Lab01

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

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

Basic R Skills

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

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

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

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

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

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

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

```r
prod(1/ seq(from = 3, by = 3, length.out = 37))#TO-DO
```

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

- Find the product of the first 387 terms of `1 * 1/2 * 1/4 * 1/8 * …`

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

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

Is this answer *exactly* correct?

No, the exact answer is just too small for the computer to calculate. It is numerical underflow. #TO-DO

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

```
-log(2)*(sum(0:386))#TO-DO #Logs allow you to change products to sums,
therefore it gives you a more exact answer.
```

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

- Create the sequence x = [Inf, 20, 18, ..., -20].

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

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

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

```
#Log(100,3)#TO-DO
```

Comment on the appropriateness of the non-numeric values.

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

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

```
x>0 & is.finite(x) #TO-DO
```

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

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

```
which(is.nan(x) | is.infinite(x))#TO-DO
```

```
##  [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))#TO-DO
```

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

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

```
#TO-DO
```

- Count the number of unique values in x.

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

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

- Cast x to a factor. Do the number of levels make sense? Yes, there are 53 levels because there are 53 unique values.

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

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

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

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

```
## 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
```

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

```
y = x[!is.nan(x) & is.finite(x)]#TO-DO. Square brackets select elts out of a
vector.
y
```

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

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

```
delta <- 1E-6
grid <- seq(0, 1 - delta, by = delta)
f <- grid**2
sum(f)*delta#TO-DO
```

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

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

```
mean(sample(c(0,1),100, replace = TRUE))#TO-DO
```

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

- 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),500, replace = TRUE, prob = c(0.1,0.9)))#TO-DO
```

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

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

```
#TO-DO
```

- 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.

```r
x_3 = factor(sample(c("none","infraction", "misdimeanor", "felony"), size
=100, replace = TRUE))#TO-DO
```

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

```r
x_3_bin = ifelse(x_3 == "none", 0, 1)
#TO-DO
```

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

```r
x_3_ord = factor (x = x_3, levels = c("none", "infraction", "misdimeanor",
"felony"), ordered = TRUE) #TO-DO
```

- Convert x_3 into three binary variables without any information loss and put them into a data matrix.

```r
X <- matrix(nrow = length(x_3), ncol = 3)
X[,1] = as.numeric(x_3 == "infraction")
X[,2] = as.numeric(x_3 == "misdimeanor")
X[,3] = as.numeric(x_3 == "felony")
X#TO-DO
```

```
##        [,1] [,2] [,3]
##   [1,]   1    0    0
##   [2,]   1    0    0
##   [3,]   0    0    1
##   [4,]   0    1    0
##   [5,]   0    0    1
##   [6,]   0    0    0
##   [7,]   1    0    0
##   [8,]   1    0    0
##   [9,]   1    0    0
##  [10,]   0    1    0
##  [11,]   1    0    0
##  [12,]   1    0    0
##  [13,]   1    0    0
##  [14,]   0    1    0
##  [15,]   0    0    0
##  [16,]   0    0    1
##  [17,]   0    1    0
##  [18,]   0    0    0
##  [19,]   0    0    0
##  [20,]   0    0    1
##  [21,]   0    1    0
##  [22,]   0    0    0
##  [23,]   0    0    1
##  [24,]   0    0    0
```

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

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

- What should the sum of each row be (in English)? 0 or 1, depending on whether or not the person committed a crime. #TO-DO

Verify that.

```
table(rowSums(X))#TO-DO
```

```
## 
##  0  1
## 30 70
```

- How should the column sum look (in English)? It is an integer between 0 and 100 representing the total number of infractions, misdemeanors,and felonies of all people in the data set. #TO-DO

Verify that.

```
colSums(X)
```

```
## [1] 24 23 23
```

```
table(x_3)#TO-DO
```

```
## x_3
##      felony  infraction misdimeanor         none
##          23          24          23           30
```

- 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.

```r
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(NA, nrow = n, ncol = 6)
rownames(X) = fake_first_names
X[,1] <- rnorm(n, mean = 17, sd = sqrt(38))
X[,2] <- runif(n, -10, 10)
X[,3] <- rpois(n, lambda = 6)
X[,4] <- rexp(n, rate = 1/9)
X[,5] <- rbinom(n, size = 20, prob = .12)
X[,6] <- sample(c(rep(1,24), rep(0,76)))
View(X)#TO-DO
```

- 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, labels = c("DOMESTIC", "FOREIGN"))
DF#TO-DO
```

```
##                      X1           X2 X3           X4 X5       X6
## Sophia   28.1170986063  6.43396351486  8 11.42027081046  1 DOMESTIC
## Emma     17.2123947017  2.63600048143  8  7.22402310252  2 DOMESTIC
```

```
## Olivia     22.3187389626  -9.13654231466   5  1.36635431601   1 DOMESTIC
## Ava        27.7173707959   1.97703395039   4 11.85421644672   3 DOMESTIC
## Mia        17.3171717246   7.63090711087   3  8.05509268557   2  FOREIGN
## Isabella   12.3398337761   8.89244759921   6  3.54355248716   1 DOMESTIC
## Riley      17.4083727918  -9.88023760729   5  2.02103665983   5 DOMESTIC
## Aria       23.9471683883  -1.84346298221   8  4.22332039615   2 DOMESTIC
## Zoe        20.0173891678  -5.00341800973  13 11.82476182710   2 DOMESTIC
## Charlotte  19.4641412953   6.98467660695   6  2.50044061756   2  FOREIGN
## Lily        6.8841207132  -9.81839857064   4  7.16994687691   4 DOMESTIC
## Layla      20.1584854437   8.78275962081   5 31.76488267255   1 DOMESTIC
## Amelia     13.7372816928   3.01143730991   8 13.40041938535   3  FOREIGN
## Emily      21.0011772252  -3.85108738206   5  2.67329922365   3 DOMESTIC
## Madelyn    15.9040083429  -8.67573669180   7 26.02246391006   3 DOMESTIC
## Aubrey     18.2941301762   6.07207261492   4 33.88333520663   1 DOMESTIC
## Adalyn     13.6306670987  -1.15808224306   3  4.59722464707   3 DOMESTIC
## Madison    13.8993090188  -7.88535466883   3  0.46483571548   2 DOMESTIC
## Chloe      19.5834342383  -0.99542366806   3  0.44174864690   3 DOMESTIC
## Harper     19.8841071473   4.71615677699   5 12.02997049745   6 DOMESTIC
## Abigail    21.8539143878   5.26071791537   8  3.42691040877   6  FOREIGN
## Aaliyah    26.2799599514   7.48988889623  10  0.66903165076   6 DOMESTIC
## Avery      15.6862314808   3.44915205613   8  3.03714670723   3 DOMESTIC
## Evelyn     24.5207554085   6.13235158846  10 21.66228418125   0  FOREIGN
## Kaylee     22.0102631207  -8.43261745293   6  9.27377201765   5 DOMESTIC
## Ella       13.9789958970   9.83174732421   6 12.28416373077   3 DOMESTIC
## Ellie      15.8483254332  -4.65449286159   5  5.52223173995   2  FOREIGN
## Scarlett   16.7972502516   3.21519288234   6 21.29695846213   0 DOMESTIC
## Arianna    18.3388435937  -4.03827960137   3 16.71836264728   3 DOMESTIC
## Hailey     13.6595874551   4.32693733834   6  5.07595261093   4 DOMESTIC
## Nora       11.9963157177  -6.77383166272   6  6.68704672329   1 DOMESTIC
## Addison    10.0361697030  -4.85395671800   3 11.55538960415   1  FOREIGN
## Brooklyn   10.4031526297   0.67006194033   4 21.32024456261   2 DOMESTIC
## Hannah     21.1256124672   2.67566733528   8 14.45990319643   1 DOMESTIC
## Mila       17.0044894580  -1.26844710670   5  2.32210486300   3 DOMESTIC
## Leah       20.3990799171  -1.78231936414  10 17.71637497022   1 DOMESTIC
## Elizabeth  12.2051935537  -1.09632021282   2  6.40547947175   2 DOMESTIC
## Sarah      26.4434083847  -3.09346973896   8  0.82918299409   4  FOREIGN
## Eliana     19.1134962998   4.16579273529   4  8.95907922632   2 DOMESTIC
## Mackenzie  21.2574093855  -6.34580250829   5 21.14239777697   2 DOMESTIC
## Peyton     17.3222431290  -3.22644438129   8 21.28681780895   2  FOREIGN
## Maria       7.8217242171  -0.37126416806   6 10.34665171764   0  FOREIGN
## Grace      22.8340173216   5.71884165518   5 14.73148946388   2 DOMESTIC
## Adeline    12.6043916095  -1.47748698015   7  0.86584681319   1 DOMESTIC
## Elena       9.3573968082   2.67884024419   3  3.76462519149   1 DOMESTIC
## Anna       23.3640449873  -6.49399968330   6  3.76616726071   1  FOREIGN
## Victoria   13.1537577524  -9.65442169923   4  0.63419669845   3 DOMESTIC
## Camilla    19.2208244399  -5.01814493909   7 26.70879705844   3 DOMESTIC
## Lillian    20.1869754422   2.81873548403  12 13.71623898481   1 DOMESTIC
## Natalie    17.8243478452  -8.53892193176   9 19.41514234318   1  FOREIGN
## Jackson    20.2097224687   1.29546718206   5  0.60791508158   2 DOMESTIC
## Aiden      16.1726095210   4.69464403111   8  3.68564360796   4 DOMESTIC
```

```
## Lucas     16.4789284203 -0.57604226284  7  5.96713505918  3 DOMESTIC
## Liam      33.1275499426  5.68749815226  6 10.23073436227  2 DOMESTIC
## Noah      17.1334823700 -3.75010692514  4  7.35840318948  4  FOREIGN
## Ethan     22.4110112393 -5.37113185506  4  0.77826770362  1 DOMESTIC
## Mason     13.5303857859  1.17648524698  5  4.37667293055  4 DOMESTIC
## Caden     14.4146804726 -5.75801182073  4  2.07202266622  2  FOREIGN
## Oliver    13.5956019139  0.62233639881  7  0.45770004625  1 DOMESTIC
## Elijah    16.5181763290  1.03758466896  6  0.28263001276  0  FOREIGN
## Grayson   30.8001663717  2.15830631088  3 54.68653008658  2  FOREIGN
## Jacob     15.9057348899  4.67257641256  6  1.03937094240  3 DOMESTIC
## Michael   15.2569176061  8.33518767729  1 14.35161085022  1 DOMESTIC
## Benjamin  12.9364978418  4.59901154973 10  0.53239222476  3 DOMESTIC
## Carter    18.9717655860  6.27668295521  5  7.30573991090  5 DOMESTIC
## James     16.6099160671 -7.39578332752  4 21.57509989580  3 DOMESTIC
## Jayden    24.4940015747 -7.64578042086  5 20.70712176621  2 DOMESTIC
## Logan     20.0551942012  7.09850279614  8  0.61573552086  2 DOMESTIC
## Alexander 16.1703566387  7.68807082437  8  1.21858396799  3  FOREIGN
## Caleb      9.5157311085 -6.36767107062  4  9.29987203274  2 DOMESTIC
## Ryan      10.9236615375 -1.39009887353  3  6.91267701573  3 DOMESTIC
## Luke      17.6878206828  9.20903252903  4  0.33168046346  1 DOMESTIC
## Daniel    17.8824220011  3.16040651407  8  0.53150707902  5 DOMESTIC
## Jack      14.0835732066 -4.63062793016  3 34.43998986852  4 DOMESTIC
## William   13.8730474271 -2.71279129200  9  0.93492527073  4 DOMESTIC
## Owen      11.3230544256 -9.63096741121  9  7.34083934836  1 DOMESTIC
## Gabriel   17.3140551717  4.58706845064  6  2.53447342431  3 DOMESTIC
## Matthew   19.2292044834 -8.71689720545 10 16.59889688575  3  FOREIGN
## Connor    27.9465601961  7.62679430190  4  9.41608770125  2 DOMESTIC
## Jayce     12.7987723081  7.65083431266 12 33.67700546833  4 DOMESTIC
## Isaac     20.9250059175  6.97589229327  8 13.41623972467  1 DOMESTIC
## Sebastian 25.4475417562 -4.14283324499  4 14.48165316059  1 DOMESTIC
## Henry     20.3255535760 -7.68715328071  5  1.86204848578  3  FOREIGN
## Muhammad  19.3224053468  6.86658281367  5  0.89087679796  1 DOMESTIC
## Cameron   23.1979012962  6.40392027795  4  4.53756862041  6 DOMESTIC
## Wyatt     16.8453014287  2.39155431744  7  2.31495066879  2 DOMESTIC
## Dylan     13.7711261139  7.00975463260  8  0.33580724197  3  FOREIGN
## Nathan    28.7970019569 -0.47425939236  7  4.20980738942  3  FOREIGN
## Nicholas  18.3450878009  3.43042110559  9  4.63456913782  0 DOMESTIC
## Julian     9.8663110100 -9.04915789608  5  1.19125616178  5 DOMESTIC
## Eli        8.5937873188 -8.96724172868  6 14.65634303651  3 DOMESTIC
## Levi      15.7726459667 -9.49095927645  5  1.63986757211  1 DOMESTIC
## Isaiah    28.6491940028  2.01419946272  4  1.74438478751  3  FOREIGN
## Landon    13.8552894249  5.70753939450  4  8.46269210581  2 DOMESTIC
## David     27.1197440379 -1.65694099385  6  4.59554157592  4  FOREIGN
## Christian 16.3367441144 -0.46075478662  7  6.19667902216  1 DOMESTIC
## Andrew    24.1393405832  5.93811369035  3  2.50256112171  3  FOREIGN
## Brayden   21.2319754503 -7.74253831245  5  5.42388661020  3 DOMESTIC
## John      20.5356838157  8.04450385738  8 31.37685165179  2 DOMESTIC
## Lincoln   15.5342208436  2.33737929724  6  0.14586088154  3 DOMESTIC
```

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

```
table(DF$X6)

##
## DOMESTIC  FOREIGN
##       76       24

table(DF$X6)/n#TO-DO

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

Print out a summary of the whole dataframe.

```
summary(DF)#TO-DO

##       X1                  X2                  X3
##  Min.   : 6.8841207   Min.   :-9.8802376   Min.   : 1.00
##  1st Qu.:13.8927436   1st Qu.:-4.8913220   1st Qu.: 4.00
##  Median :17.3653080   Median : 0.8538233   Median : 6.00
##  Mean   :18.0746704   Mean   : 0.1128202   Mean   : 5.97
##  3rd Qu.:21.0322860   3rd Qu.: 5.3674130   3rd Qu.: 8.00
##  Max.   :33.1275499   Max.   : 9.8317473   Max.   :13.00
##       X4                  X5            X6
##  Min.   : 0.14586088   Min.   :0.00   DOMESTIC:76
##  1st Qu.: 1.98128962   1st Qu.:1.00   FOREIGN :24
##  Median : 6.08190704   Median :2.00
##  Mean   : 9.26567897   Mean   :2.45
##  3rd Qu.:13.49123954   3rd Qu.:3.00
##  Max.   :54.68653009   Max.   :6.00
```

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

```
n <- 50
R <- matrix(sample(c(rep(0, 1250), rep(1, 625), rep(2,625))), nrow = n, ncol
= n)
R

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

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

```
## [5,]    0    2    0    1    1    0    0    0    2    2    1
0
## [6,]    2    0    0    2    1    2    1    0    0    0    2
0
## [7,]    2    0    0    0    1    2    0    0    1    2    2
2
## [8,]    0    2    0    0    1    0    0    0    0    0    0
1
## [9,]    0    2    2    1    0    1    1    1    1    1    0
0
## [10,]   0    1    2    1    1    1    1    0    0    2    1
1
## [11,]   1    2    2    0    1    0    0    0    2    0    0
0
## [12,]   0    0    1    0    1    0    1    2    0    0    2
1
## [13,]   0    0    0    0    0    2    0    2    1    1    2
2
## [14,]   0    2    2    0    2    1    0    0    1    1    2
0
## [15,]   2    0    0    2    0    0    0    2    2    0    1
2
## [16,]   0    1    2    0    2    0    0    2    2    2    0
0
## [17,]   0    0    1    2    0    0    0    0    1    0    0
1
## [18,]   2    0    0    2    1    0    1    2    1    0    0
2
## [19,]   0    2    2    0    0    0    0    0    1    0    1
1
## [20,]   2    0    2    1    1    2    0    0    2    2    2
2
## [21,]   2    2    1    2    2    0    1    0    0    2    1
2
## [22,]   1    2    0    1    2    0    0    0    0    1    1
0
## [23,]   0    0    1    1    2    1    0    1    1    0    0
2
## [24,]   0    0    0    0    1    1    0    0    0    2    0
2
## [25,]   1    0    0    0    0    1    2    0    0    0    2
2
## [26,]   0    1    0    0    0    0    1    2    2    2    2
0
## [27,]   2    0    2    0    0    2    0    0    0    2    0
1
## [28,]   0    0    2    0    0    0    0    0    0    0    0
0
## [29,]   0    2    0    0    0    0    0    1    2    0    0
0
```

```
## [30,]     1     1     0     0     1     0     0     0     2     2     2
0
## [31,]     0     0     1     2     1     2     1     0     0     0     0
1
## [32,]     0     2     2     0     0     0     1     0     1     0     1
1
## [33,]     0     1     0     0     1     0     1     0     0     0     2
0
## [34,]     2     2     2     2     0     0     0     2     0     0     1
2
## [35,]     0     0     2     0     1     1     1     0     0     2     0
2
## [36,]     2     2     0     0     2     0     0     0     0     1     0
1
## [37,]     0     1     2     2     1     1     1     0     2     2     0
2
## [38,]     0     0     1     0     0     2     0     0     2     2     0
2
## [39,]     0     0     0     0     0     1     0     1     1     1     0
0
## [40,]     1     1     0     0     0     1     2     0     1     0     1
0
## [41,]     0     1     0     0     0     0     1     0     1     1     0
0
## [42,]     1     1     0     0     0     0     1     0     1     1     1
1
## [43,]     0     0     0     1     1     0     2     2     2     1     0
1
## [44,]     1     0     1     1     2     0     2     0     0     0     2
0
## [45,]     0     0     0     1     1     0     2     1     0     0     0
0
## [46,]     0     0     2     0     1     2     0     0     0     0     1
1
## [47,]     0     0     1     0     2     1     1     1     1     1     0
0
## [48,]     1     1     1     2     1     1     0     1     0     2     0
2
## [49,]     1     2     0     0     2     2     2     0     2     2     1
0
## [50,]     2     0     2     2     1     0     1     0     2     1     2
1
##       [,26] [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34] [,35] [,36]
[,37]
##  [1,]     0     0     0     0     2     0     2     2     1     1     2
0
##  [2,]     1     2     2     2     1     1     0     1     2     1     2
2
##  [3,]     1     1     0     0     1     0     0     1     0     0     0
0
```

```
##  [4,]    2    0    2    2    1    0    2    1    1    1    0
0
##  [5,]    2    2    0    0    0    0    0    1    0    0    1
2
##  [6,]    2    0    2    0    0    2    1    0    1    0    1
2
##  [7,]    0    2    2    0    2    2    0    1    0    2    0
2
##  [8,]    0    0    2    2    0    0    1    1    1    0    0
1
##  [9,]    1    2    0    0    0    0    0    0    0    2    1
0
## [10,]    0    2    1    1    2    2    0    0    2    0    2
0
## [11,]    0    0    2    1    0    0    2    0    1    0    2
0
## [12,]    1    0    1    1    1    0    1    2    2    2    0
1
## [13,]    1    1    2    1    1    0    2    2    1    0    1
1
## [14,]    0    0    1    0    0    0    0    2    0    0    0
2
## [15,]    2    0    0    0    1    2    0    0    1    1    0
1
## [16,]    0    0    2    1    0    1    2    0    1    0    0
0
## [17,]    2    2    1    2    0    2    0    0    0    2    0
0
## [18,]    1    0    0    0    2    0    0    2    1    2    2
1
## [19,]    0    0    2    2    2    0    1    1    0    0    0
1
## [20,]    0    2    1    0    2    0    0    1    0    1    0
0
## [21,]    2    1    2    2    1    0    0    1    0    2    1
2
## [22,]    0    2    0    2    1    0    0    2    0    2    2
0
## [23,]    0    1    2    0    1    1    0    2    1    0    1
0
## [24,]    2    1    0    1    2    1    1    0    0    0    2
0
## [25,]    0    2    1    0    2    1    0    2    0    1    2
1
## [26,]    0    0    0    2    0    0    2    0    1    0    0
0
## [27,]    1    0    0    0    0    2    1    0    0    2    1
0
## [28,]    0    1    0    0    2    1    0    1    0    2    0
0
```

```
## [29,]     0     1     1     2     0     0     0     2     0     0     2
2
## [30,]     2     1     2     0     1     2     2     0     0     2     0
0
## [31,]     1     0     0     1     0     2     2     0     0     0     2
1
## [32,]     1     2     0     0     0     0     1     0     0     2     1
2
## [33,]     0     2     1     0     2     2     0     1     0     1     0
0
## [34,]     0     0     1     0     0     2     0     0     0     0     0
0
## [35,]     2     1     0     2     1     2     0     1     2     0     0
0
## [36,]     0     0     0     0     0     2     2     2     1     0     0
1
## [37,]     2     2     0     2     1     2     2     0     0     2     2
1
## [38,]     0     0     0     0     0     2     0     2     1     2     0
0
## [39,]     2     0     0     0     2     2     2     0     2     1     0
1
## [40,]     1     2     2     0     1     0     0     0     1     2     0
0
## [41,]     0     0     0     1     1     0     2     0     0     0     0
1
## [42,]     2     1     1     0     0     0     2     1     0     0     1
1
## [43,]     2     2     1     0     0     0     0     0     0     0     2
2
## [44,]     2     0     1     2     2     0     1     0     1     2     0
0
## [45,]     0     1     0     0     0     0     0     0     0     2     0
2
## [46,]     0     2     2     1     2     0     2     0     0     0     0
2
## [47,]     1     1     1     1     1     2     2     1     0     0     2
1
## [48,]     2     0     1     0     1     1     0     0     0     0     2
1
## [49,]     0     0     2     1     2     0     0     2     0     0     0
2
## [50,]     1     1     0     0     0     1     1     2     1     2     0
0
##      [,38] [,39] [,40] [,41] [,42] [,43] [,44] [,45] [,46] [,47] [,48]
[,49]
##  [1,]     1     0     1     0     1     1     0     1     2     0     0
1
##  [2,]     1     2     0     1     1     1     0     0     0     0     1
0
```

```
##  [3,]    0    0    2    0    1    1    1    0    0    0    2
0
##  [4,]    2    2    2    1    2    0    2    0    1    1    0
0
##  [5,]    1    0    0    0    0    0    0    2    0    0    0
1
##  [6,]    0    1    2    0    0    0    2    0    1    0    0
1
##  [7,]    0    0    2    1    2    0    0    2    0    2    0
0
##  [8,]    2    1    0    0    0    2    2    1    0    1    0
0
##  [9,]    1    0    0    1    0    0    1    2    0    1    2
1
## [10,]    0    2    1    0    2    0    2    2    2    2    2
1
## [11,]    0    1    2    2    0    1    2    0    0    2    0
0
## [12,]    2    0    2    0    2    2    1    0    0    2    0
0
## [13,]    0    0    0    0    1    2    0    0    0    0    2
0
## [14,]    2    0    2    2    2    1    0    0    1    2    0
1
## [15,]    0    0    0    1    0    0    1    0    1    0    2
0
## [16,]    2    1    2    2    0    2    0    1    1    2    0
0
## [17,]    1    0    1    2    0    0    0    0    0    1    1
1
## [18,]    0    0    0    1    0    0    1    1    1    1    2
2
## [19,]    1    0    0    2    0    1    0    0    1    0    0
0
## [20,]    0    0    2    1    0    0    0    0    0    0    0
0
## [21,]    0    2    1    0    1    0    0    0    0    1    2
0
## [22,]    2    1    2    2    0    1    0    2    2    2    1
0
## [23,]    0    0    1    0    0    0    1    1    1    2    0
1
## [24,]    0    1    2    0    0    0    0    0    0    1    1
0
## [25,]    0    0    0    0    2    1    1    0    0    2    2
1
## [26,]    1    0    0    1    1    0    0    0    2    2    0
1
## [27,]    0    0    2    2    2    1    0    0    0    0    0
0
```

```
## [28,]      1      0      1      0      0      1      0      0      1      1      1
0
## [29,]      0      2      0      2      0      0      0      0      1      1      2
0
## [30,]      1      2      0      0      1      0      0      0      1      1      0
0
## [31,]      0      0      0      0      2      2      1      0      1      1      0
0
## [32,]      2      1      0      0      1      1      1      2      2      0      0
1
## [33,]      0      0      0      0      0      1      1      2      0      1      1
0
## [34,]      0      0      0      0      1      0      2      1      0      1      2
1
## [35,]      1      0      2      1      0      1      0      1      0      0      0
0
## [36,]      0      2      1      2      2      0      2      0      0      0      1
0
## [37,]      1      0      2      1      2      0      2      0      1      2      0
1
## [38,]      2      0      1      2      0      2      1      1      0      0      1
0
## [39,]      0      1      0      2      2      2      1      0      1      0      0
2
## [40,]      1      0      0      0      0      1      0      0      1      0      0
2
## [41,]      0      1      1      1      0      0      0      1      2      0      0
0
## [42,]      0      0      0      1      0      1      1      0      1      2      1
2
## [43,]      0      1      0      0      0      0      0      0      0      1      2
0
## [44,]      0      0      1      0      0      0      1      1      2      2      0
0
## [45,]      0      2      0      1      0      0      0      1      1      2      2
1
## [46,]      0      0      2      1      2      1      1      1      0      1      0
2
## [47,]      0      2      0      1      0      1      0      2      0      1      0
0
## [48,]      0      0      2      0      1      1      0      0      0      2      0
1
## [49,]      0      0      2      0      0      1      0      0      0      1      0
2
## [50,]      2      1      0      0      0      2      0      2      0      1      1
1
##        [,50]
##  [1,]      0
##  [2,]      2
##  [3,]      0
```

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

#TO-DO

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

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

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

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

```
0
## [42,]      2      1     NA      0      2      0     NA      1      1     NA      0
2
## [43,]      1      2      2      2      2     NA      2      0      0     NA     NA
0
## [44,]      0      0      0      1     NA      2      2     NA      2      2     NA
NA
## [45,]     NA      0      0      0      1      0     NA      0      2      0      1
0
## [46,]      0      1      0      1      2      2      0      2      1      1      1
0
## [47,]      0      0     NA      2      1      0     NA     NA      1      0      0
0
## [48,]      1      2      1     NA      0      0      0      1      1     NA     NA
2
## [49,]      2      0      1      1      0      2      1     NA      0      0      0
0
## [50,]      0     NA      0     NA     NA      2      0     NA      2      2     NA
2
##      [,26] [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34] [,35] [,36]
[,37]
##  [1,]     NA      2      1     NA     NA     NA     NA      0      0      0     NA
0
##  [2,]      0      1      0      0      1     NA      0      0     NA      1     NA
NA
##  [3,]     NA      1      1      0     NA     NA      0      0      0      1      2
NA
##  [4,]      2      0      1     NA     NA     NA     NA      2      0      2      2
NA
##  [5,]      0      0      0      1     NA      0      1     NA     NA      1     NA
2
##  [6,]     NA      0      1      0      2     NA     NA      1      0     NA      0
0
##  [7,]     NA      0      2      0      2      0      0     NA     NA      2      0
1
##  [8,]      0      1      0      0      0      2      0      0     NA     NA     NA
0
##  [9,]      0      1      2      1      1      0      0     NA      2      0      0
2
## [10,]     NA     NA     NA      0     NA      1     NA      0      2     NA      0
1
## [11,]      2      1     NA     NA     NA      0     NA      1     NA      0      0
2
## [12,]      1      0      0     NA      0      0      0     NA      0      0      2
2
## [13,]     NA      2      2     NA      0     NA     NA     NA     NA     NA      2
NA
## [14,]     NA      0      0      1      2      2      0      0      0      0      1
0
## [15,]     NA      0      2      0      0      0     NA      0     NA      0      1
```

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

```
0
## [41,]    NA    NA     1    NA     0     1    NA    NA     2    NA     1
2
## [42,]     0    NA    NA     1     1    NA     1     1    NA     1    NA
2
## [43,]    NA     1     1     1     2     0     1    NA    NA     2    NA
0
## [44,]     0     0     1     0    NA     0     2     1     1     1     1
0
## [45,]     0     0    NA     2     0     1     2     0    NA     1     2
2
## [46,]     1    NA     1     0    NA     0    NA     2     0     2    NA
NA
## [47,]     0     2     0     0     2    NA     0     2    NA     1     0
NA
## [48,]     1     0     0    NA     0     1    NA     1    NA     0     0
NA
## [49,]     1     1    NA     1    NA     1    NA    NA     1     0    NA
0
## [50,]     0     0     1     0     0    NA    NA    NA    NA    NA    NA
NA
##        [,38] [,39] [,40] [,41] [,42] [,43] [,44] [,45] [,46] [,47] [,48]
[,49]
## [1,]     NA     0     2     2     1     2     2    NA     0     2    NA
NA
## [2,]      0    NA     2     0    NA     0    NA    NA    NA     2     0
0
## [3,]     NA    NA     1    NA    NA     0    NA     2     1     1    NA
2
## [4,]      0     2     2     0     0     1    NA     2     0     0     0
0
## [5,]      2     2     1     0     1     0     1     2     0     2     0
NA
## [6,]      0    NA     0    NA     0     1     0    NA     1     2    NA
0
## [7,]      0     0     0     2    NA     0     2    NA     0    NA     2
1
## [8,]     NA     2    NA     0    NA    NA     0     2     0     0    NA
NA
## [9,]      1     0     1     0    NA     1    NA    NA    NA     0     2
2
## [10,]     0     1     1    NA     2     0     0     1     0     2     0
0
## [11,]     0     0     0     2     1     2     0    NA     2     1    NA
0
## [12,]     0     0     0     2     0    NA     0     0     2    NA     2
0
## [13,]    NA    NA    NA    NA     0     2     1     2     2    NA     2
NA
## [14,]    NA     0     0     0     0     1     0     2     2     2     2
```

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

```
NA
## [40,]    2    1    0    0    0   NA   NA   NA   NA   NA   NA
NA
## [41,]    0   NA    1   NA    1   NA    1    2   NA    0    0
NA
## [42,]    0    1    1   NA   NA    0    0    0    2    2    0
0
## [43,]    2    1    1    1    0    2    2    0   NA   NA   NA
NA
## [44,]    2   NA    0   NA    0   NA   NA   NA   NA   NA    0
1
## [45,]   NA    0    2    0    0    1    0    0    2    0   NA
0
## [46,]    0    1    0    2    2    1    2    0    1   NA    1
1
## [47,]    0   NA   NA   NA   NA   NA    0    0    0    0    0
NA
## [48,]   NA   NA    0    0   NA    0    2   NA   NA    0    0
NA
## [49,]   NA   NA   NA    0   NA   NA   NA    2    0    1    2
NA
## [50,]    2   NA   NA    0    2    0    0   NA    0    1   NA
0
##       [,50]
##  [1,]     1
##  [2,]     0
##  [3,]     1
##  [4,]     1
##  [5,]     0
##  [6,]     0
##  [7,]     1
##  [8,]     2
##  [9,]     0
## [10,]     0
## [11,]    NA
## [12,]    NA
## [13,]     0
## [14,]     0
## [15,]     0
## [16,]     2
## [17,]    NA
## [18,]     0
## [19,]     0
## [20,]     0
## [21,]    NA
## [22,]     1
## [23,]     1
## [24,]    NA
## [25,]     0
## [26,]     0
```

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

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

```
order(rowSums(R, na.rm = TRUE), decreasing = TRUE)#TO-DO
```

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

- 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)#TO-DO
```

```
## 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,] 10.2347297494  7.7229338169
##  [2,]  6.2344340577  5.5586191625
```

```
##  [3,] 10.3835987404  6.2643525655
##  [4,] 10.4389238081 12.1002471875
##  [5,]  6.0573668635  7.0333024702
##  [6,]  4.7459445821  9.6117658111
##  [7,]  8.8437560759  4.7573763652
##  [8,]  9.4102022381  6.5398253067
##  [9,]  9.4531312997  5.4724720952
## [10,]  6.8537046418  6.4526325311
## [11,]  6.3600043078 22.3443983299
## [12,] 12.4650813090  5.7387325024
## [13,]  5.5724547231  6.9900054271
## [14,]  8.5790832970  5.2329387535
## [15,] 12.2605342083  6.3385905091
## [16,] 13.1899582510 10.7987731504
## [17,]  5.2453413504 12.5326443028
## [18,]  7.0231794054  7.5262697423
## [19,]  7.7237568445  5.7784833812
## [20,]  7.0033349691  6.0143654740
## [21,]  7.3802496332  4.5402991200
## [22,]  9.5829942059  6.9521540367
## [23,]  5.5995709531  6.6305490789
## [24,] 10.4018070009 14.1366250816
## [25,] 10.1151090352  6.2085974552
## [26,]  5.4598746286  7.7003848755
## [27,]  6.8046277447  6.0978367862
## [28,]  9.0445078118 10.4840971172
## [29,]  9.1839466590 10.1441647241
## [30,]  4.4918617312 11.8055996465
## [31,]  6.5102675987  7.8682319820
## [32,]  6.1653666986 11.0833584915
## [33,]  8.2164604523  9.1503278208
## [34,]  8.4293486721  7.2790025660
## [35,]  6.5876037841  8.0873735416
## [36,]  9.5996331123  6.2011917619
## [37,]  4.9407341991  5.1011273996
## [38,] 10.5842313418 10.8661637298
## [39,]  6.9173579150  6.9542839837
## [40,] 11.4822160540  6.4283247262
## [41,]  9.7369482867  8.0464175727
## [42,]  4.5362455088  8.1883114529
## [43,]  8.7028155873 10.7865172403
## [44,]  5.3885989760  4.9639942847
## [45,]  3.2730344324 10.3090286839
## [46,] 10.0355621090  6.3995745253
## [47,]  7.3616866032  8.7422594377
## [48,] 12.1159836870  9.5230358725
## [49,]  8.2042559114 12.0272242280
## [50,] 10.8432387175  5.8333426880
```

- 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(R, MARGIN = 2, function(x) sum(na.omit(x!=0)))#TO-DO
```

```
##  [1] 23 18 15 15 14 13 21 17 16 21 20 14 15 21 14 22 24 16 19 14 22 22 12
21 16
## [26] 16 25 23 14 14 15 14 14 17 21 14 22 15 18 19 18 18 16 14 19 18 21 20
15 14
```

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

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

```
## 
## $`7`
##  [1]  0  0  0  0  2 NA  1  1 NA NA NA  1  1 NA NA NA  2 NA  2 NA  0  0  1
0  1
## [26]  1 NA  2  0  2 NA  0  1 NA NA  2  2  2  0  1 NA  2  1 NA NA  2  0 NA
2 NA
## 
## $`8`
##  [1] NA  2 NA  1  2 NA NA NA  0  2  0 NA NA  0  0  0  1  2  0  0 NA  2 NA
NA  1
## [26] NA NA  0  0  2 NA  1  0  0  0  2  2  2  0  0  1 NA  2  1 NA  1  0  0
0  0
## 
## $`9`
##  [1]  2 NA  0  0  0  2  1  2 NA  2  1  0  2  0 NA  2  2 NA  0  0  2  2  1
2  2
## [26]  0  0  0 NA NA NA NA NA NA  0  0 NA  0  0 NA  1 NA NA  0 NA  2  0 NA
0  0
## 
## $`10`
##  [1]  1  2  1 NA NA  1  2 NA  1  0  1  1  0 NA  2 NA NA NA  2  0  1  0 NA
NA  2
## [26] NA NA  1 NA  2 NA NA  0 NA NA NA  1 NA  2 NA  1  0  1 NA  1 NA  1 NA
NA  1
## 
## $`11`
##  [1]  2  1  0  1  1  2  0  2  2  1  0  1  0 NA NA  1 NA  0  0  2  2  0  1
0  0
## [26]  0 NA NA  2 NA  2 NA NA  0  1  2 NA  0  0 NA  0  2 NA  1  0 NA NA  2
0 NA
## 
## $`12`
##  [1]  2  2  1  0 NA NA  2  0  1 NA NA NA  0 NA  1 NA  2 NA  2  0  0  0  0
NA NA
## [26]  0  0  0  1  0 NA  0  0 NA NA  0 NA  1  2  1  0  0 NA NA NA NA NA  1
2  0
## 
## $`13`
##  [1]  0  1 NA  2  2 NA  2  0 NA  0 NA  2  0  2  0 NA  0  2  0 NA  0  0 NA
0 NA
## [26]  2  1  0  0 NA NA  2  2  2  1  0  0  0 NA  1 NA  0 NA NA  0 NA NA  0
0  2
## 
## $`14`
##  [1] NA  1  1 NA  0  2  0 NA  1  0 NA NA  1  0 NA  0 NA NA  1  1  0  0  0
0 NA
## [26] NA NA  2  1  1  1  2 NA  0  2  0  0  1  1  1  2  2  1  0 NA  0  0  1
2  0
## 
## $`15`
```

```
##  [1] NA NA  0  0  2 NA NA  2  1 NA NA  0  1  0  0  0  2  0 NA NA  0  0  0
## 0 NA
## [26]  2  0 NA  2  1  0 NA  2 NA  0  2  0  0  0 NA NA  1  2  0  0  1  0  2
## 0 NA
##
## $`16`
##  [1]  2  1  1  0 NA  1  1  2  0  0  0  1  0  0 NA NA  0  0  0  0  2 NA  2
## NA  2
## [26] NA  2  0  1  2 NA  0  2  1  2  1 NA  2  1  0  0 NA  2  0  0  0 NA  1
## 1  0
##
## $`17`
##  [1]  2 NA NA NA NA  0 NA  2  2 NA  0  2  2  1  1  1  1  0  2  0 NA  1  1
## 2  0
## [26]  0  1  1 NA  2  0  2 NA NA  1  1  0  0  0  0  0  0  2  1  0  1  2 NA
## 1 NA
##
## $`18`
##  [1]  0 NA  0  0 NA  1 NA NA  2  2  1  0 NA  0  0  0  0  0  0  1  0  1  0
## NA NA
## [26] NA NA  0 NA  2 NA  2  0 NA  0 NA  0  1  0  1  1  2  2 NA  1  2  1  0
## 0 NA
##
## $`19`
##  [1]  2  1  1 NA NA NA NA NA  0  0  0 NA NA  2  0 NA  2  2  2  1  0  2 NA
## NA  0
## [26]  1  0 NA  0 NA  1  2 NA NA  1  1 NA  0 NA  1  0  0 NA  2  0  2  0  0
## 2  2
##
## $`20`
##  [1]  2  0 NA  1  1 NA  0  1  0  0  2  2 NA  1  0  0  0 NA NA  2 NA NA  0
## 2 NA
## [26]  2  0 NA NA  0  0  0 NA  0  0  0  1 NA NA NA  0 NA  2  2 NA  0 NA  0
## 1  0
##
## $`21`
##  [1]  0  1 NA NA  0  0  2  0  1  0  0  1  0  2  2  1  1 NA NA  0  2  2 NA
## NA  0
## [26]  2  2 NA  2 NA  2  0 NA  0 NA  2  2  1  1  0  1  1  0 NA  0  2 NA  1
## NA NA
##
## $`22`
##  [1] NA NA  2  2  1  0  2 NA  0 NA  0 NA  1  1 NA NA  2  1  0  0  2  0  0
## 1  2
## [26] NA  0  0  2 NA  1  0  0 NA  2  1 NA  0  0  0 NA  1  0  2  2  1  1  1
## 0  2
##
## $`23`
##  [1]  0  1  1  0  2  0 NA  0 NA  0  0  0  0  1 NA  0  0  2  2  0  0 NA  0
## NA NA
```

```
## [26] NA NA  0  0  0 NA NA  2  1 NA  1  0  0  0  0 NA NA NA  2  0  1  0 NA
## 0  2
##
## $`24`
##  [1]  0  0  2  2  0  1  1  1  1 NA  1  0  0 NA  2  0 NA  0  2  0  0  0  2
## NA  0
## [26] NA  0  2  1  0  1  0  2  2  2 NA  1 NA  1  0  1  0 NA NA  1  1  0 NA
## 0 NA
##
## $`25`
##  [1]  1 NA NA  1  0 NA NA  1  0  0  0  2  0  2 NA NA  2  0 NA  0  0  1  0
## NA  0
## [26]  0  0  0  2  0  0  1  0  2  0  0  0  2  1  1  0  2  0 NA  0  0  0  2
## 0  2
##
## $`26`
##  [1] NA  0 NA  2  0 NA NA  0  0 NA  2  1 NA NA NA NA  0  2 NA  1  2  0 NA
## 0  1
## [26]  0  2 NA  0  2  1  2  1  0 NA NA  0 NA  2  0 NA  0 NA  0  0  1  0  1
## 1  0
##
## $`27`
##  [1]  2  1  1  0  0  0  0  1  1 NA  1  0  2  0  0  1  0 NA  0  1  2  1  2
## 1  2
## [26] NA  0  1 NA NA  1  1 NA  1  1  2 NA  2 NA  2 NA NA  1  0  0 NA  2  0
## 1  0
##
## $`28`
##  [1]  1  0  1  1  0  1  2  0  2 NA NA  0  2  0  2  2 NA  0  0  0  1  2  1
## 0 NA
## [26]  2  2  1  0  1  1  0  0  0 NA  0  0  0  1 NA  1 NA  1  1 NA  1  0  0
## NA  1
##
## $`29`
##  [1] NA  0  0 NA  1  0  0  0  1  0 NA NA NA  1  0  1  0  2 NA  2  2 NA NA
## NA NA
## [26]  0  0  0  0 NA  0 NA  0 NA  1  0 NA  1  0  2 NA  1  1  0  2  0  0 NA
## 1  0
##
## $`30`
##  [1] NA  1 NA NA NA  2  2  0  1 NA NA  0  0  2  0  1 NA  2  0  0  0  0 NA
## 0 NA
## [26]  0  2  0  0  2 NA  1  0  2 NA NA NA  0 NA NA  0  1  2 NA  0 NA  2  0
## NA  0
##
## $`31`
##  [1] NA NA NA NA  0 NA  0  2  0  1  0  0 NA  2  0 NA  0  2  2  0  0 NA  2
## 0  0
## [26]  2 NA  0  1 NA  0  1  0  0 NA  2  1  0  0  0  1 NA  0  0  1  0 NA  1
## 1 NA
```

```
## 
## $`32`
##  [1] NA  0  0 NA  1 NA  0  0  0 NA NA  0 NA  0 NA  2 NA NA NA  0  1  0 NA
NA NA
## [26] NA  1  0  1 NA  0  0  1  1  0  0  2  1  2  0 NA  1  1  2  2 NA  0 NA
NA NA
## 
## $`33`
##  [1]  0  0  0  2 NA  1 NA  0 NA  0  1 NA NA  0  0  2  0 NA  0  0  0 NA  1
0 NA
## [26] NA  2 NA  0 NA  2  0  0 NA  2  2 NA  0  0 NA NA  1 NA  1  0  2  2  1
NA NA
## 
## $`34`
##  [1]  0 NA  0  0 NA  0 NA NA  2  2 NA  0 NA  0 NA  2 NA  0  0  2  1 NA  2
0  0
## [26] NA  1  0 NA  2  2  0  2  2 NA  2  0  2  1  0  2 NA NA  1 NA  0 NA NA
1 NA
## 
## $`35`
##  [1]  0  1  1  2  1 NA  2 NA  0 NA  0  0 NA  0  0  0  0  0  0  0  1  2  0
NA  2
## [26]  2  0  0  2 NA  1 NA NA  1 NA  1  2 NA NA  1 NA  1  2  1  1  2  1  0
0 NA
## 
## $`36`
##  [1] NA NA  2  2 NA  0  0 NA  0  0  0  2  2  1  1 NA  0 NA  0  1  0  0  2
0 NA
## [26]  1 NA  0  0 NA NA NA  2 NA  1 NA  0  0 NA  0  1 NA NA  1  2 NA  0  0
NA NA
## 
## $`37`
##  [1]  0 NA NA NA  2  0  1  0  2  1  2  2 NA  0  0  2  2  1 NA  1 NA  1  1
NA NA
## [26]  2  1  1 NA  0  2  0  1  2  2  0  0  0  0  0  2  2  0  0  2 NA NA NA
0 NA
## 
## $`38`
##  [1] NA  0 NA  0  2  0  0 NA  1  0  0  0 NA NA NA  1  1  2  0  1 NA NA  2
0  0
## [26]  0  0 NA NA NA NA  1  2  0  0  1 NA  1 NA  2  0  0  2  2 NA  0  0 NA
NA  2
## 
## $`39`
##  [1]  0 NA NA  2  2 NA  0  2  0  1  0  0 NA  0 NA  2 NA  0 NA  2  2  1 NA
2  0
## [26]  2  0 NA NA  0  0  1 NA NA  0 NA  1  1  2  1 NA  1  1 NA  0  1 NA NA
NA NA
## 
## $`40`
```

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

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

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

```r
lapply(split(R, col(R)), function(R) {list(min = min(R, na.rm = T), max =
max(R, na.rm = T), pct_missing = (sum(is.na(R)) / n), first_NA =
min(which(is.na(R))))})#TO-DO
```

```
## $`1`
## $`1`$min
## [1] 0
##
## $`1`$max
## [1] 2
##
## $`1`$pct_missing
## [1] 0.22
##
## $`1`$first_NA
## [1] 1
##
##
## $`2`
## $`2`$min
## [1] 0
##
## $`2`$max
## [1] 2
##
## $`2`$pct_missing
## [1] 0.3
##
## $`2`$first_NA
## [1] 1
```

```
## 
## 
## $`3`
## $`3`$min
## [1] 0
## 
## $`3`$max
## [1] 2
## 
## $`3`$pct_missing
## [1] 0.28
## 
## $`3`$first_NA
## [1] 11
## 
## 
## $`4`
## $`4`$min
## [1] 0
## 
## $`4`$max
## [1] 2
## 
## $`4`$pct_missing
## [1] 0.28
## 
## $`4`$first_NA
## [1] 6
## 
## 
## $`5`
## $`5`$min
## [1] 0
## 
## $`5`$max
## [1] 2
## 
## $`5`$pct_missing
## [1] 0.16
## 
## $`5`$first_NA
## [1] 13
## 
## 
## $`6`
## $`6`$min
## [1] 0
## 
## $`6`$max
## [1] 2
```

```
##
## $`6`$pct_missing
## [1] 0.3
##
## $`6`$first_NA
## [1] 2
##
##
## $`7`
## $`7`$min
## [1] 0
##
## $`7`$max
## [1] 2
##
## $`7`$pct_missing
## [1] 0.36
##
## $`7`$first_NA
## [1] 6
##
##
## $`8`
## $`8`$min
## [1] 0
##
## $`8`$max
## [1] 2
##
## $`8`$pct_missing
## [1] 0.3
##
## $`8`$first_NA
## [1] 1
##
##
## $`9`
## $`9`$min
## [1] 0
##
## $`9`$max
## [1] 2
##
## $`9`$pct_missing
## [1] 0.32
##
## $`9`$first_NA
## [1] 2
##
##
```

```
## $`10`
## $`10`$min
## [1] 0
##
## $`10`$max
## [1] 2
##
## $`10`$pct_missing
## [1] 0.46
##
## $`10`$first_NA
## [1] 4
##
##
## $`11`
## $`11`$min
## [1] 0
##
## $`11`$max
## [1] 2
##
## $`11`$pct_missing
## [1] 0.28
##
## $`11`$first_NA
## [1] 14
##
##
## $`12`
## $`12`$min
## [1] 0
##
## $`12`$max
## [1] 2
##
## $`12`$pct_missing
## [1] 0.38
##
## $`12`$first_NA
## [1] 5
##
##
## $`13`
## $`13`$min
## [1] 0
##
## $`13`$max
## [1] 2
##
## $`13`$pct_missing
```

```
## [1] 0.32
##
## $`13`$first_NA
## [1] 3
##
##
## $`14`
## $`14`$min
## [1] 0
##
## $`14`$max
## [1] 2
##
## $`14`$pct_missing
## [1] 0.26
##
## $`14`$first_NA
## [1] 1
##
##
## $`15`
## $`15`$min
## [1] 0
##
## $`15`$max
## [1] 2
##
## $`15`$pct_missing
## [1] 0.3
##
## $`15`$first_NA
## [1] 1
##
##
## $`16`
## $`16`$min
## [1] 0
##
## $`16`$max
## [1] 2
##
## $`16`$pct_missing
## [1] 0.2
##
## $`16`$first_NA
## [1] 5
##
##
## $`17`
## $`17`$min
```

```
## [1] 0
##
## $`17`$max
## [1] 2
##
## $`17`$pct_missing
## [1] 0.24
##
## $`17`$first_NA
## [1] 2
##
##
## $`18`
## $`18`$min
## [1] 0
##
## $`18`$max
## [1] 2
##
## $`18`$pct_missing
## [1] 0.3
##
## $`18`$first_NA
## [1] 2
##
##
## $`19`
## $`19`$min
## [1] 0
##
## $`19`$max
## [1] 2
##
## $`19`$pct_missing
## [1] 0.34
##
## $`19`$first_NA
## [1] 4
##
##
## $`20`
## $`20`$min
## [1] 0
##
## $`20`$max
## [1] 2
##
## $`20`$pct_missing
## [1] 0.34
##
```

```
## $`20`$first_NA
## [1] 3
##
##
## $`21`
## $`21`$min
## [1] 0
##
## $`21`$max
## [1] 2
##
## $`21`$pct_missing
## [1] 0.28
##
## $`21`$first_NA
## [1] 3
##
##
## $`22`
## $`22`$min
## [1] 0
##
## $`22`$max
## [1] 2
##
## $`22`$pct_missing
## [1] 0.24
##
## $`22`$first_NA
## [1] 1
##
##
## $`23`
## $`23`$min
## [1] 0
##
## $`23`$max
## [1] 2
##
## $`23`$pct_missing
## [1] 0.3
##
## $`23`$first_NA
## [1] 7
##
##
## $`24`
## $`24`$min
## [1] 0
##
```

```
## $`24`$max
## [1] 2
##
## $`24`$pct_missing
## [1] 0.22
##
## $`24`$first_NA
## [1] 10
##
##
## $`25`
## $`25`$min
## [1] 0
##
## $`25`$max
## [1] 2
##
## $`25`$pct_missing
## [1] 0.18
##
## $`25`$first_NA
## [1] 2
##
##
## $`26`
## $`26`$min
## [1] 0
##
## $`26`$max
## [1] 2
##
## $`26`$pct_missing
## [1] 0.34
##
## $`26`$first_NA
## [1] 1
##
##
## $`27`
## $`27`$min
## [1] 0
##
## $`27`$max
## [1] 2
##
## $`27`$pct_missing
## [1] 0.22
##
## $`27`$first_NA
## [1] 10
```

```
## 
## 
## $`28`
## $`28`$min
## [1] 0
## 
## $`28`$max
## [1] 2
## 
## $`28`$pct_missing
## [1] 0.18
## 
## $`28`$first_NA
## [1] 10
## 
## 
## $`29`
## $`29`$min
## [1] 0
## 
## $`29`$max
## [1] 2
## 
## $`29`$pct_missing
## [1] 0.32
## 
## $`29`$first_NA
## [1] 1
## 
## 
## $`30`
## $`30`$min
## [1] 0
## 
## $`30`$max
## [1] 2
## 
## $`30`$pct_missing
## [1] 0.36
## 
## $`30`$first_NA
## [1] 1
## 
## 
## $`31`
## $`31`$min
## [1] 0
## 
## $`31`$max
## [1] 2
```

```
## 
## $`31`$pct_missing
## [1] 0.28
## 
## $`31`$first_NA
## [1] 1
## 
## 
## $`32`
## $`32`$min
## [1] 0
## 
## $`32`$max
## [1] 2
## 
## $`32`$pct_missing
## [1] 0.4
## 
## $`32`$first_NA
## [1] 1
## 
## 
## $`33`
## $`33`$min
## [1] 0
## 
## $`33`$max
## [1] 2
## 
## $`33`$pct_missing
## [1] 0.36
## 
## $`33`$first_NA
## [1] 5
## 
## 
## $`34`
## $`34`$min
## [1] 0
## 
## $`34`$max
## [1] 2
## 
## $`34`$pct_missing
## [1] 0.36
## 
## $`34`$first_NA
## [1] 2
## 
## 
```

```
## $`35`
## $`35`$min
## [1] 0
##
## $`35`$max
## [1] 2
##
## $`35`$pct_missing
## [1] 0.26
##
## $`35`$first_NA
## [1] 6
##
##
## $`36`
## $`36`$min
## [1] 0
##
## $`36`$max
## [1] 2
##
## $`36`$pct_missing
## [1] 0.38
##
## $`36`$first_NA
## [1] 1
##
##
## $`37`
## $`37`$min
## [1] 0
##
## $`37`$max
## [1] 2
##
## $`37`$pct_missing
## [1] 0.26
##
## $`37`$first_NA
## [1] 2
##
##
## $`38`
## $`38`$min
## [1] 0
##
## $`38`$max
## [1] 2
##
## $`38`$pct_missing
```

```
## [1] 0.34
##
## $`38`$first_NA
## [1] 1
##
##
## $`39`
## $`39`$min
## [1] 0
##
## $`39`$max
## [1] 2
##
## $`39`$pct_missing
## [1] 0.38
##
## $`39`$first_NA
## [1] 2
##
##
## $`40`
## $`40`$min
## [1] 0
##
## $`40`$max
## [1] 2
##
## $`40`$pct_missing
## [1] 0.26
##
## $`40`$first_NA
## [1] 8
##
##
## $`41`
## $`41`$min
## [1] 0
##
## $`41`$max
## [1] 2
##
## $`41`$pct_missing
## [1] 0.34
##
## $`41`$first_NA
## [1] 3
##
##
## $`42`
## $`42`$min
```

```
## [1] 0
##
## $`42`$max
## [1] 2
##
## $`42`$pct_missing
## [1] 0.34
##
## $`42`$first_NA
## [1] 2
##
##
## $`43`
## $`43`$min
## [1] 0
##
## $`43`$max
## [1] 2
##
## $`43`$pct_missing
## [1] 0.34
##
## $`43`$first_NA
## [1] 8
##
##
## $`44`
## $`44`$min
## [1] 0
##
## $`44`$max
## [1] 2
##
## $`44`$pct_missing
## [1] 0.36
##
## $`44`$first_NA
## [1] 2
##
##
## $`45`
## $`45`$min
## [1] 0
##
## $`45`$max
## [1] 2
##
## $`45`$pct_missing
## [1] 0.3
##
```

```
## $`45`$first_NA
## [1] 1
##
##
## $`46`
## $`46`$min
## [1] 0
##
## $`46`$max
## [1] 2
##
## $`46`$pct_missing
## [1] 0.26
##
## $`46`$first_NA
## [1] 2
##
##
## $`47`
## $`47`$min
## [1] 0
##
## $`47`$max
## [1] 2
##
## $`47`$pct_missing
## [1] 0.32
##
## $`47`$first_NA
## [1] 7
##
##
## $`48`
## $`48`$min
## [1] 0
##
## $`48`$max
## [1] 2
##
## $`48`$pct_missing
## [1] 0.28
##
## $`48`$first_NA
## [1] 1
##
##
## $`49`
## $`49`$min
## [1] 0
##
```

```
## $`49`$max
## [1] 2
##
## $`49`$pct_missing
## [1] 0.34
##
## $`49`$first_NA
## [1] 1
##
##
## $`50`
## $`50`$min
## [1] 0
##
## $`50`$max
## [1] 2
##
## $`50`$pct_missing
## [1] 0.26
##
## $`50`$first_NA
## [1] 11
```

- 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(10)
n <- 1000
v <- rnorm(n, mean = -10, sd = sqrt(100))
v#TO-DO

##    [1]  -9.8125382905817 -11.8425254206906 -23.7133054992251 -
15.9916771578372
##    [5]  -7.0545487343249  -6.1020569929983 -22.0807617542949 -
13.6367601747086
##    [9] -26.2667268170309 -12.5647839412399   1.0177950308713  -
2.4421849197266
##   [13] -12.3823355601872  -0.1255529658661  -2.5860987161618  -
9.1065273350418
##   [17] -19.5494385615238 -11.9515038466724  -0.7447873790592  -
5.1702147516339
##   [21] -15.9631063672021 -31.8528683816953 -16.7486593787512 -
31.1906119191017
##   [25] -22.6519802153090 -13.7366155515470 -16.8755543038792 -
18.7215882671769
##   [29] -11.0176100622482 -12.5378053010246 -28.5374045447914 -
10.7794606607537
##   [33]  -0.3143365947546  -8.1507404000969 -23.7994357833758 -
24.3551436236037
##   [37]  -6.3791277139339 -27.5908675375971 -13.2454400957233 -
16.5156298854466
```

```
##   [41]    0.8655139944051 -17.6254488003129 -18.2866253500109   -
1.6552609691155
##   [45] -19.6765198675991 -10.2881533547586  -7.6747484742461 -
13.0120868150418
##   [49] -16.7761458314933  -3.4477236376478 -14.0063754703174 -
13.3455656507335
##   [53]    3.6795395319196  11.3776710365012  -4.9418073547097   -
2.1365761576084
##   [57] -19.0221194417864  -4.6710300767167 -16.4589425354921   -
7.0901251157023
##   [61] -22.3759446887722 -14.5617627511781 -18.3032265472473   -
6.5988435632574
##   [65]    0.6637639568217   2.1612583807980  -2.6430934236695 -
14.8120861731558
##   [69]   -4.3725523714188 -22.4631971188920  -6.1907778737432 -
24.3042725279669
##   [73] -20.4844550487860 -12.1850355053459 -24.8993623673554
1.7270628121431
##   [77] -24.7982702157166 -14.3038781607722 -20.5163864204345
5.2258634405410
##   [81]   -4.0717194541392 -12.2266150901927  -2.8710572375154   -
2.8339916625895
##   [85]   -5.5975813561586  -8.4116937868190  -3.4023586166805
12.2051966293556
##   [89] -21.8394507406540 -10.7395583449749 -14.1635467488652 -
11.9148234375263
##   [93]   -9.3045521859260   1.5534831801052  -4.0504265304951 -
24.1964510835699
##   [97] -26.0667724535804  -1.0707410043682  -8.5183204481227
2.2702839010139
##  [101] -17.6180433917803  -5.8062459411009 -20.3994336463235   -
2.8842603400737
##  [105] -16.3321301496783  -4.3682533554985  -3.3901331416840 -
26.5805085732545
##  [109]    0.2816797701792   1.2795361401459 -22.8015460342218
1.2886822740957
##  [113] -14.6413452716498 -13.1576020953137  -0.7570685316505   -
9.2285527601422
##  [117]    0.3992360511188  -2.5811379326182   2.5554485828951   -
0.4908103354382
##  [121] -14.8136560727329  -7.9711822203016 -10.3173974383773   -
21.9558030033457
##  [125]   -3.7631876315157 -19.1480448366691  -7.5124199229190 -
20.6262279318038
##  [129] -13.6398224719576 -22.0699485337827   4.2921278138977   -
3.6656410901717
##  [133] -29.9681561765642 -16.8183217309621 -14.6005547931070 -
19.8306919414776
##  [137]   -5.0466828711166  -2.7418249976747  -3.3270126810708   -
0.4521356353341
```

```
##   [141] -26.7533217929194 -22.0518539249191 -29.6325248922053
4.7075230981397
##   [145]  -6.2752766144940   0.6587933403768  -4.6935013164268  -
8.9801655411587
##   [149]   3.3778246578648  -9.1276523150887 -13.9110420740045 -
12.4986748459556
##   [153]   1.5510474589615 -18.6472723983100 -18.6667834236831 -
33.2101703034786
##   [157]  -3.9116983108215   1.5000604820099 -21.9959767173686 -
25.8000075454988
##   [161]  -3.4683380635781 -15.4940848512297  -4.7894547468747 -
16.9940306640950
##   [165] -14.3890931479220 -16.7731929611669  -0.4085880522465 -
24.6817332946240
##   [169]  -8.1623610733187 -24.3514718265180 -21.3739989812347 -
14.1464532687800
##   [173]  -8.5606571184864   0.6202433069828 -15.7079390273540
2.7718137641215
##   [177]  -7.7171067945992 -13.0881306450274  -0.4017086940442  -
4.5117762518792
##   [181]  -5.7448690622802  -3.5649996487183 -23.6030614350351 -
11.9850610640319
##   [185]  -3.8069732312462  10.6820960503683 -13.0528475419725  -
7.1875438777014
##   [189]  -3.0868266329410  -9.5363856185668  -8.8697063837404  -
0.0466812571087
##   [193] -16.8115136132165 -22.7705724668769 -24.6869774983108 -
13.1347406653587
##   [197] -27.0365949266331 -23.5051465613771 -21.0209367720916 -
20.9954301452935
##   [201]   2.1551377619565  -6.6912351489586   3.9027511927468  -
1.2795301497889
##   [205] -20.8081702266027  -5.0417840855346   0.5262755621631 -
22.7464995015128
##   [209] -11.9366672842338 -22.9508364255337  -8.5811971532135
2.6171505198662
##   [213] -14.3150032806965 -28.2271258950182  -6.4745604124689 -
23.4845144147378
##   [217]  -2.9231168209257 -14.1089093679878 -14.4604517992225 -
20.4115630166875
##   [221] -13.2922471615401 -12.8282162413235  -5.6757087450465 -
13.0760709506342
##   [225] -10.5663630788932  -2.6648457979973  -9.0268838033482
6.3089173658816
##   [229]  -4.3938930099780   3.2956476445216 -12.7882349563446 -
22.6673154414092
##   [233] -12.4914839404027  -9.8201158543120  -6.2292727288967  -
2.0399144247256
##   [237] -18.4067741709857 -32.0547175082621 -21.2805599106249 -
23.4130995880245
```

```
##  [241]    6.0511404288097   -2.5557627151146   -1.3791779404662   -
6.0484418452380
##  [245]   -4.9088130366967  -11.2255012583063   -9.0741535282172  -
13.5787991433363
##  [249]  -13.5965522434701    0.2857072088428    0.7789259245098   -
0.6821878476750
##  [253]  -24.6079386697760  -19.0607557624934  -16.8034783139241
0.6316603678904
##  [257]  -16.9241315212615  -21.3362826529090  -20.9461543379722  -
20.1290361883673
##  [261]   -5.8972267411411   -5.2225955807321  -33.2987954506654   -
9.8374453482326
##  [265]   -0.1964647685352   -1.9365173518264   -8.8039911110870  -
34.3661560431758
##  [269]   -9.6897752387761  -13.3574669799984  -12.6377616192376  -
13.5585246088020
##  [273]  -14.8115479829018   -7.7726453218213   14.2991031869739
4.9629811873421
##  [277]  -17.1720820275909  -14.6705390018763   -3.3707654714059
13.0017689094660
##  [281]   -6.7248985878341   -9.3613651838309  -21.3956093996767
1.8041020362035
##  [285]   -9.5861152296685  -22.1359356338470   -9.2680422337219  -
12.5732459434554
##  [289]   -7.3319358905787    3.8772432571642   -8.0692036497606   -
4.0768337739957
##  [293]  -18.2997452691578   -6.0742671835751   -6.1513238931919
0.5104466572565
##  [297]    1.5579748458375  -20.3443795894203  -12.5446806580427
2.7368426608477
##  [301]    5.0254463898139   -4.0959053285336  -16.3068545138345   -
2.0765046270573
##  [305]   -8.7461542987692   -6.7724502875197  -14.4558320945259   -
2.3315606553862
##  [309]  -24.0350302182772  -21.7604677961141   -4.8840353081520
3.1676526377830
##  [313]   13.9291294709557  -10.6776940849240  -12.0378506645272
9.9643445216969
##  [317]    5.4321779434101  -22.2833762626182   16.4448799222478   -
2.4298629172563
##  [321]    0.5534519215293   -0.4205510469419   -1.6612094235735  -
11.6927557001864
##  [325]  -14.0443364307844   -7.0439842629709  -12.3187450723486  -
14.4807823162639
##  [329]   -9.7768920342761   -9.5553270276387   -5.1927883470936   -
3.6438014483043
##  [333]  -30.0074239307650  -16.9065550376296  -11.3064518930652  -
13.4425178302364
##  [337]  -10.5241282396513   -9.0387607945088   -7.3359294676787   -
4.4520652472126
```

```
##  [341]    2.3544587854851   -7.1486661869311 -14.5879292777288   -
3.7652197813763
##  [345] -17.2399509164038    6.1941870348572 -16.1667341021694   -
6.1545894255312
##  [349]   11.1452131280045 -20.2856736628788 -18.8678796566786
2.7114600133104
##  [353] -26.0508544127984    1.2227338293318  11.5843864176903   -
5.7175338697736
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##  [997]   -4.7175172561890   -7.1633026119330 -10.1213930489634 -
11.9191377747732
```

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

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

```
##     [1]   -9.8125382905817 -11.8425254206906 -23.7133054992251 -
15.9916771578372
##     [5]   -7.0545487343249   -6.1020569929983 -22.0807617542949 -
13.6367601747086
##     [9] -26.2667268170309 -12.5647839412399    1.0177950308713  -
2.4421849197266
##    [13] -12.3823355601872   -0.1255529658661   -2.5860987161618  -
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##    [17] -19.5494385615238 -11.9515038466724   -0.7447873790592  -
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##    [21] -15.9631063672021 -31.8528683816953 -16.7486593787512 -
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##    [25] -22.6519802153090 -13.7366155515470 -16.8755543038792 -
```

```
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##    [29] -11.0176100622482 -12.5378053010246 -28.5374045447914   -
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##    [37]   -6.3791277139339 -27.5908675375971 -13.2454400957233   -
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##  [813]  -2.5416077121940  -5.0517584335736 -10.2193146172307  -
4.1197767373419
##  [817]  -2.4350892599763 -14.9402627261870 -17.3331562861347 -
10.0102039398779
##  [821]  -1.9417430322349   1.0930938187503 -13.0967948215953 -
19.0857824812747
##  [825]  -7.3697387231332 -10.2091780757642 -12.1234250764778 -
```

```
20.3110391977497
##  [829]  -8.6048926030375  -8.3378201538353 -19.8465964905627  -
9.7736592922938
##  [833]  -2.1466996733904 -21.7918952425080   9.1079077756379  -
15.3800149491958
##  [837]  -1.1572357097661  -8.5269036329116 -20.0842736285689  -
1.6181100779241
##  [841] -21.6823913740479  -5.4568186708000  -7.8742713249553  -
15.5308634742956
##  [845]  -9.7656997482033  -3.5182110960861 -27.4279473520386  -
4.0483733908813
##  [849] -18.7852901298319  -3.5556242870789 -16.2909850266660  -
10.9820018968384
##  [853]  -3.1578230083224 -23.8468603099041   5.5494558598051  -
18.1434134188457
##  [857] -18.4363108589257   0.2492742587361  -8.8429662360384  -
7.5850596012720
##  [861] -23.9081614168685   5.2606084457092  -9.5348376327860
2.3998235965392
##  [865]  -6.9142736453721  -2.1437239549793   1.1747870473614  -
10.0498227234439
##  [869] -11.7841821019019  -3.0377093105292  -4.7820279150645  -
14.4782659024346
##  [873]  -5.9459939595531 -17.3696442466941  -7.4425198558953  -
12.8493350493357
##  [877] -10.3112132499334 -14.8585888696012 -11.3508808415585  -
24.8071872283751
##  [881]   2.5636912568560  -7.9095835009043  -6.8684321040987
0.7514823866383
##  [885] -12.8662517457042 -10.3197742743150 -17.4273339663881
10.8522019215140
##  [889]  -1.4510958959000   0.0044599614444 -21.8411791008532  -
25.4110255512378
##  [893] -12.1173300076082  -8.2964743003733 -16.9077737443293
6.9772073903203
##  [897] -10.7268996260587 -17.1760885628929 -14.1651443830786
11.9358676105577
##  [901]  -4.5765217421848   0.2366760898180  -1.8717389128953
3.0102707741098
##  [905]  -4.3204358905164 -11.2007144226305 -14.9200270625871  -
7.9922802460666
##  [909]  -8.3520070119999  -3.0634230377443  -8.6667574666339  -
17.3946315863072
##  [913] -13.9751881524778  -7.4284136063703 -12.8017391914418
0.0796759211016
##  [917]   1.5521962402319 -12.0279494913341 -13.2140954708239  -
26.2105391706051
##  [921]  -4.3189474100682  -3.2871975282205   4.6025952177705  -
26.3771937428622
##  [925]   2.9850108220997 -11.5369982879414   5.7914884558458
```

```
10.5523518552608
##  [929]    2.8448665087213   -5.8259668272002    1.5985360728644    -
5.0840974428155
##  [933]    1.0200871771494   -4.3142956971968 -13.6391708511682    -
8.6304362923845
##  [937]   -2.7572457289469    5.3998160594704   -0.1300766528528 -
19.4602199796870
##  [941] -16.1268068422097    2.8688659034770 -15.5665015992992 -
10.2297772216073
##  [945]    3.2474112266228   -7.3610233098449   -1.5866098092116 -
12.6413748901856
##  [949]   -1.1323070809281   -7.7451424430973   -4.5516727533891
1.7625072675557
##  [953] -13.1357524185268   -4.9462331148863    5.3970129858793
4.9100271069654
##  [957]   -7.5631051533232 -14.1531432635225 -30.3517276221818 -
16.4335789783104
##  [961]   -9.4617851897070 -13.8956188390521    8.7782555336490 -
24.5760672674387
##  [965]   -2.7614462162304 -22.1807626153914 -13.0575886988837    -
9.7560228337793
##  [969]   -6.4773389881232   -1.7621024448896   -4.0221343890048
2.9563746444499
##  [973] -15.7806617916108   -8.2702501953435 -15.8119624600776 -
17.8259059633484
##  [977] -26.6682920426637 -17.1347324830373 -15.0667582780123 -
16.9518394411486
##  [981]   -4.5839218883509 -15.8107729636208   -5.6916794897939    -
3.2829881041342
##  [985] -14.3350730550368 -17.8098342889453   -5.8370181762388 -
18.2162059963196
##  [989]   -7.8892410964089   -2.4517683025882    7.8010975268365    -
3.3405231809554
##  [993] -10.1073381954854 -22.0105460642858 -16.4339778448903    -
2.0270768952201
##  [997]   -4.7175172561890   -7.1633026119330 -10.1213930489634 -
11.9191377747732
```

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

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

```
## [1] -9.8862525833
```

- 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))#TO-DO
```

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

- 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))#TO-DO
```

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