Lab 1

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

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

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

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

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

- Sum up the first 103 terms of the series 1 + 1/2 + 1/4 + 1/8 + . . .

```
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/(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?

The answer is not exactly correct because we experienced numerical underflow

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

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

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

- Create the sequence `x = [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.

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

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

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

```
which(y == 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? In the integer data type there is no infinity or no NAN

```
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
```

```
x
```

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

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

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

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

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

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

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

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

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

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

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

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

```
## [1] 0.884
```

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

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

```
## [1] 0.909
```

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

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

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

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

```
?factor
```

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

```
x_3_matrix = matrix(nrow = length(x_3), ncol = 3)
x_3_matrix[ , 1] = as.numeric(x_3 == "infraction")
x_3_matrix[ , 2] = as.numeric(x_3 == "felony")
x_3_matrix[ , 3] = as.numeric(x_3 == "misdimeanor")
colnames(x_3_matrix) = c("is_infraction", "is_felony", "is_misdimeanor")
x_3_matrix
```

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

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

The sum of each row should be either 0 or 1. An individual that has a record of "none" will be captured by a row with the sum of 0.

Verify that.

```
rowSums(x_3_matrix)
```

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

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

The column should sum up to roughly 25 if the sample(c())) function truly has equal probability of assigning criminal levels.

Verify that.

```
colSums(x_3_matrix)
```

```
##  is_infraction      is_felony is_misdimeanor
##             24             25             29
```

- 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"
)

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

```
##                    [,1]           [,2] [,3]            [,4] [,5] [,6]
## Sophia    21.0338007405 -4.00284694973    5 0.0446132500139    3    1
## Emma      14.8465919148  9.75827042479    6 0.1334909744928    1    0
## Olivia    13.7861390762  8.28336256091    7 0.0656357516224    2    0
## Ava       20.1569349163 -9.50797969010    6 0.0266486758235    4    1
## Mia       11.2500347213  9.75628689397    4 0.0790453332770    0    0
## Isabella  12.1317296420  3.64927040879    6 0.1077233785675    1    0
## Riley     10.5914966861  4.52036416158    3 0.0045338264770    2    1
## Aria      13.6078641613  5.00859005842    6 0.0449775161946    3    0
## Zoe       21.6919843122  5.10639288928    4 0.0231308499869    4    0
## Charlotte 13.5853859241 -8.76582714729    3 0.1325783901284    6    1
## Lily      23.8343941779 -8.68912381586    8 0.2117805075221    3    0
## Layla     11.1070035560 -8.00324857235    8 0.0904681045101    3    0
## Amelia    18.8984519445 -9.33218385559    9 0.1267416302275    4    1
## Emily      8.3022316773 -0.15383844264   11 0.0876163071139    2    1
## Madelyn   16.8535564747 -1.11540870275    2 0.0217923224490    3    0
## Aubrey    -1.3257400226 -6.60828856286    5 0.0564887421206    1    1
## Adalyn    10.4883213888  1.76787269302    5 0.2412825104436    1    0
## Madison   23.0814077159 -1.51876500808    4 0.0382478398238    3    1
## Chloe      8.4115186369  5.65372773912   14 0.4751351410769    5    0
## Harper    13.2671268213  8.94944194704    5 0.1405159790643    3    0
## Abigail    7.8566148185  2.45194523130    8 0.1037493564920    3    1
## Aaliyah   13.7319253815  4.79118470568    4 0.0118802070825    4    0
## Avery     22.5742249621 -7.32990298886   12 0.0270842096308    1    0
## Evelyn     9.7682735769  0.41635468602    4 0.0311367161468    1    0
## Kaylee    10.9508727311 -9.98156530317    3 0.0710876639932    2    0
## Ella      15.5331124697 -2.50006929040    4 0.1644300007065    0    0
## Ellie     10.6398205160  4.05042340048    8 0.1238749424570    5    0
## Scarlett  10.8842385040  2.28800474666    4 0.1368354687214    1    0
## Arianna   23.4231488442  3.20224570576    5 0.2774677005882    1    0
## Hailey    13.4669628559 -1.14420713857    6 0.4438590446461    2    0
## Nora       9.7785366579  3.64052575547    5 0.0034513313634    2    0
## Addison   19.1635826250 -9.71308275126    2 0.0894440302786    3    0
## Brooklyn  16.3190742578  1.89013717696    6 0.0200635005589    4    0
## Hannah    17.5286911504 -2.81503128354    7 0.0112110285295    2    0
## Mila      23.5493982376  6.64789864328    7 0.1014856861651    3    0
## Leah      25.7298496566 -0.23971855640    4 0.0581379489452    3    0
## Elizabeth 25.1875617498  7.12194119580    5 0.1886898270818    6    0
## Sarah     18.7679672494  4.41241895314    5 0.0662924767886    0    0
## Eliana    17.0104159311  6.70944635291    4 0.0207683669084    2    0
## Mackenzie 24.3364535842  0.62974540517    4 0.2303258470270    2    0
## Peyton    12.2383029717  5.96279597841    9 0.5927086126560    4    1
## Maria     30.0061121543  5.22850914858    9 0.1260647087142    3    0
## Grace     19.3979646918  2.77291605715    6 0.0129179966946    3    0
## Adeline   11.5567107537 -4.78049070109    8 0.2408627908052    2    0
## Elena     15.1594431006  2.32559158467    8 0.2431657012926    2    1
## Anna      18.3279612812 -4.03786812909   11 0.1412802571384    2    0
## Victoria  16.8682588318 -7.60930346325   12 0.2403604245294    1    1
## Camilla   19.7721607171 -4.43769809324    7 0.0118858338748    5    0
## Lillian    5.1299120932 -0.85050702561    4 0.0363479952406    0    0
## Natalie   14.2016978955  6.85560448561    9 0.0462932187902    2    0
## Jackson   14.1961932039 -6.24204883818    4 0.0724643292423    1    0
## Aiden     16.9963088440  7.18084688764    7 0.0512846562908    5    1
## Lucas     11.1627617106  8.57106121723    4 0.1242409926896    2    0
## Liam      17.4541076260  5.49823297188    2 0.0112134871177    2    0
## Noah      15.4040682064 -9.31023423094    4 0.0964618575609    3    0
## Ethan      9.0394726337  2.33853303362   10 0.1611254411760    1    0
## Mason     15.2406054301 -7.22366711590    7 0.3505215079165    2    0
## Caden     24.5502718241  3.47088538110   10 0.0145783722918    3    0
## Oliver    16.9528903150 -4.48851423804    3 0.1414334617715    4    0
## Elijah    16.1825823686  0.64962655306    5 0.0841834029757    1    0
## Grayson   11.6733727829  7.50769569073    4 0.0569606186926    0    0
## Jacob     23.2539926686  9.29826793261   11 0.2308309732119    2    0
## Michael   18.7859850904  6.02505883202   11 0.0549111100328    3    1
## Benjamin   8.8413719668 -6.77348078229    9 0.1005795492434    2    1
## Carter    13.2587125209  2.46083064470    6 0.0602773531444    1    0
## James     14.8374857672  4.10757062025    8 0.0506852138270    1    1
## Jayden    13.9411374916 -1.53344968334   11 0.0269026220259    2    0
## Logan      8.0426297529  3.80718810018    9 0.0723280944965    0    0
## Alexander  9.0697044387  0.32815725077    4 0.0271896600234    2    1
## Caleb      9.9099562623 -4.89958856720    4 0.2473909095896    2    0
## Ryan      17.8064887312  9.71996294800    6 0.0866623605658    1    0
## Luke      14.4737747121 -8.87365504634    7 0.0137357362546    5    0
## Daniel    21.8927288163 -8.54193090461    8 0.0133758923039    2    0
## Jack      12.0683054794 -4.94881659281    6 0.0510282159473    0    0
## William    6.6967077631  1.95695393719    3 0.0789476258427    2    1
## Owen      16.7547627854 -1.37131532654    4 0.1176745288234    3    0
## Gabriel   21.6437234533  8.83663245477    4 0.0341459147425    1    0
## Matthew    8.0040404906 -8.34140213672    4 0.0335829788302    3    0
## Connor    12.2131529597 -1.43550199457    3 0.0532010394252    0    0
## Jayce     24.7237535538 -8.69726166129    4 0.0343709282267    3    0
## Isaac     15.7051445327 -8.88600753620    3 0.0986771175798    3    0
## Sebastian 18.0149819574  9.54685135279    7 0.0145477665485    1    0
## Henry     16.6867439604 -5.19735625014    7 0.1151834077466    3    0
## Muhammad  13.7606631170  3.55915428139    7 0.4226328488206    2    1
## Cameron   24.9457216766 -6.90430133138    7 0.0044845556423    1    0
## Wyatt     14.6398604695 -7.16087991372    6 0.1778783733963    2    1
## Dylan     20.5334694191  0.77375824098    9 0.0108096177675    2    0
## Nathan    18.1662452272  0.21414410323   10 0.3438211495596    3    0
## Nicholas  11.0527580597 -5.25207844097    4 0.1362163360287    5    0
## Julian    13.4982174682 -2.23285576794    3 0.0566994360545    2    0
## Eli       10.3398095501  8.23295261245    9 0.0798137278429    0    1
## Levi      21.3716446358 -0.74553988408    4 0.0402732752264    1    0
## Isaiah    15.1393616084 -6.25549208838   11 0.3382187535179    2    0
## Landon    19.3408406575 -5.32363748178    4 0.1987676125754    3    1
## David     18.7006359149  7.16443934944    8 0.1694094184693    1    1
## Christian 11.9644723291  5.05099453032    4 0.0615463598838    1    0
## Andrew    19.3663775583  7.55499009974    9 0.0438315844577    3    0
## Brayden   23.8107161103  3.99710392114    8 0.0398135119532    1    0
## John      24.1305684010  4.64877506718   10 0.0418418229351    4    0
## Lincoln   19.0891993586  1.04692106601    8 0.0776670898989    1    1
```

- 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.

```r
df = data.frame(X)
df$X6 = factor(df$X6, levels = c(0,1), labels = c("DOMESTIC", "FOREIGN"))
View(df,"Lab 01 df")
```

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

```r
table(df$X6)
```

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

```r
table(df$X6)/n
```

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

Print out a summary of the whole dataframe.

```r
summary(df)
```

```
##        X1                  X2                    X3
##  Min.   :-1.325740   Min.   :-9.98156530   Min.   : 2.00
##  1st Qu.:11.644207   1st Qu.:-5.01095151   1st Qu.: 4.00
##  Median :15.322337   Median : 0.71169240   Median : 6.00
##  Mean   :15.797880   Mean   : 0.23622887   Mean   : 6.31
##  3rd Qu.:19.347225   3rd Qu.: 5.01919118   3rd Qu.: 8.00
##  Max.   :30.006112   Max.   : 9.75827042   Max.   :14.00
##        X4                     X5              X6
##  Min.   :0.0034513314   Min.   :0.00   DOMESTIC:76
##  1st Qu.:0.0358537285   1st Qu.:1.00   FOREIGN :24
##  Median :0.0750657096   Median :2.00
##  Mean   :0.1105003253   Mean   :2.25
##  3rd Qu.:0.1377555963   3rd Qu.:3.00
##  Max.   :0.5927086127   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(nrow=n, ncol=n, sample(c(rep(0, n*n*0.5), rep(1, n*n*0.25), rep(2, n*n*0.25))))
df <- data.frame(R)
df
```

```
##    X1 X2 X3 X4 X5 X6 X7 X8 X9 X10 X11 X12 X13 X14 X15 X16 X17 X18 X19 X20 X21
## 1   1  0  0  2  0  2  2  0  2   1   1   0   1   0   0   1   0   0   1   1   2
## 2   0  1  0  1  0  2  1  0  0   1   1   2   2   0   0   1   0   0   0   0   0
## 3   1  2  0  0  1  1  1  0  0   2   0   1   0   0   0   1   2   1   0   0   0
## 4   2  0  0  0  2  0  0  1  0   0   0   2   0   2   2   0   0   0   0   0   1
## 5   1  1  0  0  0  1  1  2  1   0   1   1   0   0   1   2   0   0   0   1   2
## 6   2  0  0  2  0  1  0  0  1   1   0   1   2   2   1   2   0   2   0   0   0
## 7   2  1  0  0  2  2  0  0  2   2   0   1   1   1   0   1   0   2   1   1   0
## 8   1  0  0  2  2  2  2  0  0   0   0   0   2   2   1   1   0   0   2   1   1
## 9   0  0  0  2  2  0  2  0  1   0   0   1   0   0   0   1   2   0   2   1   2
## 10  0  1  2  0  1  0  0  0  2   0   1   0   0   0   0   0   0   1   0   2   0
## 11  2  0  0  0  1  1  0  1  0   1   0   0   1   0   0   0   0   0   1   1   1
## 12  1  0  2  0  0  0  1  0  1   0   1   0   1   2   2   0   1   2   1   0   2
## 13  0  1  0  1  2  1  0  0  0   0   0   2   2   1   2   0   0   1   1   0   2
## 14  0  1  2  0  0  2  0  1  2   2   0   0   1   0   0   0   2   0   1   0   0
## 15  1  2  0  1  0  1  2  1  1   0   0   0   0   2   2   2   1   2   2   1   0
## 16  1  0  2  0  1  1  0  2  0   1   0   0   1   0   2   2   2   1   0   0   2
## 17  1  2  0  0  1  0  1  0  2   0   0   0   2   0   1   2   0   1   2   2   0
## 18  2  2  0  1  2  0  0  2  0   0   0   0   1   1   2   0   1   1   1   2   0
## 19  1  1  1  0  2  0  2  0  0   2   0   2   2   0   2   1   0   2   0   0   1
## 20  2  2  0  1  0  2  0  2  0   1   1   1   0   0   0   1   2   1   0   1   1
## 21  2  1  1  2  0  0  0  2  2   1   2   0   0   1   0   2   0   2   1   0   0
## 22  1  0  1  0  0  1  2  2  2   1   0   1   0   2   0   2   2   1   1   0   0
## 23  1  2  2  0  0  1  1  0  1   2   0   0   0   2   2   2   0   2   1   2   2
## 24  0  2  0  0  0  0  0  0  2   1   1   0   1   1   1   1   0   0   2   0   1
## 25  1  0  2  0  2  1  1  2  0   0   2   2   0   2   1   1   0   1   1   2   0
## 26  2  2  0  0  0  2  0  1  0   1   2   0   0   2   1   2   0   0   1   1   1
## 27  0  1  0  0  2  1  2  0  0   1   2   0   1   2   0   1   0   1   2   1   0
## 28  2  2  0  0  1  0  2  1  0   2   0   0   0   0   0   0   1   0   0   0   1
## 29  0  0  0  0  0  0  0  1  2   0   0   2   0   0   0   2   2   2   0   0   0
## 30  2  2  1  0  2  1  1  0  0   1   0   0   0   0   0   1   0   0   1   1   1
## 31  0  0  0  1  2  0  0  1  0   0   1   0   0   1   0   2   1   1   0   0   0
## 32  0  0  2  2  0  1  1  0  2   1   1   1   2   0   1   1   1   0   1   0   1
## 33  1  2  1  0  1  0  2  1  1   2   1   1   0   0   1   0   2   0   0   0   0
## 34  2  0  0  2  2  0  0  1  2   0   0   2   1   0   0   1   0   2   0   0   0
## 35  0  2  1  2  0  1  0  2  0   0   2   0   0   1   0   1   2   0   0   0   2
## 36  0  0  0  0  1  2  0  2  1   0   0   0   2   0   2   1   2   0   0   0   2
## 37  0  2  2  0  0  0  0  1  0   2   1   0   0   0   2   1   0   1   2   2   2
## 38  2  2  0  0  2  1  0  2  1   2   2   0   2   1   2   0   0   0   0   2   1
## 39  0  0  0  1  0  0  2  0  1   1   0   1   1   0   0   2   0   0   1   2   1
## 40  0  2  0  0  2  0  0  2  0   0   0   0   0   1   0   0   0   0   0   0   0
## 41  1  0  0  2  0  0  0  0  1   0   0   2   0   2   0   2   0   1   0   0   0
## 42  2  0  0  0  0  0  0  0  0   0   0   1   1   0   2   2   2   0   0   0   1
## 43  2  2  1  2  1  2  1  0  0   0   2   2   0   2   0   0   0   2   0   1   0
## 44  1  0  1  1  0  0  2  1  0   0   1   0   0   0   0   2   0   1   2   2   0
## 45  0  0  0  0  0  0  2  2  2   1   1   1   2   0   1   2   2   2   1   0   0
## 46  1  0  0  2  0  0  0  0  0   0   0   0   2   0   0   0   2   0   1   1   0
## 47  2  0  0  0  2  1  1  0  1   0   1   0   0   0   0   1   0   0   2   2   0
## 48  0  0  0  0  2  2  2  1  1   1   2   0   0   0   1   2   1   2   0   2   2
## 49  0  0  0  2  0  0  0  1  1   0   0   0   2   0   0   1   0   2   1   1   0
## 50  1  2  0  2  1  1  2  1  0   0   0   0   2   2   0   2   0   0   0   0   0
##    X22 X23 X24 X25 X26 X27 X28 X29 X30 X31 X32 X33 X34 X35 X36 X37 X38 X39 X40
## 1    2   2   2   2   0   0   0   2   0   0   0   0   0   2   0   0   2   2   1
## 2    0   0   2   0   0   1   0   2   1   0   0   2   0   0   0   2   0   1   1
## 3    0   2   1   1   0   1   0   0   0   0   2   2   0   2   0   1   0   0   0
## 4    0   1   0   2   0   2   2   2   1   2   0   0   2   2   1   2   2   0   0
## 5    0   0   0   0   0   2   1   1   1   0   1   0   0   0   0   1   0   0   0
## 6    2   0   2   0   0   1   2   0   1   1   2   2   1   2   0   0   0   2   0
## 7    0   2   0   2   0   2   2   2   0   0   0   0   2   0   0   1   2   0   0
## 8    1   0   2   0   0   0   0   1   0   2   0   0   0   2   2   1   1   2   0
## 9    1   2   0   0   0   0   2   1   1   0   0   0   0   0   0   1   0   2   0
## 10   2   2   0   0   1   0   0   1   1   0   0   2   0   2   0   0   0   1   2
## 11   0   2   2   0   2   0   1   0   1   2   0   0   1   2   1   0   1   0   2
## 12   1   0   2   0   1   0   2   0   2   2   2   0   0   2   0   2   0   2   1
## 13   2   0   0   0   0   1   2   0   0   0   1   2   0   2   1   1   1   0   0
## 14   2   1   0   1   1   1   2   0   2   0   0   2   1   1   0   0   2   1   2
## 15   1   2   1   0   0   0   0   0   1   0   1   1   2   1   1   1   2   1   1
## 16   2   0   0   1   0   0   0   2   2   2   1   0   0   0   2   0   0   0   0
## 17   1   0   2   0   2   1   2   1   2   0   0   0   0   2   2   2   2   0   2
## 18   0   0   2   0   0   0   2   2   1   2   0   2   1   1   2   0   0   0   0
## 19   0   0   2   1   0   0   0   1   0   2   0   0   0   2   1   2   0   2   0
## 20   0   0   0   2   2   0   2   0   1   0   2   0   2   1   0   0   0   0   2
## 21   2   0   1   1   2   0   0   1   0   1   2   0   0   2   2   2   0   0   0
## 22   0   1   0   1   0   0   0   2   1   0   0   2   1   0   2   0   0   2   0
## 23   2   1   0   2   0   1   0   0   0   1   2   2   1   2   0   0   1   0   0
## 24   0   0   2   1   0   0   2   0   0   1   1   2   2   1   1   0   1   0   0
## 25   2   0   0   1   0   0   1   0   0   0   0   0   0   1   2   0   0   2   0
## 26   1   2   1   1   0   0   2   1   0   0   2   0   2   2   2   1   1   1   0
## 27   0   0   0   0   0   0   1   0   0   0   1   1   0   0   1   0   2   2   0
## 28   0   0   0   0   0   1   2   0   0   2   1   0   0   1   0   1   1   2   2
## 29   0   2   2   2   0   2   1   1   1   1   0   0   0   0   1   0   0   2   1
## 30   1   1   2   0   0   0   1   0   2   0   1   1   1   2   0   0   1   1   0
## 31   0   2   0   1   0   0   1   0   0   2   0   1   0   0   1   2   0   1   2
## 32   0   0   2   1   1   0   0   2   0   1   0   2   0   0   2   1   0   0   1
## 33   1   0   0   1   0   0   0   2   0   0   0   0   2   0   1   2   0   1   1
## 34   2   1   2   2   0   2   0   0   2   2   0   0   0   2   0   0   1   0   2
## 35   0   0   0   1   0   0   0   0   1   0   2   0   2   0   1   2   0   1   0
## 36   2   0   2   1   2   0   1   0   0   1   0   0   2   0   1   1   2   0   2
## 37   0   0   0   0   2   0   2   2   1   2   2   0   0   0   1   0   0   0   2
## 38   1   0   1   1   0   1   2   2   0   1   1   0   2   0   0   0   2   1   0
## 39   1   0   0   0   2   0   2   0   0   1   0   0   2   2   1   0   0   0   2
## 40   0   2   2   0   0   2   1   0   0   2   2   2   1   1   0   2   2   0   2
## 41   1   0   2   0   2   1   0   1   0   1   0   1   1   1   0   0   1   0   1
## 42   1   2   0   2   0   0   1   2   0   1   2   2   0   0   0   1   0   2   2
## 43   1   0   0   2   1   1   1   2   2   0   0   0   0   2   1   1   2   1   1
## 44   0   0   0   2   0   2   1   0   0   1   0   0   0   2   0   1   0   1   1
## 45   2   0   0   2   0   0   0   2   0   0   0   0   2   2   0   2   2   1   2
## 46   0   2   2   0   0   2   2   1   2   0   1   2   0   2   0   1   2   2   0
## 47   0   0   1   1   0   0   0   0   0   1   0   0   0   1   1   2   0   0   2
## 48   1   0   2   0   0   2   2   1   0   1   2   0   0   2   0   1   0   0   1
## 49   0   0   0   0   2   2   2   0   0   1   0   2   0   1   2   0   0   1   2
## 50   0   0   1   0   1   0   1   1   1   0   1   2   0   0   0   1   1   2   0
##    X41 X42 X43 X44 X45 X46 X47 X48 X49 X50
## 1    1   1   0   0   0   0   0   0   0   1
## 2    1   2   2   0   2   1   0   2   1   2
## 3    0   2   1   0   2   2   2   0   0   0
## 4    1   0   0   0   0   2   0   0   0   1
## 5    0   0   2   1   0   2   2   0   0   1
## 6    2   0   0   0   0   1   0   0   1   0
## 7    0   0   2   0   1   1   0   0   0   2
## 8    0   2   1   1   0   1   0   1   0   1
## 9    2   0   1   0   0   0   0   2   2   0
## 10   0   1   1   0   0   0   1   2   1   1
## 11   2   1   0   2   0   0   1   0   0   0
## 12   1   0   0   0   0   2   1   0   0   0
## 13   2   2   1   2   0   0   2   0   2   0
## 14   1   1   1   0   1   0   1   0   0   0
## 15   0   2   2   2   0   0   1   2   2   0
## 16   2   0   0   0   0   0   0   1   0   0
## 17   1   1   2   1   1   0   0   0   0   1
## 18   1   0   2   2   0   1   0   2   2   0
## 19   0   1   1   1   1   1   1   0   0   0
## 20   0   1   1   2   2   0   0   2   0   1
## 21   0   0   0   0   2   0   0   2   1   0
## 22   0   2   0   1   0   2   0   2   0   1
## 23   0   0   0   2   1   1   0   0   0   0
## 24   0   2   0   2   2   0   2   1   1   0
## 25   2   1   0   0   2   0   0   0   0   0
## 26   0   1   1   0   0   0   0   0   0   0
## 27   0   1   2   1   2   2   0   1   1   1
## 28   0   2   0   0   1   0   0   0   1   1
## 29   2   0   2   0   0   0   0   2   0   2
## 30   1   0   2   1   2   0   1   1   2   0
## 31   2   1   1   0   2   1   2   1   1   0
## 32   2   2   1   0   1   0   1   1   1   0
## 33   0   0   0   0   2   2   0   0   0   1
## 34   0   1   1   2   0   2   1   1   0   0
## 35   1   0   2   1   0   0   1   0   1   0
## 36   0   1   0   1   0   0   2   2   0   0
## 37   2   2   0   1   1   0   1   0   0   2
## 38   1   1   1   1   0   0   1   0   1   2
## 39   0   2   1   1   0   2   0   2   2   1
## 40   0   2   0   0   1   2   2   2   0   2
## 41   1   0   0   1   2   2   1   2   1   0
## 42   0   0   0   1   2   2   0   0   0   0
## 43   0   1   2   2   0   0   2   2   0   1
## 44   1   0   0   0   1   1   2   1   0   2
## 45   0   2   1   0   1   1   0   2   0   0
## 46   1   0   1   2   0   0   2   1   0   0
## 47   0   1   2   0   0   0   0   2   2   0
## 48   1   1   0   0   0   0   2   0   0   2
## 49   0   1   1   2   0   1   0   2   0   2
## 50   2   0   1   0   0   0   0   0   1   1
```

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

```r
n <- 50
R <- matrix(nrow=n, ncol=n, sample(c(rep(0, n*n*0.5), rep(1, n*n*0.25), rep(2, n*n*0.25))))
random_holes = matrix(nrow=n, ncol=n, sample(c(rep(0, n*n*0.7), rep(3, n*n*0.3))))
for(i in 1:n){
  for(j in 1:n){
    if(random_holes[i,j] == 3){
      R[i, j] = NA
    }
  }
}
R
```

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

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

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

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

- 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.

```
matrix(c(apply(X, 1, sd, na.rm = TRUE), apply(X, 2, sd, na.rm = TRUE)), nrow = 50, ncol = 2)
```

```
## Warning in matrix(c(apply(X, 1, sd, na.rm = TRUE), apply(X, 2, sd, na.rm =
## TRUE)), : data length [106] is not a sub-multiple or multiple of the number of
## rows [50]
```

```
##               [,1]          [,2]
##  [1,]  8.7192088504  6.7707937089
##  [2,]  6.0790751680  6.0736959232
##  [3,]  5.4792317702  4.6183517320
##  [4,]  9.7097797339  6.6588941488
##  [5,]  5.1551021496  7.9997220736
##  [6,]  4.6945081300  4.5505609573
##  [7,]  3.8025384702  7.5803541126
##  [8,]  5.0544270385  9.4139028969
##  [9,]  8.0811929352  7.3280642134
## [10,]  7.3506318867  6.3368483348
## [11,] 10.9621322233  4.8710444850
## [12,]  6.7356717854  8.9767551542
## [13,]  9.4730926305  7.1461204841
## [14,]  4.7445064440  5.9431039464
## [15,]  6.7299003243  5.1452128182
## [16,]  3.8026808776  5.7078925028
## [17,]  4.0536988036  6.5404552520
## [18,]  9.1106974339  4.1767876193
## [19,]  5.2240055732  3.4177257475
## [20,]  5.2256446671  4.9224292521
## [21,]  3.4067754138  7.0551865615
## [22,]  5.0233537613  7.8806613083
## [23,] 10.7248475616 10.2885914286
## [24,]  3.8472563057  5.9536033890
## [25,]  6.7301894592  2.3024696905
## [26,]  6.5461864631  6.6818113397
## [27,]  4.2353162972  8.4062440767
## [28,]  4.1194646146  5.4985734800
## [29,]  8.9949120094  5.0664094521
## [30,]  5.4952693827 11.1648881100
## [31,]  3.6975678740  7.9474622153
## [32,]  9.3740053446  7.1377261864
## [33,]  6.1493069283  7.5588396950
## [34,]  7.4076711198  5.0582234600
## [35,]  8.7876470154 11.0172007933
## [36,] 10.1046626730  7.2165577878
## [37,]  9.2824794252  8.1626743510
## [38,]  7.2626618763  7.3680248087
## [39,]  6.4335656249  5.5422233825
## [40,]  9.4921940774  5.5819194053
## [41,]  4.5704120149  4.8963494488
## [42,] 11.3479590259  8.5382763981
## [43,]  7.3061441789  7.8885018675
## [44,]  5.9364156119  8.3209436436
## [45,]  5.7745066974  7.0803624197
## [46,]  8.3883863686  4.5701753365
## [47,]  8.9046181414  7.3360559478
## [48,]  8.4852167452  9.1829981698
## [49,]  2.5105931555  9.1026172803
## [50,]  5.6906274516  7.4746787943
```

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

```r
apply(X, 2, function(v){sum((v == 1 | v == 2), na.rm = TRUE)})
```

```
## [1]  0  0  3  0 51 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.

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

```
## $`1`
##  [1] NA NA  1 NA NA  1  0 NA  0  2  2  0 NA  0 NA NA  0  1  0  1  1  1  2  0  0
## [26] NA  0  1  0  1  2  0  1 NA  1  0  0  2 NA NA NA  0  0  1  1  0  2  0 NA  2
## 
## $`2`
##  [1] NA  2 NA  0  1  0  0  0  2  2 NA  2 NA NA NA  2  0 NA NA NA  1 NA NA NA  0
## [26]  1  0  0  2  2  0  2 NA  2  1  1  0  0  1  2  0 NA NA  2  0 NA  0  0  1 NA
## 
## $`3`
##  [1]  2  2 NA  2  0  1  0  0  1 NA NA NA  0  1  2 NA  0  0  1  1  2 NA  1  0  0
## [26]  1  1  1  0 NA NA  1  0  0  2  0  0  1 NA NA  0 NA  2 NA  1  1  0 NA  0 NA
## 
## $`4`
##  [1]  1 NA NA  2 NA NA  0  1  1  0  2  2 NA  1  0  0 NA  0 NA NA  0  0  1  1 NA
## [26] NA  0 NA NA  0  2  1 NA NA NA  2  0 NA  1 NA  1  0 NA  2  0  2  1  1  1  2
## 
## $`5`
##  [1] NA  0  2 NA NA  1  0  2  0  0  0  1 NA  0 NA  2  1 NA  2  1  0  1  1 NA  0
## [26]  0  2  0  0  0  1  1  1  2  2  0  0  0  0 NA NA  0 NA  0  0  1  0  1  0 NA
## 
## $`6`
##  [1] NA  0  0  2 NA  2 NA  1  0  1 NA  0 NA  0  1 NA  1 NA NA  0 NA NA NA NA  2
## [26]  1 NA  0  0  2  1 NA  0 NA  2  0  1  2  0 NA NA NA  0 NA NA  0 NA  2  1 NA
## 
## $`7`
##  [1]  0  0  2 NA  0 NA NA  2  1  2 NA  1 NA  0  0 NA  2  1  0  2  1  1  1 NA NA
## [26]  0 NA  2  0  2  0  1  0  2  0  0  0  1  0  0  2  0  1  0  0  0  1 NA NA  0
## 
## $`8`
##  [1]  2  1  2 NA NA  0  0  1  0  1  2  2  0  0  2 NA  2  0 NA  2  2  1  2  0  0
## [26]  2  2 NA  2  0  0  1  0 NA  0  0 NA  1 NA  0  1  2  1  1  0 NA  0 NA  1 NA
##
## $`9`
##  [1] NA NA NA  2  2  0  1  1  0 NA  0  2 NA  1 NA  0  1  0 NA  0  0  0  2  0  1
## [26]  2  1 NA  0  1  2 NA  1  0 NA NA  0 NA  0 NA  0  1  2  0 NA  2 NA  0  0  1
##
## $`10`
##  [1]  0  2 NA  1  0 NA NA  1  2  2 NA  0 NA  0 NA NA  1  1  0 NA  1 NA  0  0 NA
## [26]  1 NA  0  1  2  0  0 NA  0  1  0  2  0  1 NA  2  0 NA NA  0  2  2  1  2 NA
##
## $`11`
##  [1]  1  0  1  1  0  0  2  1  2  1  1  1  1 NA NA  0  0  0  1 NA NA  0  0  0  0
## [26] NA NA  1  0  0  0  2  0 NA  0  1  0  2  0  0  0  2  0  0  1 NA  1 NA  0  0
##
## $`12`
##  [1]  2  0 NA  1  2 NA  0 NA NA  0  0 NA  0  1  0  2  2  0 NA  1  0  1  2  0  0
## [26] NA NA NA  1  0  0  0  0 NA  0  1  2  1  2  0  0 NA NA  0  0  0  1 NA  0 NA
##
## $`13`
##  [1]  2  0  1  0 NA NA  1  2 NA  1 NA  2 NA  1  0 NA  0  2 NA  0  0  0  2 NA NA
## [26]  0  2  0  2 NA  1  2  1  2  0  0  0  1  2 NA  0  1  1 NA  0  2  1 NA NA  0
##
## $`14`
##  [1] NA NA  2  0  1 NA  1  0 NA NA NA  2 NA  0 NA  0  0  0  0  2 NA  0 NA  1  0
## [26]  2  2  2  0  1  1 NA NA  0  2  2  0 NA  0 NA  0 NA  0 NA  1  0 NA NA NA NA
##
## $`15`
##  [1]  0  2  1  0 NA NA NA  0  0  0 NA NA  0  1 NA NA  1 NA  0  2  0  0  0  2  1
## [26]  0 NA NA NA  0  2 NA  2  0  0  0 NA  0  0 NA  0  1  0  1  0 NA  0 NA  0  2
##
## $`16`
##  [1] NA  0 NA  1  1  1 NA  0  1  0 NA  0 NA  0 NA  1  0  0  0  0  1 NA NA NA NA
## [26] NA  1  0  2  0  0  0  0  0  0  0  2  2 NA  0 NA  0  0 NA  2  2  0  0  2 NA
##
## $`17`
##  [1] NA NA  0  0  0  1  1  0  0  0  1  1  2 NA  2  0  0  0  0 NA  2  1  1 NA  0
## [26]  1  0 NA  2  2  2  0  0  0  0  0  1  0 NA  1  0  0 NA  1 NA  0  0  2 NA  0
##
## $`18`
##  [1]  0 NA  1  2  2  1  0 NA  1 NA  0  1  1  0  0 NA  0  0  0  2  1  0 NA  0  1
## [26]  2  2  0  0 NA  2 NA  0 NA  2  2  1  0  0  2  0 NA  0  0 NA NA  0  0 NA  0
##
## $`19`
##  [1]  0  1  2 NA  2  0 NA  2  0 NA  1 NA  2 NA  0  0 NA NA  2  2  0  2  1 NA  0
## [26] NA  0  0 NA NA NA  0  0  2  0 NA  2  0  1  0 NA  1  0  1  0  0  2  0  1 NA
##
## $`20`
##  [1]  0 NA  0 NA  0  1 NA  0  2 NA  0  0  0  0  2  1  2 NA  0  1  1 NA  1  0 NA
## [26]  0  0 NA  0  1 NA  2  1 NA  1  2 NA  0  0  0  2  0 NA NA  0  1 NA  1  2  2
##
## $`21`
##  [1] NA  1 NA  0  2  0 NA NA  0  0 NA  1  1 NA  0  2 NA  0 NA  0  0  1 NA  0  0
## [26]  2 NA  1 NA NA  0  0  2  0  0 NA  0  1  0 NA  1  0 NA NA NA  0  1  2 NA  1
##
```

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

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

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

```
lapply(split(R, col(R)), function(R) {list(min = min(R, na.rm = T), max = max(R, na.rm = T), pct_missin
```

```
## $`1`
## $`1`$min
## [1] 0
##
## $`1`$max
## [1] 2
##
## $`1`$pct_missing
## [1] 0.28
##
## $`1`$first_NA
## [1] 1
##
##
## $`2`
## $`2`$min
## [1] 0
##
## $`2`$max
## [1] 2
##
## $`2`$pct_missing
## [1] 0.34
##
## $`2`$first_NA
## [1] 1
##
##
## $`3`
## $`3`$min
## [1] 0
##
## $`3`$max
## [1] 2
##
## $`3`$pct_missing
## [1] 0.28
##
## $`3`$first_NA
## [1] 3
```

```
##
##
## $`4`
## $`4`$min
## [1] 0
##
## $`4`$max
## [1] 2
##
## $`4`$pct_missing
## [1] 0.36
##
## $`4`$first_NA
## [1] 2
##
##
## $`5`
## $`5`$min
## [1] 0
##
## $`5`$max
## [1] 2
##
## $`5`$pct_missing
## [1] 0.22
##
## $`5`$first_NA
## [1] 1
##
##
## $`6`
## $`6`$min
## [1] 0
##
## $`6`$max
## [1] 2
##
## $`6`$pct_missing
## [1] 0.44
##
## $`6`$first_NA
## [1] 1
##
##
## $`7`
## $`7`$min
## [1] 0
##
## $`7`$max
## [1] 2
##
## $`7`$pct_missing
## [1] 0.22
##
```

```
## $`7`$first_NA
## [1] 4
##
##
## $`8`
## $`8`$min
## [1] 0
##
## $`8`$max
## [1] 2
##
## $`8`$pct_missing
## [1] 0.22
##
## $`8`$first_NA
## [1] 4
##
##
## $`9`
## $`9`$min
## [1] 0
##
## $`9`$max
## [1] 2
##
## $`9`$pct_missing
## [1] 0.3
##
## $`9`$first_NA
## [1] 1
##
##
## $`10`
## $`10`$min
## [1] 0
##
## $`10`$max
## [1] 2
##
## $`10`$pct_missing
## [1] 0.32
##
## $`10`$first_NA
## [1] 3
##
##
## $`11`
## $`11`$min
## [1] 0
##
## $`11`$max
## [1] 2
##
## $`11`$pct_missing
## [1] 0.18
##
## $`11`$first_NA
## [1] 14
##
##
## $`12`
## $`12`$min
## [1] 0
##
## $`12`$max
## [1] 2
##
## $`12`$pct_missing
## [1] 0.28
##
## $`12`$first_NA
## [1] 3
##
##
## $`13`
## $`13`$min
## [1] 0
##
## $`13`$max
## [1] 2
##
## $`13`$pct_missing
## [1] 0.28
##
## $`13`$first_NA
## [1] 5
##
##
## $`14`
## $`14`$min
## [1] 0
##
## $`14`$max
## [1] 2
##
## $`14`$pct_missing
## [1] 0.4
##
## $`14`$first_NA
## [1] 1
##
##
## $`15`
## $`15`$min
## [1] 0
##
## $`15`$max
## [1] 2
```

```
##
## $`15`$pct_missing
## [1] 0.32
##
## $`15`$first_NA
## [1] 5
##
##
## $`16`
## $`16`$min
## [1] 0
##
## $`16`$max
## [1] 2
##
## $`16`$pct_missing
## [1] 0.3
##
## $`16`$first_NA
## [1] 1
##
##
## $`17`
## $`17`$min
## [1] 0
##
## $`17`$max
## [1] 2
##
## $`17`$pct_missing
## [1] 0.2
##
## $`17`$first_NA
## [1] 1
##
##
## $`18`
## $`18`$min
## [1] 0
##
## $`18`$max
## [1] 2
##
## $`18`$pct_missing
## [1] 0.24
##
## $`18`$first_NA
## [1] 2
##
##
## $`19`
## $`19`$min
## [1] 0
##
```

```
## $`19`$max
## [1] 2
##
## $`19`$pct_missing
## [1] 0.3
##
## $`19`$first_NA
## [1] 4
##
##
## $`20`
## $`20`$min
## [1] 0
##
## $`20`$max
## [1] 2
##
## $`20`$pct_missing
## [1] 0.28
##
## $`20`$first_NA
## [1] 2
##
##
## $`21`
## $`21`$min
## [1] 0
##
## $`21`$max
## [1] 2
##
## $`21`$pct_missing
## [1] 0.36
##
## $`21`$first_NA
## [1] 1
##
##
## $`22`
## $`22`$min
## [1] 0
##
## $`22`$max
## [1] 2
##
## $`22`$pct_missing
## [1] 0.22
##
## $`22`$first_NA
## [1] 11
##
##
## $`23`
## $`23`$min
## [1] 0
##
## $`23`$max
## [1] 2
##
## $`23`$pct_missing
## [1] 0.18
##
## $`23`$first_NA
## [1] 13
##
##
## $`24`
## $`24`$min
## [1] 0
##
## $`24`$max
## [1] 2
##
## $`24`$pct_missing
## [1] 0.34
##
## $`24`$first_NA
## [1] 5
##
##
## $`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] 0.22
##
## $`26`$first_NA
## [1] 1
##
##
```

```
## $`27`
## $`27`$min
## [1] 0
##
## $`27`$max
## [1] 2
##
## $`27`$pct_missing
## [1] 0.36
##
## $`27`$first_NA
## [1] 1
##
##
## $`28`
## $`28`$min
## [1] 0
##
## $`28`$max
## [1] 2
##
## $`28`$pct_missing
## [1] 0.42
##
## $`28`$first_NA
## [1] 2
##
##
## $`29`
## $`29`$min
## [1] 0
##
## $`29`$max
## [1] 2
##
## $`29`$pct_missing
## [1] 0.4
##
## $`29`$first_NA
## [1] 5
##
##
## $`30`
## $`30`$min
## [1] 0
##
## $`30`$max
## [1] 2
##
## $`30`$pct_missing
## [1] 0.2
##
## $`30`$first_NA
## [1] 7
```

```
##
##
## $`31`
## $`31`$min
## [1] 0
##
## $`31`$max
## [1] 2
##
## $`31`$pct_missing
## [1] 0.26
##
## $`31`$first_NA
## [1] 1
##
##
## $`32`
## $`32`$min
## [1] 0
##
## $`32`$max
## [1] 2
##
## $`32`$pct_missing
## [1] 0.18
##
## $`32`$first_NA
## [1] 16
##
##
## $`33`
## $`33`$min
## [1] 0
##
## $`33`$max
## [1] 2
##
## $`33`$pct_missing
## [1] 0.3
##
## $`33`$first_NA
## [1] 1
##
##
## $`34`
## $`34`$min
## [1] 0
##
## $`34`$max
## [1] 2
##
## $`34`$pct_missing
## [1] 0.28
##
```

```
## $`34`$first_NA
## [1] 2
##
##
## $`35`
## $`35`$min
## [1] 0
##
## $`35`$max
## [1] 2
##
## $`35`$pct_missing
## [1] 0.46
##
## $`35`$first_NA
## [1] 2
##
##
## $`36`
## $`36`$min
## [1] 0
##
## $`36`$max
## [1] 2
##
## $`36`$pct_missing
## [1] 0.34
##
## $`36`$first_NA
## [1] 2
##
##
## $`37`
## $`37`$min
## [1] 0
##
## $`37`$max
## [1] 2
##
## $`37`$pct_missing
## [1] 0.38
##
## $`37`$first_NA
## [1] 1
##
##
## $`38`
## $`38`$min
## [1] 0
##
## $`38`$max
## [1] 2
##
## $`38`$pct_missing
## [1] 0.32
##
## $`38`$first_NA
## [1] 6
##
##
## $`39`
## $`39`$min
## [1] 0
##
## $`39`$max
## [1] 2
##
## $`39`$pct_missing
## [1] 0.3
##
## $`39`$first_NA
## [1] 1
##
##
## $`40`
## $`40`$min
## [1] 0
##
## $`40`$max
## [1] 2
##
## $`40`$pct_missing
## [1] 0.28
##
## $`40`$first_NA
## [1] 3
##
##
## $`41`
## $`41`$min
## [1] 0
##
## $`41`$max
## [1] 2
##
## $`41`$pct_missing
## [1] 0.26
##
## $`41`$first_NA
## [1] 11
##
##
## $`42`
## $`42`$min
## [1] 0
##
## $`42`$max
## [1] 2
```

```
##
## $`42`$pct_missing
## [1] 0.22
##
## $`42`$first_NA
## [1] 1
##
##
## $`43`
## $`43`$min
## [1] 0
##
## $`43`$max
## [1] 2
##
## $`43`$pct_missing
## [1] 0.32
##
## $`43`$first_NA
## [1] 1
##
##
## $`44`
## $`44`$min
## [1] 0
##
## $`44`$max
## [1] 2
##
## $`44`$pct_missing
## [1] 0.32
##
## $`44`$first_NA
## [1] 1
##
##
## $`45`
## $`45`$min
## [1] 0
##
## $`45`$max
## [1] 2
##
## $`45`$pct_missing
## [1] 0.34
##
## $`45`$first_NA
## [1] 4
##
##
## $`46`
## $`46`$min
## [1] 0
##
```

```
## $`46`$max
## [1] 2
##
## $`46`$pct_missing
## [1] 0.34
##
## $`46`$first_NA
## [1] 4
##
##
## $`47`
## $`47`$min
## [1] 0
##
## $`47`$max
## [1] 2
##
## $`47`$pct_missing
## [1] 0.42
##
## $`47`$first_NA
## [1] 2
##
##
## $`48`
## $`48`$min
## [1] 0
##
## $`48`$max
## [1] 2
##
## $`48`$pct_missing
## [1] 0.28
##
## $`48`$first_NA
## [1] 3
##
##
## $`49`
## $`49`$min
## [1] 0
##
## $`49`$max
## [1] 2
##
## $`49`$pct_missing
## [1] 0.3
##
## $`49`$first_NA
## [1] 4
##
##
## $`50`
## $`50`$min
## [1] 0
##
## $`50`$max
## [1] 2
##
## $`50`$pct_missing
## [1] 0.36
##
## $`50`$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(7)
n <- 1000
v <- rnorm(n, mean = -10, sd = sqrt(100))
v
```

```
##    [1]  12.872471613405 -21.967716822223 -16.942925104355 -14.122929511368
##    [5] -19.706733411195 -19.472799452281  -2.518606597094 -11.169552258872
##    [9]  -8.473423737178  11.899781073294  -6.430137696710  17.167517831307
##   [13]  12.814519259896  -6.759794598615   8.960670668099  -5.323194886783
##   [17] -18.938007230854 -13.073282995372 -10.048224222676  -0.118358505001
##   [21]  -1.602496403759  -2.946581690945   3.059647208117 -23.879962165929
##   [25]   2.729168642552  -8.158072287642  -2.477201042600  -4.082549475373
##   [29] -19.830525957710 -12.760639551120 -18.708510225686  -2.812894469158
##   [33]  -8.893471222307 -10.784667679717 -14.204904593420 -15.621258762853
##   [37]  -0.024865552447 -21.051300588133 -11.422878307746  -6.850050951121
##   [41]   2.185505345073 -16.993170786855 -12.854327515287 -23.115526726094
##   [45] -13.910124314493 -14.015266130950   3.505175809230  -4.088099729108
##   [49]  -8.994745443714  -0.689280044799 -12.627423485665 -10.076681047127
##   [53]  -6.328469934544   7.071625451376  -2.762597374716  -5.189639512921
##   [57] -25.678682442253  -6.817497165192  -8.340085493226 -18.999076296282
##   [61]  -9.236285261394  -8.408447217373  -4.563258152903  -2.951926473870
##   [65]  -6.810308574429   1.092497889711  -2.308458053429   1.534736747789
##   [69]   2.606835026809  -2.993764934277  -5.673728391540 -19.226017182569
##   [73] -16.155842066309 -18.666596882514 -26.395170871811 -23.258392438434
##   [77] -18.890367276380 -15.576023303021 -10.624023088383  14.226929771594
##   [81]  -6.574146498527  -9.957517637479  -9.707801579983 -13.934234291213
##   [85] -17.927045627889 -13.117018652952 -13.460685917809 -13.046075882453
##   [89] -27.858934874445  -4.127253281420   6.357944344466 -16.454234736344
##   [93]  -3.810078312127  -7.636064015987  -1.534991012484 -15.736457388497
##   [97]   1.179932039962 -25.400011319330 -14.381238993001 -11.506729708964
##  [101]  -4.809416347270  -4.124602950981 -10.793330610552 -21.743610148694
##  [105]  -6.912778823616 -26.038785426835  -0.087103749473   0.232204447004
##  [109]  -1.598545611165  -8.799213920443 -14.262550554457  -5.410737564960
##  [113]  -3.549520523061  -3.884694507098 -18.892112938688   5.438923486922
##  [117] -22.417636048850   1.034473403913  -0.172276433244  -6.956728259668
##  [121] -25.547182161953   5.698907764003  -3.115503067159 -11.776036589516
##  [125]  -2.707987340709   5.332509314471  -4.934215519946  -9.666723237367
##  [129] -24.675507151376   0.191577159290 -15.933393332234  -1.875901100392
##  [133]  -1.338321696948  -6.316916967592   1.348190986188 -17.570992800679
##  [137]  -5.547794311013  -0.840670561472  -7.302412575818   0.075404488840
##  [141] -24.614332649228 -18.747856107393  -8.347710616423  -7.927929732459
## [145]  -5.176381092062 -10.716583748081 -18.889284253762  -5.140564297858
## [149]  -6.595032427639 -20.979241939866 -13.556944427786   0.973004107235
## [153] -19.066919699925 -12.074566241375  -3.211385659530 -17.977877412248
## [157] -25.915389379775   1.803481245176   2.225692898381 -10.109091865598
## [161]  -6.544775342523  -9.058108419514  -9.932066321262  -2.573771219008
## [165]   0.421865361616 -13.193371382304  -6.773566037765  -3.149470211730
## [169]  -6.797572256549 -29.149380240243 -33.399628993987  -5.171357064211
## [173]   1.785300473814 -22.927770335029  -3.842269147556  -7.439579191134
## [177]  -2.721609976095   3.241109185364  -8.528415098214 -15.985393927546
## [181]  11.925299267792  13.271127955782   1.348695997695 -11.908845561884
## [185]  -5.251554360063 -15.454749352582   0.556485448708  -5.709781675071
## [189] -28.199564141556 -16.919760890394 -29.318282476756   2.096720126449
## [193] -12.790000483072 -20.957832269415 -11.021860424633  -6.429770418438
## [197] -18.823025657507 -10.566477939583 -15.810189514208  -3.559118109345
## [201]  10.233440532460  -1.375075024398 -10.249094914784  -3.993650510171
## [205]   2.164807350484 -21.765315497183 -16.093400343200  -6.127374267900
## [209] -23.991401444828   2.324918507156  -9.844924993510 -26.209590519721
## [213] -16.654646643047 -15.748405095731 -19.018929754680   4.915993703655
## [217] -11.372793171938  -8.917183019222 -20.352151033152 -14.447439187217
## [221] -11.960492656875 -22.693644917495  -0.464788153493  -5.274533461741
## [225] -15.587781013907   2.420645597365 -10.152584661862 -17.917883891997
## [229] -14.016187425474 -28.967012895361  -0.280250655751 -15.139548559075
## [233]  -9.854383273101 -12.609355702082   5.223583920091 -24.733697457848
## [237] -10.165580140537  -9.754593911184 -10.012569888595 -14.339327066248
## [241] -14.055590568275  -8.447666811274 -19.723818180092   5.481749304093
## [245] -13.701233330067   9.615252568594 -16.099955758511 -10.774287574080
## [249] -28.288592626879  -1.940757580837 -24.775917800752 -39.732557129817
## [253] -23.397621419614 -12.658420263565 -13.839934082877 -16.029423299642
## [257] -16.515240372179   7.576715092821 -10.190348651873  -8.447153875381
## [261] -17.608464408616 -25.497269072103  17.501650117285   0.474232483745
## [265]  -0.820075262363  -5.298904919823 -16.173720878349  -9.578937272834
## [269] -19.018989012885   3.395832098225  -1.961456498985  -6.815213468868
## [273] -11.904533066533 -20.872666906117  -8.546002708815  14.628002507678
## [277]  -0.763803077893  -2.581233120211   4.160217918960   2.516633702646
## [281]  11.089056909611  -2.896873970732 -24.751820086636 -15.897264837166
## [285]  -8.602967535240 -15.117242332947  -8.490626488469  -5.579606046603
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## [293] -20.682726813330 -10.114121246577 -28.652813396458  -9.817491365004
## [297] -12.470205455542 -19.194251122442 -31.731644324665 -16.493770544535
## [301]  -4.747384502013 -12.757273107576  -9.452902346972 -13.882496057350
## [305] -14.170230460279 -21.641751651550   7.378641350770 -12.540773501895
## [309] -19.737186232485   1.111989466255  -0.265009435765   2.571286758474
## [313]   7.762875832498 -36.831685222502  -3.401369248543   1.794496668503
## [317]  -6.064862235379 -21.898586670803 -13.565273652886 -24.655080439444
## [321] -20.907301520956 -16.572542156317  12.629410039421  -9.123099705279
## [325]  -2.324769983833 -16.131574639645  -8.474970300890 -15.917074467713
## [329] -19.607049671060 -15.849579949172  -3.433271106590 -12.902495879937
## [333]  -0.959022710715  -8.009797762973 -10.515748068775 -19.082051794861
## [337] -21.424783394131  -0.096750642353  -8.877267222866   1.496316741612
## [341] -19.104953238995 -21.038197165156 -26.348673063289 -26.163824942052
## [345] -18.367370074867   0.929991155745   2.350981802016  -8.279333983534
## [349]  -8.795068297610  -4.424673296652  -5.086168379688 -10.690126243766
## [353] -23.507963149139  -2.006424288163 -13.200940770234 -13.569511893780
## [357] -15.107279378471 -28.788800824498 -19.518450898789  12.731566149315
## [361]  -7.973123700028 -33.085546978706 -10.566356633383  -9.371561579545
## [365]  -2.897718626085 -15.923073973115  -7.014753696966  -3.574643732881
## [369]  11.127950955741  -0.822203668345 -25.728547528753  -0.073582685835
## [373]  -5.204791287152 -12.965805554160  -1.841597652808 -19.997716130581
## [377]  -4.507897056172  -7.202287955447  -0.833641102450 -27.312572577836
## [381] -24.795810668193  12.298110273848  -6.135010535521  -3.397343124530
## [385] -12.762352096932  -7.240670014901 -32.742312015109  -0.919142600520
## [389] -20.862531082837 -12.155267146110 -17.334273762143  -7.878821648863
## [393] -19.391419034328 -16.191936366639  -7.559888420808  -6.282566165746
## [397]  -3.727917812449 -20.731139258813 -17.086927142320  -0.928683282158
## [401] -13.197056384927   1.650659409543 -16.217105488530   2.482131897476
## [405]   4.404015417580  -2.380065619484  -4.406287649565   5.992638060614
## [409] -10.984577348497 -24.495537840845 -12.576613060225 -30.330713305359
## [413]  -4.130358284782  -8.394134675026  -8.868471319014  -4.283093930927
## [417] -19.655296541985  -6.819988469880 -11.735075898317 -19.126111808927
## [421] -28.468947726120  -3.304819819353 -11.087865188456   5.665753513316
## [425] -18.448452316645   0.976492844501  -6.991196572223 -17.769662521649
## [429] -10.384341786515   1.094895688729  -4.636747344805 -13.633484581605
## [433] -11.055007115217  -6.661253571613  -1.897689477666 -26.836953829160
## [437]  -3.342721570597 -17.923875349022   5.277233032314 -24.866923981931
## [441] -16.711485814442   6.751774465665  -3.880679392662 -12.322056456631
## [445]  -3.947066815328 -21.591061240025 -21.644292718054 -18.699249474685
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## [453] -17.556488212307 -12.415946189219   0.971588993329 -19.466127511475
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## [461] -10.224518561571 -11.020509577127  -6.995914032981  -1.933795870060
## [465] -10.372058945554 -24.564759923517 -16.238906466381 -11.695982724849
## [469]   2.761231679036 -12.559144771312 -11.653682710396 -14.273211111287
## [473] -10.568727469011 -24.453835958572   8.828070195665  -8.831099819239
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## [481] -10.225318714676  13.309609732628 -10.988303469125  -8.335684214723
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## [489]  -8.309618144194 -25.056791688762  -0.050670525891   2.439084075687
## [493] -10.362568258711 -14.112558781390   2.841489642462 -21.178076585829
## [497] -18.350697046668   5.008116976672  -1.008491395016 -14.564120778160
## [501] -12.060157504066 -15.878436062056 -16.854529455776   0.048241824918
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## [521]  -1.226987686856  -1.574646642318 -10.515839881304 -16.901214028455
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##  [581]  -6.689742443341 -14.612469359136  -6.409607596910 -15.157911793492
##  [585]  -4.127237765338   6.196110261620  -5.547687708082   2.552612015603
##  [589] -15.749066492200  -6.839105121923 -31.878705648775  13.721013197035
##  [593]  -0.234201301992  -3.855481885272 -13.152626540799  -7.689620505123
##  [597]  10.754800908060  -3.473151015039 -10.373962981155 -17.063915073722
##  [601] -22.278317049470  -8.658415494020 -13.732334891652  -9.609396247603
##  [605]  -8.568756771622  -8.950527486366  -3.978042584465 -11.183954935898
##  [609]  -4.408304570133  -9.581386215845  -9.363788839195   4.662036944248
##  [613] -14.726308684443  -8.365254615983  -6.936498366099  -2.074237816563
##  [617] -19.490767537104  -0.952130176755 -13.401104077035   5.310074986935
##  [621]  -6.105966111607  -5.040180197149  -3.551413235578 -10.437647725401
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##  [629] -17.287825107981 -12.206076917261  -6.956460324739  -0.073478555285
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##  [697]  -6.619850480029   4.366194044266  -5.966692552805 -17.464889872585
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##  [705] -10.522303617259 -24.350177918729   0.510526575190  12.405947407498
##  [709]  -2.996165395420 -21.730810959967 -14.950070012354  -7.213234170984
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##  [717] -15.366960780347  -6.916124799322  -5.782062062791  -5.613381248278
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##  [733] -12.891217354260 -13.829635830296  -0.812880289862   0.170490047941
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##  [757] -10.608861752204 -24.535688298390  -8.910019714861 -11.416282648309
##  [761]   5.959384172893   4.549929995592 -10.684785502221 -13.211479724381
##  [765] -10.185998061267 -23.216974574262 -12.577997736457  -5.269486721308
##  [769]  -0.778225679482 -18.538609574587 -29.252757339341   5.615640305115
##  [773] -20.050498452922 -14.408200571469 -31.483718234524  -9.517133330218
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##  [809] -15.930888114912 -16.315692881270  -0.246242022503  -2.769562743778
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##  [825] -16.751628890458 -13.106693360540 -16.005111491183 -20.369207248781
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##  [837] -14.947016996592  -8.480544532024 -12.080007675539  -9.541381871117
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##  [861] -15.840222339420 -17.723139563798  -7.801394288200   2.963879571083
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##  [869]  -6.047064441329 -20.961269086410  -0.157193147323 -18.708681108268
##  [873] -32.382468652491  -0.779303493659 -17.490915984286  -3.144824619933
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##  [917] -29.725111024210  -1.770043524425 -10.510756797090   6.103621389461
##  [921] -11.406225053230  -4.972541895380 -16.631202914794  -0.940235029870
##  [925]  -6.902961553306 -10.357866637201   1.090774462701  -6.045807901086
##  [929] -18.400512601066   1.834966810208  -8.475447813960   5.397407765932
##  [933]  -4.905611329856  -9.396502645723 -12.916025068891   3.067559592445
##  [937]  -9.815688422226 -15.524546389937 -12.487366077558  -4.543429504181
##  [941]  -7.376345315955  -8.034538559457   4.158751017303 -15.531001607141
##  [945]  -5.356769512998 -15.039140464046  -7.065603989812 -17.655169397586
##  [949]  19.669187313082 -14.458930363515 -13.902677124620 -11.893545874773
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##  [957]  -9.532624357703  -4.143431955514   6.881143609086 -10.117587747315
##  [961]  -1.273073988344   9.507920689407 -17.820301679700  -8.343707636389
##  [965]  -9.383872671240 -10.576851214867 -19.255099364193 -13.098149650159
##  [969] -10.272738381363   0.697656002750 -13.289921411254 -21.345611119426
##  [973] -11.624453502072 -21.329477261404  -6.727531315286 -21.783721351349
##  [977]   0.887857348503  -2.054888935559  -7.230564488892   1.882102031161
##  [981] -19.014107159856   1.767633501520 -16.878013255347 -10.982598837137
##  [985] -33.004184115677 -13.689166605317 -18.538289130631 -14.264981485821
##  [989] -13.944686571838 -16.607274665608  -4.434340827129   2.165840477745
##  [993] -15.717274275258 -26.222380304574  -0.394898811674  -6.440400915854
##  [997] -12.733881218686   4.954292212338 -28.951541455614   3.405233477848
```

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

```r
set.seed(7)
n <- 1000
v <- rnorm(n, mean = -10, sd = sqrt(100))
v
```

```
##    [1]  12.872471613405 -21.967716822223 -16.942925104355 -14.122929511368
##    [5] -19.706733411195 -19.472799452281  -2.518606597094 -11.169552258872
##    [9]  -8.473423737178  11.899781073294  -6.430137696710  17.167517831307
##   [13]  12.814519259896  -6.759794598615   8.960670668099  -5.323194886783
##   [17] -18.938007230854 -13.073282995372 -10.048224222676  -0.118358505001
##   [21]  -1.602496403759  -2.946581690945   3.059647208117 -23.879962165929
##   [25]   2.729168642552  -8.158072287642  -2.477201042600  -4.082549475373
##   [29] -19.830525957710 -12.760639551120 -18.708510225686  -2.812894469158
##   [33]  -8.893471222307 -10.784667679717 -14.204904593420 -15.621258762853
##   [37]  -0.024865552447 -21.051300588133 -11.422878307746  -6.850050951121
##   [41]   2.185505345073 -16.993170786855 -12.854327515287 -23.115526726094
##   [45] -13.910124314493 -14.015266130950   3.505175809230  -4.088099729108
##   [49]  -8.994745443714  -0.689280044799 -12.627423485665 -10.076681047127
##   [53]  -6.328469934544   7.071625451376  -2.762597374716  -5.189639512921
##   [57] -25.678682442253  -6.817497165192  -8.340085493226 -18.999076296282
##   [61]  -9.236285261394  -8.408447217373  -4.563258152903  -2.951926473870
##   [65]  -6.810308574429   1.092497889711  -2.308458053429   1.534736747789
##   [69]   2.606835026809  -2.993764934277  -5.673728391540 -19.226017182569
##   [73] -16.155842066309 -18.666596882514 -26.395170871811 -23.258392438434
##   [77] -18.890367276380 -15.576023303021 -10.624023088383  14.226929771594
##   [81]  -6.574146498527  -9.957517637479  -9.707801579983 -13.934234291213
##   [85] -17.927045627889 -13.117018652952 -13.460685917809 -13.046075882453
##   [89] -27.858934874445  -4.127253281420   6.357944344466 -16.454234736344
##   [93]  -3.810078312127  -7.636064015987  -1.534991012484 -15.736457388497
##   [97]   1.179932039962 -25.400011319330 -14.381238993001 -11.506729708964
##  [101]  -4.809416347270  -4.124602950981 -10.793330610552 -21.743610148694
##  [105]  -6.912778823616 -26.038785426835  -0.087103749473   0.232204447004
##  [109]  -1.598545611165  -8.799213920443 -14.262550554457  -5.410737564960
##  [113]  -3.549520523061  -3.884694507098 -18.892112938688   5.438923486922
##  [117] -22.417636048850   1.034473403913  -0.172276433244  -6.956728259668
##  [121] -25.547182161953   5.698907764003  -3.115503067159 -11.776036589516
##  [125]  -2.707987340709   5.332509314471  -4.934215519946  -9.666723237367
##  [129] -24.675507151376   0.191577159290 -15.933393332234  -1.875901100392
##  [133]  -1.338321696948  -6.316916967592   1.348190986188 -17.570992800679
##  [137]  -5.547794311013  -0.840670561472  -7.302412575818   0.075404488840
##  [141] -24.614332649228 -18.747856107393  -8.347710616423  -7.927929732459
##  [145]  -5.176381092062 -10.716583748081 -18.889284253762  -5.140564297858
##  [149]  -6.595032427639 -20.979241939866 -13.556944427786   0.973004107235
##  [153] -19.066919699925 -12.074566241375  -3.211385659530 -17.977877412248
##  [157] -25.915389379775   1.803481245176   2.225692898381 -10.109091865598
##  [161]  -6.544775342523  -9.058108419514  -9.932066321262  -2.573771219008
##  [165]   0.421865361616 -13.193371382304  -6.773566037765  -3.149470211730
##  [169]  -6.797572256549 -29.149380240243 -33.399628993987  -5.171357064211
##  [173]   1.785300473814 -22.927770335029  -3.842269147556  -7.439579191134
##  [177]  -2.721609976095   3.241109185364  -8.528415098214 -15.985393927546
##  [181]  11.925299267792  13.271127955782   1.348695997695 -11.908845561884
##  [185]  -5.251554360063 -15.454749352582   0.556485448708  -5.709781675071
##  [189] -28.199564141556 -16.919760890394 -29.318282476756   2.096720126449
##  [193] -12.790000483072 -20.957832269415 -11.021860424633  -6.429770418438
##  [197] -18.823025657507 -10.566477939583 -15.810189514208  -3.559118109345
##  [201]  10.233440532460  -1.375075024398 -10.249094914784  -3.993650510171
##  [205]   2.164807350484 -21.765315497183 -16.093400343200  -6.127374267900
##  [209] -23.991401444828   2.324918507156  -9.844924993510 -26.209590519721
##  [213] -16.654646643047 -15.748405095731 -19.018929754680   4.915993703655
##  [217] -11.372793171938  -8.917183019222 -20.352151033152 -14.447439187217
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##  [225] -15.587781013907   2.420645597365 -10.152584661862 -17.917883891997
##  [229] -14.016187425474 -28.967012895361  -0.280250655751 -15.139548559075
##  [233]  -9.854383273101 -12.609355702082   5.223583920091 -24.733697457848
##  [237] -10.165580140537  -9.754593911184 -10.012569888595 -14.339327066248
##  [241] -14.055590568275  -8.447666811274 -19.723818180092   5.481749304093
##  [245] -13.701233330067   9.615252568594 -16.099955758511 -10.774287574080
##  [249] -28.288592626879  -1.940757580837 -24.775917800752 -39.732557129817
##  [253] -23.397621419614 -12.658420263565 -13.839934082877 -16.029423299642
##  [257] -16.515240372179   7.576715092821 -10.190348651873  -8.447153875381
##  [261] -17.608464408616 -25.497269072103  17.501650117285   0.474232483745
##  [265]  -0.820075262363  -5.298904919823 -16.173720878349  -9.578937272834
##  [269] -19.018989012885   3.395832098225  -1.961456498985  -6.815213468868
##  [273] -11.904533066533 -20.872666906117  -8.546002708815  14.628002507678
##  [277]  -0.763803077893  -2.581233120211   4.160217918960   2.516633702646
##  [281]  11.089056909611  -2.896873970732 -24.751820086636 -15.897264837166
##  [285]  -8.602967535240 -15.117242332947  -8.490626488469  -5.579606046603
##  [289] -11.623991225992  -0.281614589640 -16.712654817862   6.383971613652
##  [293] -20.682726813330 -10.114121246577 -28.652813396458  -9.817491365004
##  [297] -12.470205455542 -19.194251122442 -31.731644324665 -16.493770544535
##  [301]  -4.747384502013 -12.757273107576  -9.452902346972 -13.882496057350
##  [305] -14.170230460279 -21.641751651550   7.378641350770 -12.540773501895
##  [309] -19.737186232485   1.111989466255  -0.265009435765   2.571286758474
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##  [333]  -0.959022710715  -8.009797762973 -10.515748068775 -19.082051794861
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##  [365]  -2.897718626085 -15.923073973115  -7.014753696966  -3.574643732881
##  [369]  11.127950955741  -0.822203668345 -25.728547528753  -0.073582685835
##  [373]  -5.204791287152 -12.965805554160  -1.841597652808 -19.997716130581
##  [377]  -4.507897056172  -7.202287955447  -0.833641102450 -27.312572577836
##  [381] -24.795810668193  12.298110273848  -6.135010535521  -3.397343124530
##  [385] -12.762352096932  -7.240670014901 -32.742312015109  -0.919142600520
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##  [393] -19.391419034328 -16.191936366639  -7.559888420808  -6.282566165746
##  [397]  -3.727917812449 -20.731139258813 -17.086927142320  -0.928683282158
##  [401] -13.197056384927   1.650659409543 -16.217105488530   2.482131897476
##  [405]   4.404015417580  -2.380065619484  -4.406287649565   5.992638060614
##  [409] -10.984577348497 -24.495537840845 -12.576613060225 -30.330713305359
## [413]  -4.130358284782  -8.394134675026  -8.868471319014  -4.283093930927
## [417] -19.655296541985  -6.819988469880 -11.735075898317 -19.126111808927
## [421] -28.468947726120  -3.304819819353 -11.087865188456   5.665753513316
## [425] -18.448452316645   0.976492844501  -6.991196572223 -17.769662521649
## [429] -10.384341786515   1.094895688729  -4.636747344805 -13.633484581605
## [433] -11.055007115217  -6.661253571613  -1.897689477666 -26.836953829160
## [437]  -3.342721570597 -17.923875349022   5.277233032314 -24.866923981931
## [441] -16.711485814442   6.751774465665  -3.880679392662 -12.322056456631
## [445]  -3.947066815328 -21.591061240025 -21.644292718054 -18.699249474685
## [449] -12.611057175170 -14.941956643974 -23.058227313342  10.234126207356
## [453] -17.556488212307 -12.415946189219   0.971588993329 -19.466127511475
## [457] -21.339599212694 -18.833835227370  -4.835866014099 -13.379553988032
## [461] -10.224518561571 -11.020509577127  -6.995914032981  -1.933795870060
## [465] -10.372058945554 -24.564759923517 -16.238906466381 -11.695982724849
## [469]   2.761231679036 -12.559144771312 -11.653682710396 -14.273211111287
## [473] -10.568727469011 -24.453835958572   8.828070195665  -8.831099819239
## [477]  -5.788672972571   5.774043820963 -12.513885242267 -10.556243358561
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## [485] -12.696354001784  -1.555263918571   4.087677491323 -25.662362205067
## [489]  -8.309618144194 -25.056791688762  -0.050670525891   2.439084075687
## [493] -10.362568258711 -14.112558781390   2.841489642462 -21.178076585829
## [497] -18.350697046668   5.008116976672  -1.008491395016 -14.564120778160
## [501] -12.060157504066 -15.878436062056 -16.854529455776   0.048241824918
## [505] -17.726490929748 -29.937337010814 -19.092544845767 -15.631560806002
## [509] -22.178556170847 -28.203178528754 -13.996293460866  11.183683482010
## [513]   4.151575459115  -4.352348842263 -20.812971641995 -19.419760935071
## [517] -12.441834432318   0.854885538228  -4.416561728569 -31.762283505580
## [521]  -1.226987686856  -1.574646642318 -10.515839881304 -16.901214028455
## [525] -28.389828452840  -7.169620829691 -32.525900826544  -2.656498130598
## [529]  -8.541942593502 -16.494285809241 -15.612243601396  -6.652079508510
## [533]  -9.679815729876   2.369171894445  -9.435865761835 -11.454327083996
## [537] -15.923496259370 -22.607129804552 -16.836057842745 -11.634371954676
## [541] -14.384735082636 -15.787030149867   5.810904318315   5.406613104409
## [545]  -2.970189955616 -10.637486177995 -17.406239843769 -20.339471661621
## [549] -12.960636625179 -24.429497248816 -10.271916534102   5.613929786412
## [553] -19.910781580742  -9.958060141351 -10.448048417905 -16.886536691845
## [557] -11.302546486332  -8.449072123468   2.773415519807   0.535482122839
## [561] -13.717165462765 -11.031325008967  14.980736060963 -17.772608660121
## [565]  -2.426154226258  -9.774549647217 -26.500315279247 -18.891162160291
## [569] -16.083697219598 -12.130629042640   4.712112557731  -5.336115257225
## [573]   8.183583613942   9.233962123120 -15.390035643105 -13.862788010896
## [577] -18.618076658804 -14.020065834036  -4.010371803866  -9.181627183922
## [581]  -6.689742443341 -14.612469359136  -6.409607596910 -15.157911793492
## [585]  -4.127237765338   6.196110261620  -5.547687708082   2.552612015603
## [589] -15.749066492200  -6.839105121923 -31.878705648775  13.721013197035
## [593]  -0.234201301992  -3.855481885272 -13.152626540799  -7.689620505123
## [597]  10.754800908060  -3.473151015039 -10.373962981155 -17.063915073722
## [601] -22.278317049470  -8.658415494020 -13.732334891652  -9.609396247603
## [605]  -8.568756771622  -8.950527486366  -3.978042584465 -11.183954935898
## [609]  -4.408304570133  -9.581386215845  -9.363788839195   4.662036944248
## [613] -14.726308684443  -8.365254615983  -6.936498366099  -2.074237816563
## [617] -19.490767537104  -0.952130176755 -13.401104077035   5.310074986935
## [621]  -6.105966111607  -5.040180197149  -3.551413235578 -10.437647725401
## [625] -23.568687285836  -4.085606058035 -29.882972366137  -0.813888660075
##  [629] -17.287825107981 -12.206076917261  -6.956460324739  -0.073478555285
##  [633] -10.732678368289 -10.117440175223   0.048726356127  -7.466565705440
##  [637] -19.986035416767 -18.014069584814   1.808544350710  -1.770852823701
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##  [645] -21.674019239164 -15.483774328985 -20.411208725147  -9.852099605910
##  [649] -25.893993336897 -21.771155007746  -2.139626186640   8.980149382032
##  [653] -14.137980664720  -3.223346986227 -18.572453050935 -11.210586546374
##  [657] -17.171705718454 -14.607225076451 -10.540307283246   8.482138499670
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##  [685] -24.436498482544   0.796787923153  -6.243623932995 -19.928700166037
##  [689]   0.982030826772 -16.478479412518 -10.051898587511 -11.355064316790
##  [693]   2.993083239702 -29.015560068148   2.119188916066 -15.918783445530
##  [697]  -6.619850480029   4.366194044266  -5.966692552805 -17.464889872585
##  [701]   3.431231835646 -11.853945836005  -0.273988702830  -0.788365002913
##  [705] -10.522303617259 -24.350177918729   0.510526575190  12.405947407498
##  [709]  -2.996165395420 -21.730810959967 -14.950070012354  -7.213234170984
##  [713]  -2.842869056687 -31.632929893910 -14.520037121549 -19.752897855745
##  [717] -15.366960780347  -6.916124799322  -5.782062062791  -5.613381248278
##  [721] -19.863947403073 -16.665123832099  -7.457115710450 -18.050674713325
##  [725]  -6.370493315032  -2.480961777131 -19.389595953928 -13.121951426097
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##  [733] -12.891217354260 -13.829635830296  -0.812880289862   0.170490047941
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##  [741] -11.420755000700  -3.860994960506   0.570122283091  19.614931092388
##  [745]  -3.540613430524  -6.517727797808 -20.518626890398  -5.000609361961
##  [749] -11.343538734518 -22.183341707394   9.838025383783 -27.440932049593
##  [753]  -6.779615632734 -29.793476163008  -2.748701781935 -13.841720448558
##  [757] -10.608861752204 -24.535688298390  -8.910019714861 -11.416282648309
##  [761]   5.959384172893   4.549929995592 -10.684785502221 -13.211479724381
##  [765] -10.185998061267 -23.216974574262 -12.577997736457  -5.269486721308
##  [769]  -0.778225679482 -18.538609574587 -29.252757339341   5.615640305115
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##  [777] -12.210946754467 -13.266841645410  -5.997889849111 -20.329352771652
##  [781] -25.361456731577   6.012589094505  -6.127402999500  -1.048749627781
##  [785]  -5.007292633633 -15.714773141919 -16.604622847770 -12.511563714834
##  [789]  -7.475602537191  -7.723421655219  -7.261346785244   0.710747122578
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##  [865]   1.106416428217 -16.272974941005   6.175099841597  -2.768130022240
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##  [877]  10.565702784232 -20.970050004075 -14.691920711776  -8.151816146919
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##  [917] -29.725111024210  -1.770043524425 -10.510756797090   6.103621389461
##  [921] -11.406225053230  -4.972541895380 -16.631202914794  -0.940235029870
##  [925]  -6.902961553306 -10.357866637201   1.090774462701  -6.045807901086
##  [929] -18.400512601066   1.834966810208  -8.475447813960   5.397407765932
##  [933]  -4.905611329856  -9.396502645723 -12.916025068891   3.067559592445
##  [937]  -9.815688422226 -15.524546389937 -12.487366077558  -4.543429504181
##  [941]  -7.376345315955  -8.034538559457   4.158751017303 -15.531001607141
##  [945]  -5.356769512998 -15.039140464046  -7.065603989812 -17.655169397586
##  [949]  19.669187313082 -14.458930363515 -13.902677124620 -11.893545874773
##  [953]  -0.702198762766 -24.979589292461 -12.378168144822  -6.620183905515
##  [957]  -9.532624357703  -4.143431955514   6.881143609086 -10.117587747315
##  [961]  -1.273073988344   9.507920689407 -17.820301679700  -8.343707636389
##  [965]  -9.383872671240 -10.576851214867 -19.255099364193 -13.098149650159
##  [969] -10.272738381363   0.697656002750 -13.289921411254 -21.345611119426
##  [973] -11.624453502072 -21.329477261404  -6.727531315286 -21.783721351349
##  [977]   0.887857348503  -2.054888935559  -7.230564488892   1.882102031161
##  [981] -19.014107159856   1.767633501520 -16.878013255347 -10.982598837137
##  [985] -33.004184115677 -13.689166605317 -18.538289130631 -14.264981485821
##  [989] -13.944686571838 -16.607274665608  -4.434340827129   2.165840477745
##  [993] -15.717274275258 -26.222380304574  -0.394898811674  -6.440400915854
##  [997] -12.733881218686   4.954292212338 -28.951541455614   3.405233477848
```

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

```
average_v <- mean(v)
std_error <- sd(v)/n
average_v
```

```
## [1] -9.9695167087
```

```
std_error
```

```
## [1] 0.0098232172659
```

- 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?

```
fifth_percentile <- quantile(v, probs = 0.05)
qnorm(0.05, mean = -10, sd = sqrt(100))
```

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

```
fifth_percentile
```

```
##            5%
## -25.895063139
```

- 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?

```
pnorm(0, mean = -10, sd = sqrt(100))
```

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

```
ecdf(v)(0)
```

```
## [1] 0.844
```