA  1  0  0  2  1  0  2  2  0  1  0 NA  0 NA NA  0  0  0
##
## $`34`
##  [1]  0  0  1 NA  1  1  1  2  1  1  1  2  1  0  2  1  2  1  0  1  0  0 NA  2  0
## [26]  2  2  0 NA  2  0  0 NA  0  1  1  2 NA  0 NA  0  1  1  2  0 NA  1  0 NA  0
##
## $`35`
##  [1]  2 NA  0 NA  1  0 NA  2  1  0  0  0  1 NA  0 NA  1 NA  1  0  2  1  0  2 NA
## [26]  0  1 NA  0 NA  0  1 NA  2  0 NA  0  0  0  1  0  1  0 NA  1 NA  0  2  1 NA
##
## $`36`
##  [1]  1  2  0  0  0  2  1  0  2  0  0  1 NA  2  2  0  1 NA  1  0 NA NA  0  2  2
## [26]  1  1  1  2  0  0 NA  0  0 NA  0  0 NA  0  2  1  0  0  1  0  0  0  1 NA  2
##
## $`37`
##  [1]  2  0  0 NA  1  1  1 NA  0 NA  0  1  0  2 NA  2  0 NA  0  1 NA  0  1  0 NA
## [26] NA NA  1  0  1  2  2  0  0 NA  0  0  0  0 NA  1 NA  0  2 NA  2  1  0  2  0
##
## $`38`
##  [1]  2 NA  1  1  1  2 NA  2  1  2 NA  2  1  2  0 NA  2  2  0  1  0  1  0  2  2
## [26]  0 NA NA NA  0  2 NA NA NA  1 NA NA  0  0  1  0 NA NA  0 NA NA  1  0  1  1
##
## $`39`
##  [1] NA  2  0  1  2  2 NA  2  2  2  0  1  0  0  0  2  0 NA  0  0  0  2  0 NA  2
## [26] NA  1  0  1 NA NA  2 NA NA NA  0 NA  1 NA  1 NA  1 NA  2 NA  2  0 NA NA NA
##
## $`40`
##  [1]  0  0  2 NA NA NA  2  1  0  0 NA  1  0  0 NA  2  1  0  1  2 NA  0 NA NA  2
## [26]  1  0  0  0 NA  0  1  0  2  1 NA  0  1  0  0  0  2  0 NA NA  0  2  1  2  0
##
## $`41`
##  [1]  1  1  2  1  2  0  1  1  0  0  0  0 NA  0  1  2  1  2  0  1 NA NA NA  1  0
## [26]  2  0  0  1  0 NA NA  1  2  0 NA NA  2  0  0 NA  0  0  1  0 NA  0 NA  0 NA
##
```

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

- 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()
lapply(split(R, col(R)), function(x){as.list(c(min=min(x,na.rm=TRUE), max=max(x,na.rm = TRUE),
      pct_missing = mean(is.na(x)), first_NA=(which.min(is.na(x)))))})
```

```
## $`1`
## $`1`$min
## [1] 0
##
## $`1`$max
## [1] 2
##
## $`1`$pct_missing
## [1] 0.4
##
## $`1`$first_NA
## [1] 1
##
##
## $`2`
## $`2`$min
## [1] 0
##
## $`2`$max
## [1] 2
##
## $`2`$pct_missing
## [1] 0.36
##
## $`2`$first_NA
## [1] 1
##
##
## $`3`
## $`3`$min
## [1] 0
##
## $`3`$max
## [1] 2
##
## $`3`$pct_missing
## [1] 0.3
##
## $`3`$first_NA
## [1] 1
##
##
## $`4`
## $`4`$min
## [1] 0
##
## $`4`$max
## [1] 2
##
## $`4`$pct_missing
## [1] 0.4
##
## $`4`$first_NA
## [1] 1
##
##
## $`5`
## $`5`$min
## [1] 0
##
## $`5`$max
## [1] 2
```

```
##
## $`5`$pct_missing
## [1] 0.24
##
## $`5`$first_NA
## [1] 1
##
##
## $`6`
## $`6`$min
## [1] 0
##
## $`6`$max
## [1] 2
##
## $`6`$pct_missing
## [1] 0.38
##
## $`6`$first_NA
## [1] 1
##
##
## $`7`
## $`7`$min
## [1] 0
##
## $`7`$max
## [1] 2
##
## $`7`$pct_missing
## [1] 0.36
##
## $`7`$first_NA
## [1] 1
##
##
## $`8`
## $`8`$min
## [1] 0
##
## $`8`$max
## [1] 2
##
## $`8`$pct_missing
## [1] 0.22
##
## $`8`$first_NA
## [1] 2
##
##
## $`9`
## $`9`$min
## [1] 0
##
```

```
## $`9`$max
## [1] 2
##
## $`9`$pct_missing
## [1] 0.2
##
## $`9`$first_NA
## [1] 1
##
##
## $`10`
## $`10`$min
## [1] 0
##
## $`10`$max
## [1] 2
##
## $`10`$pct_missing
## [1] 0.32
##
## $`10`$first_NA
## [1] 2
##
##
## $`11`
## $`11`$min
## [1] 0
##
## $`11`$max
## [1] 2
##
## $`11`$pct_missing
## [1] 0.28
##
## $`11`$first_NA
## [1] 1
##
##
## $`12`
## $`12`$min
## [1] 0
##
## $`12`$max
## [1] 2
##
## $`12`$pct_missing
## [1] 0.36
##
## $`12`$first_NA
## [1] 1
##
##
## $`13`
## $`13`$min
## [1] 0
##
## $`13`$max
## [1] 2
##
## $`13`$pct_missing
## [1] 0.34
##
## $`13`$first_NA
## [1] 1
##
##
## $`14`
## $`14`$min
## [1] 0
##
## $`14`$max
## [1] 2
##
## $`14`$pct_missing
## [1] 0.24
##
## $`14`$first_NA
## [1] 1
##
##
## $`15`
## $`15`$min
## [1] 0
##
## $`15`$max
## [1] 2
##
## $`15`$pct_missing
## [1] 0.36
##
## $`15`$first_NA
## [1] 1
##
##
## $`16`
## $`16`$min
## [1] 0
##
## $`16`$max
## [1] 2
##
## $`16`$pct_missing
## [1] 0.22
##
## $`16`$first_NA
## [1] 1
##
##
```

```
## $`17`
## $`17`$min
## [1] 0
##
## $`17`$max
## [1] 2
##
## $`17`$pct_missing
## [1] 0.32
##
## $`17`$first_NA
## [1] 3
##
##
## $`18`
## $`18`$min
## [1] 0
##
## $`18`$max
## [1] 2
##
## $`18`$pct_missing
## [1] 0.16
##
## $`18`$first_NA
## [1] 1
##
##
## $`19`
## $`19`$min
## [1] 0
##
## $`19`$max
## [1] 2
##
## $`19`$pct_missing
## [1] 0.34
##
## $`19`$first_NA
## [1] 1
##
##
## $`20`
## $`20`$min
## [1] 0
##
## $`20`$max
## [1] 2
##
## $`20`$pct_missing
## [1] 0.3
##
## $`20`$first_NA
## [1] 2
```

```
##
##
## $`21`
## $`21`$min
## [1] 0
##
## $`21`$max
## [1] 2
##
## $`21`$pct_missing
## [1] 0.26
##
## $`21`$first_NA
## [1] 1
##
##
## $`22`
## $`22`$min
## [1] 0
##
## $`22`$max
## [1] 2
##
## $`22`$pct_missing
## [1] 0.36
##
## $`22`$first_NA
## [1] 1
##
##
## $`23`
## $`23`$min
## [1] 0
##
## $`23`$max
## [1] 2
##
## $`23`$pct_missing
## [1] 0.24
##
## $`23`$first_NA
## [1] 1
##
##
## $`24`
## $`24`$min
## [1] 0
##
## $`24`$max
## [1] 2
##
## $`24`$pct_missing
## [1] 0.24
##
```

```
## $‘24‘$first_NA
## [1] 2
##
##
## $‘25‘
## $‘25‘$min
## [1] 0
##
## $‘25‘$max
## [1] 2
##
## $‘25‘$pct_missing
## [1] 0.28
##
## $‘25‘$first_NA
## [1] 1
##
##
## $‘26‘
## $‘26‘$min
## [1] 0
##
## $‘26‘$max
## [1] 2
##
## $‘26‘$pct_missing
## [1] 0.5
##
## $‘26‘$first_NA
## [1] 1
##
##
## $‘27‘
## $‘27‘$min
## [1] 0
##
## $‘27‘$max
## [1] 2
##
## $‘27‘$pct_missing
## [1] 0.24
##
## $‘27‘$first_NA
## [1] 1
##
##
## $‘28‘
## $‘28‘$min
## [1] 0
##
## $‘28‘$max
## [1] 2
##
## $‘28‘$pct_missing
## [1] 0.26
##
## $`28`$first_NA
## [1] 1
##
##
## $`29`
## $`29`$min
## [1] 0
##
## $`29`$max
## [1] 2
##
## $`29`$pct_missing
## [1] 0.2
##
## $`29`$first_NA
## [1] 1
##
##
## $`30`
## $`30`$min
## [1] 0
##
## $`30`$max
## [1] 2
##
## $`30`$pct_missing
## [1] 0.32
##
## $`30`$first_NA
## [1] 5
##
##
## $`31`
## $`31`$min
## [1] 0
##
## $`31`$max
## [1] 2
##
## $`31`$pct_missing
## [1] 0.32
##
## $`31`$first_NA
## [1] 2
##
##
## $`32`
## $`32`$min
## [1] 0
##
## $`32`$max
## [1] 2
```

```
##
## $‘32‘$pct_missing
## [1] 0.36
##
## $‘32‘$first_NA
## [1] 1
##
##
## $‘33‘
## $‘33‘$min
## [1] 0
##
## $‘33‘$max
## [1] 2
##
## $‘33‘$pct_missing
## [1] 0.24
##
## $‘33‘$first_NA
## [1] 1
##
##
## $‘34‘
## $‘34‘$min
## [1] 0
##
## $‘34‘$max
## [1] 2
##
## $‘34‘$pct_missing
## [1] 0.16
##
## $‘34‘$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] 0.16
##
## $`36`$first_NA
## [1] 1
##
##
## $`37`
## $`37`$min
## [1] 0
##
## $`37`$max
## [1] 2
##
## $`37`$pct_missing
## [1] 0.26
##
## $`37`$first_NA
## [1] 1
##
##
## $`38`
## $`38`$min
## [1] 0
##
## $`38`$max
## [1] 2
##
## $`38`$pct_missing
## [1] 0.32
##
## $`38`$first_NA
## [1] 1
##
##
## $`39`
## $`39`$min
## [1] 0
##
## $`39`$max
## [1] 2
##
## $`39`$pct_missing
## [1] 0.36
##
## $`39`$first_NA
## [1] 2
##
##
## $`40`
## $`40`$min
## [1] 0
##
## $`40`$max
## [1] 2
##
## $`40`$pct_missing
## [1] 0.24
##
## $`40`$first_NA
## [1] 1
##
##
## $`41`
## $`41`$min
## [1] 0
##
## $`41`$max
## [1] 2
##
## $`41`$pct_missing
## [1] 0.24
##
## $`41`$first_NA
## [1] 1
##
##
## $`42`
## $`42`$min
## [1] 0
##
## $`42`$max
## [1] 2
##
## $`42`$pct_missing
## [1] 0.44
##
## $`42`$first_NA
## [1] 2
##
##
## $`43`
## $`43`$min
## [1] 0
##
## $`43`$max
## [1] 2
##
## $`43`$pct_missing
## [1] 0.36
##
## $`43`$first_NA
## [1] 1
##
##
```

```
## $‘44‘
## $‘44‘$min
## [1] 0
##
## $‘44‘$max
## [1] 2
##
## $‘44‘$pct_missing
## [1] 0.36
##
## $‘44‘$first_NA
## [1] 2
##
##
## $‘45‘
## $‘45‘$min
## [1] 0
##
## $‘45‘$max
## [1] 2
##
## $‘45‘$pct_missing
## [1] 0.36
##
## $‘45‘$first_NA
## [1] 1
##
##
## $‘46‘
## $‘46‘$min
## [1] 0
##
## $‘46‘$max
## [1] 2
##
## $‘46‘$pct_missing
## [1] 0.28
##
## $‘46‘$first_NA
## [1] 1
##
##
## $‘47‘
## $‘47‘$min
## [1] 0
##
## $‘47‘$max
## [1] 2
##
## $‘47‘$pct_missing
## [1] 0.26
##
## $‘47‘$first_NA
## [1] 1
```

```
##
##
## $`48`
## $`48`$min
## [1] 0
##
## $`48`$max
## [1] 2
##
## $`48`$pct_missing
## [1] 0.38
##
## $`48`$first_NA
## [1] 1
##
##
## $`49`
## $`49`$min
## [1] 0
##
## $`49`$max
## [1] 2
##
## $`49`$pct_missing
## [1] 0.32
##
## $`49`$first_NA
## [1] 1
##
##
## $`50`
## $`50`$min
## [1] 0
##
## $`50`$max
## [1] 2
##
## $`50`$pct_missing
## [1] 0.3
##
## $`50`$first_NA
## [1] 1
```

- 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(4)
v = rnorm(1000,-10,10)
v
```

```
##    [1]  -7.8324513713642 -15.4249257226343  -1.0885535492767  -4.0401942281253
##    [5]   6.3561800111297  -3.1072455808028 -22.8124663010116 -12.1314451927836
##    [9]   8.9653987190927   7.7686321368272  -4.3339550181968  -9.8428054599543
##   [13]  -6.1694266148285 -10.4513711591331  -9.6564809260301  -8.3097322578169
##   [17]   1.6502683902767 -10.4420399725209 -11.0036844258590 -12.8344456887359
##   [21]   5.4081498087098  -8.3483098029008   3.0762236025457   2.8825687792158
##   [25]  -4.0710305935197 -12.8294368432227   2.5588402559985  -0.9016084877138
##   [29] -19.2802810507435   2.4018083800314  -8.4653582044537   0.5193257898961
##   [33] -17.5421121281752 -24.8218911965123  -1.3886812750228 -14.0451983075700
##   [37] -12.2740541727362  -0.6590382913751 -14.6589587979095 -16.3754349857022
##   [41]   3.4370862619937  -8.1846461540206   2.9251233641714 -26.8804857586479
##   [45] -18.2099357763095 -18.6214614409977  -9.0115631086205 -13.7565514419836
##   [49]  -2.7609584471574 -27.9738201857254 -16.6374314157622 -16.2372648872918
##   [53] -10.7963243183816  -5.6437523717059   9.7090096972424 -15.9675867250913
##   [57] -15.5250721160896  -3.0403336629889 -11.5566396460798   3.4889819519773
##   [61] -20.6852307048677   0.6445074680413 -23.1272176453748  10.6369470225190
##   [65]  -8.6861698933732 -12.3168844891494 -13.9735552297346  -1.1056791771863
##   [69]  -4.7383096050327 -11.7127324296262  -8.4132310255675 -14.8566506617243
##   [73] -19.5890607499921  -8.1948270789294  -2.7826571718108 -13.6954047812080
##   [77]  -7.6246168746034 -16.6592211241491 -17.9680750984276 -10.5169693131138
##   [81]   2.8692833329751 -12.1414966273839 -15.7474546430140 -24.7072704429233
##   [85] -20.3273843282250 -23.0652485523967 -18.3825240731914 -21.3065368102478
##   [89]  -6.3125182471698 -12.0180302033088 -22.7765990277316 -17.9801248066858
##   [93]  -8.4091757705400  -3.8520236685655  -3.1205203761359 -10.4705101105624
##   [97]  13.3032167829949 -15.7756599098099  -0.3152086570815 -12.7753562746232
##  [101]  -3.1519806401798 -11.1511350954142 -13.5647517981848 -11.0577160763906
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##  [109] -20.9850750875349 -27.2801975364219  -5.7236177544311  -2.5543535475620
##  [113]  -1.3477920298551  -6.9467118994392 -11.1402279124744  -5.7634775975168
##  [117] -17.9770968680686 -16.0419724936976   7.1501059375090 -17.1594827779811
##  [121] -11.3323561218624 -19.9976506261358   8.7376011706371 -13.3738843202208
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##  [129] -15.9441868168787 -33.8224283134454   0.7801897371074  -3.3175489497738
##  [133] -19.6462566673111 -29.7523733186460 -15.8477390072805  -0.3072296379406
##  [137]  -4.4770767406144 -10.8215550071389 -26.7671375844017   2.1260742701799
##  [141]   0.0049987097878  -2.8067100921154 -18.4436415204234  -3.7801460965259
##  [145] -17.2261378035159 -14.4947862513666 -21.9550605006888  -6.0952763698316
##  [149] -15.1637664263657  -0.9013102206412  -1.2301534704133 -18.1619580987187
##  [153]   5.3929326989720   3.7452571560923 -14.8324871116582  -4.4965004966110
##  [157] -18.5736566300704 -17.0696136617247 -30.9707753342934   0.9943675475969
##  [161]  -6.5796591095044  -5.0917051958284 -19.3199902596906 -24.2789198389777
##  [165]  -0.2423490539247 -25.4634118777066  -9.8229652078095 -17.7471740122194
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##  [173] -15.9476285300720 -32.5793821702836   6.8260721179796  -9.2770931557875
##  [177] -14.4002409317358  -3.7342660741173 -17.9979605943741 -21.2798602223184
##  [181] -20.2501605344749  -9.2892827050230  -6.1828883835384 -26.2258831749572
##  [185]   9.0054266988982 -17.1617916636651  -6.1954033109427  -5.5915715259854
##  [189]  -7.4267414165496 -11.7944853714205 -16.9012767925998 -10.0042280246649
##  [193]  -4.3441910355540 -22.0874700978382 -13.4617115601407 -16.5019704442710
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##  [205] -17.6784172558659   5.2467258054377 -34.2208730728055  -4.4367168247110
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## [293]  -6.9747500614419 -16.6381065083213  -9.3704414130395 -21.8766282431571
## [297] -14.2050339491678 -17.4762044852645 -11.2632725456587 -20.1866709632299
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## [397] -18.5020133605676 -13.3873558236743 -10.5971107572186 -11.5388110220697
## [401] -21.8211600581477  -5.4374065956134 -12.3828725653696  -1.8783626508217
## [405] -17.3065452328998 -31.9428105764677   0.0153984361657   1.6737952151332
## [409]  -2.3035779004986   5.8798765649452  -6.4865030086320 -15.3433804372848
## [413] -12.8487863656193 -10.5272416139710  -9.3555659734279 -15.7866675842086
## [417] -10.1258841763989  -0.9433231983191 -15.1074006250613  -7.8431799524275
## [421] -15.8378925533226 -22.1700913362187  -8.2977888678943  -8.6891375874973
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## [429] -10.2506252490535  -3.3492560907669   3.2289780428138  21.7418674511858
## [433] -28.6854279544613 -23.4813040232776  13.0365435429312  -7.4450979854552
## [437]  -1.3168144933442  -6.4416031315751 -21.4548292550249  -7.0411850795767
## [441] -16.9596706701090   1.8502297739477   5.2519889664303  -5.7915062705065
##  [445]   5.5916136416113   6.2846716797368  -8.2688857218900 -13.3915799715593
##  [449] -22.7719283028053  -9.3957992750705 -21.3435200576579 -10.6336075249717
##  [453] -17.3257619817865   0.7403842006881   4.7886440531740 -35.3300931833164
##  [457] -18.1974022621338  -6.8113484037563 -19.7010061437956 -13.8610363399670
##  [461] -10.3629046850949  -2.1264088179022  -5.7080640682207  -3.4350878263549
##  [465] -17.4849748296863  -9.8812708361802 -16.0678532725572   4.0598619740138
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##  [497] -10.9078939669718 -11.7283157448672 -14.5930618871961 -15.8164463474872
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##  [517] -11.3609646591952 -14.0690300003733   5.5237750179980  -1.3460866437334
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##  [553]   4.9909001048141 -25.0117860832229  16.9071637057071 -10.2356868811362
##  [557] -12.4040637361824 -18.9396004085894  -5.4261176158118 -13.9941156881012
##  [561]   1.6761361055467 -18.7339181054402  -4.3598618343891  -0.5978564313449
##  [565] -19.6762513229627  -4.9140026826806 -22.5042456768426  -8.5004301550492
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##  [577] -18.5986828921236 -18.7185054393606 -18.9984399566452   3.2739583591199
##  [581]  -4.7332867501805  -5.1694086968676  -8.3868922962599 -12.4868547537907
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##  [605] -23.4689498221512 -18.0185588654065   6.0487105720398   0.9881828340171
##  [609] -20.1593272281983  -9.5197603691479  -2.2853750224047  -2.8224966049036
##  [613]  -4.3594699233989 -12.4106082433546 -30.6505997573705   3.2507208519962
##  [617]  -2.5605356812244 -12.8278709034443 -13.9094563934875 -14.0878216671111
##  [621] -14.9866736842019  -1.1810499228554  -4.2176941475141  -9.7115993033335
##  [625]   0.6324817875717 -12.5783508326181 -16.8694716972491 -32.4140190480516
##  [629]  -9.6972483847208  -5.6216110110471 -15.0290816073031  -5.4584938112310
##  [633]  -6.2015109276391 -21.5626307430645   0.3884901768413   1.6248276823550
##  [637] -13.6906593473351  -6.5639290425107  -8.2924433816492  -2.2278994874427
##  [641] -21.6146312122049  -8.0524439462044  -7.4030727868883 -15.0210075576450
##  [645]  -9.5656746383838 -33.3297063736770 -18.0585546342289  -1.7539599630371
##  [649] -25.9506596773344   4.9613066040223  -7.0114054220846  -9.4396555889889
##  [653] -10.7867610085589 -16.3971380603433 -13.3579648249253  -9.4017462033347
##  [657]   3.6242992844398 -14.9298321624731 -21.4196327004069  -4.9757990813144
##  [661]  -7.3193152725863  10.9776495887316  -6.0093519480012   5.9048998367882
##  [665] -11.0727225075469  -2.5952906993653 -10.7864182234495  -6.5878490430398
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##  [673] -14.4061091647045   5.4607580367335   5.0704212775420  -6.1475023613796
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##  [749]  -2.3696740319944  -5.1248037675601 -15.5908964169370  -5.7158482913788
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##  [773]  -9.8379862797419 -34.2334441641971 -24.8936451640858 -15.3444771523084
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##  [917]  -5.0769272347424  -0.4578052269394  13.3324953592890  -9.6899147287520
##  [921]  -6.3220185651772 -21.3781407091996 -10.6891716227111 -23.5505447202784
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##  [929] -13.7057690660742 -25.4217239197298  -3.1159995235159 -23.9374645793441
##  [933]  -0.3165551676830  -7.0573883363347 -12.5267851499196   1.1370681060162
##  [937] -28.5501868163096   5.6986773197559  -9.8254716251416 -24.7921925491897
##  [941]   1.9367943211421 -16.3164838724712   0.6363246149522 -25.3195057292875
##  [945]  -7.4048617955020 -20.7287516688072 -23.1291865295131 -15.8907147495286
##  [949] -19.4293790606179 -27.5705091053286  -8.8593063457873 -12.0135924266856
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##  [957] -15.8339550274643 -24.1795217190653  -1.7797799731564 -27.7689127277641
##  [961]  -8.9697619127024  -6.7472808605543 -14.3750761297236  -4.2929936974001
##  [965]   2.7633156641789 -28.7409706273097   3.9093003758657 -12.9988709265493
##  [969] -14.2966611269457 -33.9705236059324   0.8048689758231 -18.5404309604086
##  [973]  -8.2656425054633 -14.1729109822476 -10.9334121668430 -12.4437343440463
##  [977] -11.6598462514422 -18.9908007303464  -6.6553376648335 -34.4813401499633
##  [981] -19.2968426863836  -2.8959133816087  -1.8152152960080   8.1470526175240
##  [985]  -4.0711960085121 -15.0142424440741  -7.0250882240964 -12.4792811177999
##  [989]  -5.5566738592491 -12.4104563632533  -7.1146461718776  -6.5656741775662
##  [993]  -5.9945210325515  -9.1494835331051 -17.0081857175132  -6.1145031743155
##  [997]   3.1239739250156 -10.7795538869059  -4.0934966717173  -0.4231406937109
```

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

```
set.seed(4)
v= rnorm(1000,-10,10)
v
```

```
##    [1]  -7.8324513713642 -15.4249257226343  -1.0885535492767  -4.0401942281253
##    [5]   6.3561800111297  -3.1072455808028 -22.8124663010116 -12.1314451927836
##    [9]   8.9653987190927   7.7686321368272  -4.3339550181968  -9.8428054599543
##   [13]  -6.1694266148285 -10.4513711591331  -9.6564809260301  -8.3097322578169
##   [17]   1.6502683902767 -10.4420399725209 -11.0036844258590 -12.8344456887359
##   [21]   5.4081498087098  -8.3483098029008   3.0762236025457   2.8825687792158
##   [25]  -4.0710305935197 -12.8294368432227   2.5588402559985  -0.9016084877138
##   [29] -19.2802810507435   2.4018083800314  -8.4653582044537   0.5193257898961
##   [33] -17.5421121281752 -24.8218911965123  -1.3886812750228 -14.0451983075700
##   [37] -12.2740541727362  -0.6590382913751 -14.6589587979095 -16.3754349857022
##   [41]   3.4370862619937  -8.1846461540206   2.9251233641714 -26.8804857586479
##   [45] -18.2099357763095 -18.6214614409977  -9.0115631086205 -13.7565514419836
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##  [61] -20.6852307048677   0.6445074680413 -23.1272176453748  10.6369470225190
##  [65]  -8.6861698933732 -12.3168844891494 -13.9735552297346  -1.1056791771863
##  [69]  -4.7383096050327 -11.7127324296262  -8.4132310255675 -14.8566506617243
##  [73] -19.5890607499921  -8.1948270789294  -2.7826571718108 -13.6954047812080
##  [77]  -7.6246168746034 -16.6592211241491 -17.9680750984276 -10.5169693131138
##  [81]   2.8692833329751 -12.1414966273839 -15.7474546430140 -24.7072704429233
##  [85] -20.3273843282250 -23.0652485523967 -18.3825240731914 -21.3065368102478
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## [133] -19.6462566673111 -29.7523733186460 -15.8477390072805  -0.3072296379406
## [137]  -4.4770767406144 -10.8215550071389 -26.7671375844017   2.1260742701799
## [141]   0.0049987097878  -2.8067100921154 -18.4436415204234  -3.7801460965259
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## [297] -14.2050339491678 -17.4762044852645 -11.2632725456587 -20.1866709632299
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## [405] -17.3065452328998 -31.9428105764677   0.0153984361657   1.6737952151332
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## [429] -10.2506252490535  -3.3492560907669   3.2289780428138  21.7418674511858
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## [477]   3.2532220312781   0.4436245631104 -16.5291202885733 -26.5977631924380
## [481] -25.0997184570513  -6.8711750625666 -28.9767746808896 -16.0520826220955
## [485] -13.5103104512024 -20.1035168642614 -14.4842448803702  -1.3196545472286
## [489]  -9.2088589029926 -16.6656887612782 -11.0740243044352  -5.2480547775397
## [493] -18.3685666638405  -5.7188301635755 -16.4592049199449  -4.2335251565749
## [497] -10.9078939669718 -11.7283157448672 -14.5930618871961 -15.8164463474872
## [501] -26.4468033407132 -18.1997591577837 -26.7823963858272  -5.7583503518595
## [505] -13.4878657771789 -10.5233180570825 -12.7466433073305  -4.8469533690733
## [509] -23.0552003121652   6.9910020663419 -15.0251733861613 -13.0490327312044
## [513] -16.5477715230627  -7.2648639519155 -27.2411675680720 -14.8959652057275
## [517] -11.3609646591952 -14.0690300003733   5.5237750179980  -1.3460866437334
## [521]  -6.5139341316497 -22.5844894042728  -5.2416852845877  -1.2707437069158
## [525] -15.4357582035756  -8.0556068870064  -6.0111271265384  -8.6948516058414
## [529] -15.9459685562073  -2.9826012977119 -11.5393588677302  -4.1400860683759
## [533]   1.6778806383968 -33.0251974787097  -1.7981258592122  -2.7787581137345
## [537]  -9.0235093009070   6.3767856804231 -15.3941249500325 -14.5269093499424
## [541] -22.4223327272307  -9.5575141372945  -9.9304458271081 -19.9358776800566
## [545]  -2.8477513957092  -3.9972108593860 -10.5490333988007  -3.0224968669591
## [549]  -1.8550254441734 -33.2057283924974 -18.8678473334555  -3.6291176492959
## [553]   4.9909001048141 -25.0117860832229  16.9071637057071 -10.2356868811362
## [557] -12.4040637361824 -18.9396004085894  -5.4261176158118 -13.9941156881012
## [561]   1.6761361055467 -18.7339181054402  -4.3598618343891  -0.5978564313449
## [565] -19.6762513229627  -4.9140026826806 -22.5042456768426  -8.5004301550492
## [569]  -6.9474459754861 -12.9725455951932 -18.6531499610403 -19.2754162319005
## [573]  12.1360789868142  -6.5583075712340  -7.2992855788667 -20.9592020511737
## [577] -18.5986828921236 -18.7185054393606 -18.9984399566452   3.2739583591199
## [581]  -4.7332867501805  -5.1694086968676  -8.3868922962599 -12.4868547537907
## [585] -17.9419875597225   8.2774788390367  -1.8172203755742  -2.7458033509954
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## [593]   1.1874744384899  -3.2648103952933 -22.4235554816921 -15.5096625631941
## [597]  -2.4723529509449 -28.1335325399644 -12.8469707585015 -13.6043813599938
## [601] -31.5320420496253 -15.7274229508645  -2.5897587236689 -12.3280048234833
## [605] -23.4689498221512 -18.0185588654065   6.0487105720398   0.9881828340171
## [609] -20.1593272281983  -9.5197603691479  -2.2853750224047  -2.8224966049036
## [613]  -4.3594699233989 -12.4106082433546 -30.6505997573705   3.2507208519962
## [617]  -2.5605356812244 -12.8278709034443 -13.9094563934875 -14.0878216671111
## [621] -14.9866736842019  -1.1810499228554  -4.2176941475141  -9.7115993033335
## [625]   0.6324817875717 -12.5783508326181 -16.8694716972491 -32.4140190480516
## [629]  -9.6972483847208  -5.6216110110471 -15.0290816073031  -5.4584938112310
## [633]  -6.2015109276391 -21.5626307430645   0.3884901768413   1.6248276823550
## [637] -13.6906593473351  -6.5639290425107  -8.2924433816492  -2.2278994874427
## [641] -21.6146312122049  -8.0524439462044  -7.4030727868883 -15.0210075576450
## [645]  -9.5656746383838 -33.3297063736770 -18.0585546342289  -1.7539599630371
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## [653] -10.7867610085589 -16.3971380603433 -13.3579648249253  -9.4017462033347
## [657]   3.6242992844398 -14.9298321624731 -21.4196327004069  -4.9757990813144
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## [665] -11.0727225075469  -2.5952906993653 -10.7864182234495  -6.5878490430398
## [669] -29.7132023322737 -11.2263564784880  -0.8712173875144  -6.2238401378810
## [673] -14.4061091647045   5.4607580367335   5.0704212775420  -6.1475023613796
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## [681] -12.9838290089534  -7.2911811571896  -5.8060304597548 -19.0099211805564
## [685]  -2.5298871370630   3.7139063431264  -2.1729011300732 -35.9865154925708
## [689] -24.4553339458145  -8.9526257305346  -7.9602313603256 -16.2882498411660
## [693] -20.7025410534901 -19.1882533451251 -11.4660634025223  -3.1683107200586
## [697] -19.5424712035564 -12.3411751072823 -16.3109507328654  -5.8616791604997
## [701]  -4.3884495610975 -14.9258053827289  -0.7124080764144 -18.3915561668796
## [705]  -3.6123412692771 -12.0850615288624 -11.8575528236676  -9.8813150244453
##  [709] -27.1371954903924 -13.0990355337389 -16.4731751038445 -16.1163528013476
##  [713]  -7.1263772478557  -6.8069134357277   4.2396090469039 -11.2722988056356
##  [717]  -2.4827475354795 -16.4499281471788 -25.0293866807398 -14.4161855725561
##  [721]   3.4871617483670   1.2484845803875  -3.1836688526914  -8.6212334840080
##  [725] -12.0637678118104 -29.5683471784934  -6.8874876668711   7.3817426876745
##  [729]  -8.8495686802185  14.4921248879251 -15.9978605778972 -10.6967567922988
##  [733]  -2.5702083737158 -15.4028289163649  -8.4545064506726 -16.9433873784498
##  [737] -22.9444602942447 -18.4887327266963   5.1288593628705   0.1319226172932
##  [741]  -0.4326540036761  -5.5172121003544 -20.0054015936977  -4.3256842264073
##  [745]  11.6833000279905 -17.6325570912955  13.8780596207415 -15.6212694873260
##  [749]  -2.3696740319944  -5.1248037675601 -15.5908964169370  -5.7158482913788
##  [753]   0.4114282756590  -0.2528272525421 -18.6360184252421 -15.0480823643408
##  [757]  -2.8027878854884  -7.1447750312279 -15.8440848508680  -4.9102878337849
##  [761] -20.0438734554707 -14.5489886680075 -13.3389527064813  -7.5535995349664
##  [765] -22.0537749115968 -24.5937434748203  -6.2585401292886  -8.3380917951203
##  [769]   3.9699994187868 -20.2043895728416  -7.1101911244553   9.5872411048475
##  [773]  -9.8379862797419 -34.2334441641971 -24.8936451640858 -15.3444771523084
##  [777] -10.8404040084734  -8.3124203420025 -11.9893325528229   2.4779392896803
##  [781]  -5.6723656720850 -10.7648674832874 -11.3949574042239 -12.4122311718515
##  [785] -17.9469837921184  -0.4667287556824 -20.5177175155094 -17.9268279282751
##  [789]  13.9673005507415 -20.9622074989800  -6.6803845219708 -23.8818334568199
##  [793]   2.1429620278557 -20.0623925980068 -15.6570344685048  -9.3471382564776
##  [797] -19.8336706849614 -24.9933101318081 -14.2370989367272 -20.2092657182491
##  [801] -16.2460193728787  -0.0601543263598 -25.1694286676757 -10.1582281637774
##  [805] -21.9966157021347  -7.7654429134648  -4.6813909874470 -12.3538218876171
##  [809] -10.7826443014650 -11.6428904016847  -0.0566278833273  -7.6387006569116
##  [813] -15.3065766089298  -6.9269399577135  -8.8115756920790   6.5304539873687
##  [817] -20.9592885109876 -22.6063329032856 -14.6638625628558 -33.6729396467808
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##  [857]   2.2860162426397 -15.6021962577650 -25.2495802187495  -7.4856075660635
##  [861]   2.3561495240054   7.0327024660864 -20.7549668162323  -4.4504530161323
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##  [873] -13.7146425914469 -25.9545416297070 -22.4024761099425  -7.6035494667451
##  [877]  15.2530217141490  -7.7749993254961 -30.7935758279447   6.6322200943885
##  [881] -28.8246739346890 -11.0196485616338 -10.0339952602044 -14.2967355099696
##  [885]  -8.9130377118630   1.2186391904022 -23.4287404563505  -8.8623831628975
##  [889] -13.6064822154323 -20.5560414864713   3.5431280086188   1.0913625508336
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##  [905] -24.2924102085385  -3.7786196847981 -14.8037623643887 -13.2295302635015
##  [909] -26.6036565205299  -5.0413972289034 -13.9759315219111   2.8673774404700
##  [913]   0.6906423724836  -2.3139972772441  -8.6169585593165 -10.9003367619215
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##  [941]   1.9367943211421 -16.3164838724712   0.6363246149522 -25.3195057292875
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##  [953]  -1.8805246824238  -1.2460143549841   0.2202319947706  -3.5778707197878
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##  [969] -14.2966611269457 -33.9705236059324   0.8048689758231 -18.5404309604086
##  [973]  -8.2656425054633 -14.1729109822476 -10.9334121668430 -12.4437343440463
##  [977] -11.6598462514422 -18.9908007303464  -6.6553376648335 -34.4813401499633
##  [981] -19.2968426863836  -2.8959133816087  -1.8152152960080   8.1470526175240
##  [985]  -4.0711960085121 -15.0142424440741  -7.0250882240964 -12.4792811177999
##  [989]  -5.5566738592491 -12.4104563632533  -7.1146461718776  -6.5656741775662
##  [993]  -5.9945210325515  -9.1494835331051 -17.0081857175132  -6.1145031743155
##  [997]   3.1239739250156 -10.7795538869059  -4.0934966717173  -0.4231406937109
```

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

```
mean(v)
```

```
## [1] -10.344279656
```

```
se = sqrt(var(v)/length(v))
se
```

```
## [1] 0.30652067496
```

- 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(v, 0.05)
  ```

  ```
  ##            5%
  ## -26.528463845
  ```

  ```
  qnorm(0.05, -10,10)
  ```

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

  ```
  #Yes in theory I would expected a similar value because it has to be close to 'v'
  #since both are normally distributed and at the 5%tile; the value had to be around -26.
  ```

- 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?

```
inv_quan_v = ecdf(v)
inv_quan_v(0)
```

```
## [1] 0.854
```

```
pnorm(0,-10,10)
```

```
## [1] 0.84134474607
```

```
#Yes in theory this is appropriate (~84%ile) considering that theoretically,
#v is very accurate in depicting the cdf up until the value of 0.
#Therefore, since 'v' is a good approximation of a normal, then we know that theoretically we expec
#a similar value.
```