Lab 1

Enoch Kim

11:59PM February 18, 2021

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Is this answer *exactly* correct?

No, not exactly correct because the number is too small, 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.

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

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

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

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

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

```
?which
```

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

```
which(!y)
```

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

```
which(y==FALSE)
```

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

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

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

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

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

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

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

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

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

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

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

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

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

```
as.factor(x)
```

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

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

```
as.integer(x)
```

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

```
##  [1] NA  4  4  4  4  4  4  4  4  4  4  3  3  3  3  3  3  3  3  3  3  3  3  3
## [26]  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.

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

```
## [1] 0.5
```

- 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] 0.912
```

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

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

```
## [1] 0.915
```

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

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

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

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

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

```
Y = matrix(nrow = length(x_3), ncol = 3)

Y[,1] = as.numeric(x_3_ord == "infraction")
Y[,2] = as.numeric(x_3_ord == "misdimeanor")
Y[,3] = as.numeric(x_3_ord == "felony")

colnames(Y) = c("Infaction", "Misdimeanor", "Felony")

Y
```

```
##       Infaction Misdimeanor Felony
##  [1,]         1           0      0
##  [2,]         1           0      0
##  [3,]         0           0      0
##  [4,]         0           1      0
```

```
##   [5,]         0           0      1
##   [6,]         0           1      0
##   [7,]         0           1      0
##   [8,]         0           0      0
##   [9,]         0           1      0
##  [10,]         0           0      1
##  [11,]         0           0      0
##  [12,]         0           0      1
##  [13,]         0           1      0
##  [14,]         0           1      0
##  [15,]         0           0      0
##  [16,]         0           0      1
##  [17,]         0           0      1
##  [18,]         0           0      1
##  [19,]         0           0      0
##  [20,]         0           0      0
##  [21,]         0           0      1
##  [22,]         0           0      0
##  [23,]         0           0      0
##  [24,]         1           0      0
##  [25,]         0           0      1
##  [26,]         0           1      0
##  [27,]         0           1      0
##  [28,]         1           0      0
##  [29,]         0           0      0
##  [30,]         0           1      0
##  [31,]         0           0      1
##  [32,]         0           0      0
##  [33,]         1           0      0
##  [34,]         0           1      0
##  [35,]         0           1      0
##  [36,]         0           1      0
##  [37,]         0           1      0
##  [38,]         0           1      0
##  [39,]         0           0      0
##  [40,]         0           1      0
##  [41,]         0           1      0
##  [42,]         1           0      0
##  [43,]         0           0      0
##  [44,]         0           0      1
##  [45,]         0           1      0
##  [46,]         1           0      0
##  [47,]         1           0      0
##  [48,]         1           0      0
##  [49,]         0           0      0
##  [50,]         0           0      0
##  [51,]         0           0      1
##  [52,]         1           0      0
##  [53,]         0           0      1
##  [54,]         0           1      0
##  [55,]         0           0      0
##  [56,]         1           0      0
##  [57,]         0           1      0
##  [58,]         0           0      0
```

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

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

The row sum of each row should be either a 0 or 1 due to a 100 rows.

Verify that.

```
rowSums(Y)
```

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

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

The column sum, each columns should equal the total amount who committed a infraction, misdemeanor or felony.

Verify that.

```
colSums(Y)
```

```
##   Infaction Misdimeanor      Felony
##          22          30          20
```

- 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.

```
n = 100
p = 6
X = matrix(NA, nrow = n, ncol = p)

X[,1] = rnorm(n, mean = 17, sd = sqrt(38))
X[,2] = runif(n, min = -10, max = 10)
X[,3] = rpois(n, lambda = 6)
X[,4] = rexp(n, rate = 9)
X[,5] = rbinom(n, size = 20, prob = 0.12)
X[,6] = sample(rep(c(0,1), times = c(76,24), size = 100))

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"
)

colnames(X) = c(
  "realization",
  "uniform",
  "poisson",
  "exponential",
```

```
  "binomial",
  "binary_variable"
)

rownames(X) = fake_first_names
rownames(X)
```

```
##   [1] "Sophia"    "Emma"      "Olivia"    "Ava"       "Mia"       "Isabella"
##   [7] "Riley"     "Aria"      "Zoe"       "Charlotte" "Lily"      "Layla"
##  [13] "Amelia"    "Emily"     "Madelyn"   "Aubrey"    "Adalyn"    "Madison"
##  [19] "Chloe"     "Harper"    "Abigail"   "Aaliyah"   "Avery"     "Evelyn"
##  [25] "Kaylee"    "Ella"      "Ellie"     "Scarlett"  "Arianna"   "Hailey"
##  [31] "Nora"      "Addison"   "Brooklyn"  "Hannah"    "Mila"      "Leah"
##  [37] "Elizabeth" "Sarah"     "Eliana"    "Mackenzie" "Peyton"    "Maria"
##  [43] "Grace"     "Adeline"   "Elena"     "Anna"      "Victoria"  "Camilla"
##  [49] "Lillian"   "Natalie"   "Jackson"   "Aiden"     "Lucas"     "Liam"
##  [55] "Noah"      "Ethan"     "Mason"     "Caden"     "Oliver"    "Elijah"
##  [61] "Grayson"   "Jacob"     "Michael"   "Benjamin"  "Carter"    "James"
##  [67] "Jayden"    "Logan"     "Alexander" "Caleb"     "Ryan"      "Luke"
##  [73] "Daniel"    "Jack"      "William"   "Owen"      "Gabriel"   "Matthew"
##  [79] "Connor"    "Jayce"     "Isaac"     "Sebastian" "Henry"     "Muhammad"
##  [85] "Cameron"   "Wyatt"     "Dylan"     "Nathan"    "Nicholas"  "Julian"
##  [91] "Eli"       "Levi"      "Isaiah"    "Landon"    "David"     "Christian"
##  [97] "Andrew"    "Brayden"   "John"      "Lincoln"
```

```
X
```

```
##             realization         uniform poisson      exponential binomial
## Sophia    26.27852514141  6.694818958640       6 0.02087997722167        5
## Emma       8.91935329424 -1.561439684592       9 0.21627150392261        2
## Olivia    26.71335803199 -8.595638759434       4 0.06270584774514        3
## Ava        7.72020733653  7.491162079386       2 0.17173652619685        2
## Mia       18.78483312740  7.108601578511       8 0.00285312099394        1
## Isabella  16.66077788697  9.562046220526       9 0.05641796926243        4
## Riley     14.36731785505  5.725711942650       8 0.34284043471194        4
## Aria      10.07754297018 -4.113678070717       7 0.04374509330632        3
## Zoe       17.72624112645  7.210613521747       6 0.05434454920598        2
## Charlotte 19.06599425434 -4.041015962139      13 0.01756113446835        1
## Lily      20.00093454400  1.108331247233       4 0.27546232585533        2
## Layla     30.56401318371  8.482363359071       5 0.08624116879318        4
## Amelia    19.66403941265 -3.837294625118       5 0.10292836371342        2
## Emily     11.02702042969  9.569845115766       1 0.01096163645726        3
## Madelyn    3.92345892306  5.594685371034       7 0.08460260875915        5
## Aubrey    20.51209540522  4.798805662431       2 0.09728051451710        3
## Adalyn    15.16383050751 -0.934683918022       5 0.14046363801125        0
## Madison    9.88803201714 -4.498868645169       8 0.47044711012252        0
## Chloe     15.38532556439  9.563058931381       6 0.20379200638891        0
## Harper    10.68835984236  3.702669790946       7 0.03966516991042        3
## Abigail    0.78001127970  3.794206017628       6 0.18778738537409        3
## Aaliyah   13.96807085331 -2.218597717583       6 0.01732281435074        4
## Avery     26.92714176497 -2.750548389740       8 0.05362655387984        0
## Evelyn    19.12353572011  8.104424732737       9 0.07530765375122        0
## Kaylee     6.56233586033 -4.717678730376       4 0.44229544262241        3
```

```
## Ella      24.04127469846 -0.181723972782       3 0.02063285549068        3
## Ellie     11.97777745435 -0.688755852170       6 0.03196679097083        1
## Scarlett  10.05249815569  4.468592940830       6 0.02791019394580        3
## Arianna   18.10574219651 -7.306144060567       4 0.09728023988866        3
## Hailey     7.59165653160 -7.402177192271       6 0.25698231417964        3
## Nora      16.56399238655 -8.054753271863       4 0.06776930215872        1
## Addison   11.79496270416  2.240672600456       9 0.00422752599582        3
## Brooklyn   9.79773068884  6.003253343515       6 0.02674963966840        2
## Hannah    14.19200291956  0.094904871657       5 0.09918904221253        3
## Mila      18.87667371228  0.452763997018       5 0.17584865560029        3
## Leah      22.65032969971 -0.976015515625       5 0.16005562486246        1
## Elizabeth 12.76437346353  0.797628136352       4 0.00148247006453        3
## Sarah     22.66331517886 -2.117914175615       6 0.13649205832523        1
## Eliana    17.36212036288  5.492505775765       8 0.08704955554618        2
## Mackenzie 25.68091450566 -5.848233904690       2 0.21707816007131        7
## Peyton    22.67276199099  1.345403962769       6 0.14605515582765        1
## Maria     21.40161409969  6.644945563748       8 0.01783247488577        1
## Grace     10.89532171519  1.082164007239       7 0.27188408890787        4
## Adeline   17.77250432577  9.039265508763       4 0.10896112945292        4
## Elena      7.00130654606  8.626377526671       6 0.06497227954161        2
## Anna      18.54222474409  4.889712035656       1 0.07303129643616        1
## Victoria  21.81162559515  3.515069838613       6 0.03877097435503        3
## Camilla   20.05136674763  3.004123787396      10 0.01121678389609        0
## Lillian   13.53183889978 -4.912374257110       7 0.00690596411005        2
## Natalie   16.85498948124  8.456637668423       8 0.02351471103935        4
## Jackson   23.88722882039 -8.338617691770       5 0.04102630775101        1
## Aiden     16.71280644409 -3.973309225403       9 0.16627425637404        0
## Lucas     -3.40829309123  9.708769582212       3 0.04517443090056        1
## Liam      22.80341466617  6.705372235738       5 0.12866115859346        2
## Noah      29.73418969241 -2.462350847200       4 0.16298391462095        2
## Ethan      6.76475094455  1.291331406683       7 0.06362303289481        3
## Mason     23.52810191990  7.572944778949       4 0.00458063795971        1
## Caden      8.66496511453  4.811545447446       4 0.00036354592123        3
## Oliver    19.85120530792 -0.756510826759       5 0.05205625781996        3
## Elijah    13.48123849676  9.123675804585       7 0.01792171488826        1
## Grayson   10.12003722684  3.345167641528       4 0.01892040649474        2
## Jacob     12.00668789224 -7.816018806770       5 0.18230275356068        3
## Michael   27.10733060865  6.435705404729       6 0.01824011660037        2
## Benjamin  16.94556556154 -8.593963235617       5 0.06104970584935        4
## Carter    19.73649017177  3.076094044372       9 0.20532664759186        0
## James     15.55639925053  5.157510740682       8 0.18928185663184        0
## Jayden    22.89217069744 -2.133849272504       7 0.08873476822290        3
## Logan     15.52899107188 -9.282648032531       5 0.10453856156465        1
## Alexander 13.45896947720  4.892866606824       7 0.01310566916234        2
## Caleb     15.58030272938 -7.062921244651       5 0.00761428853083        2
## Ryan      19.21932196418  4.787671351805       5 0.17391880272924        2
## Luke      16.69336601785  8.814328126609       6 0.07849624876708        0
## Daniel    10.82660945220  2.774246623740       5 0.05784974738749        2
## Jack      26.04270656742 -3.935623741709       6 0.15917785808309        2
## William   15.64281568151 -2.616145615466       7 0.35715996206548        2
## Owen      22.72698337185  5.665198308416       5 0.01641504549566        4
## Gabriel   19.95140604835  0.705996556208      10 0.12891302381486        0
## Matthew    2.86490169078  4.225933430716      12 0.07980679579824        2
## Connor     8.28463623241  0.509758647531       2 0.03422773904217        2
```

```
## Jayce     12.06911265778  1.496346159838       6 0.07229028398999        2
## Isaac     13.70381269779 -3.756378139369      10 0.09311408642213        1
## Sebastian 20.35950130885  6.485142423771       3 0.06155193222018        4
## Henry     21.97989734794  8.421110250056       8 0.13540558816605        1
## Muhammad  14.05851013452  1.505929883569       4 0.23399362401257        1
## Cameron   12.54587573330  2.782521401532      13 0.04544563255169        1
## Wyatt     16.90494033910 -9.966981182806       5 0.01015532289247        2
## Dylan     32.56885710993 -6.685676537454       7 0.06764856581059        5
## Nathan    21.91375450051 -8.084584665485       3 0.06197191226400        2
## Nicholas  12.36616932699  0.362721495330       7 0.01260094743015        2
## Julian    10.87647652067 -0.565789509565       7 0.01363541387642        2
## Eli       22.97998746717 -8.488065418787       6 0.23932527645850        3
## Levi      12.82287426063 -0.104802032001       5 0.23893299226297        3
## Isaiah    27.73276121564 -1.360273002647       2 0.01385915057120        1
## Landon     0.16848691812 -3.762606931850       5 0.52164398963594        1
## David      6.43435727827  6.738317073323       3 0.06132492490320        0
## Christian  7.15329812687  2.003671117127       5 0.12412016062220        2
## Andrew    33.09594531021 -1.825555637479       4 0.04381335378736        2
## Brayden   31.98663923484  7.872754638083       4 0.06228266087257        1
## John      12.88071904378  0.683736973442       7 0.12418694141785        2
## Lincoln    8.78833746718 -9.912230675109       5 0.01748270277555        0
##           binary_variable
## Sophia                  0
## Emma                    1
## Olivia                  0
## Ava                     0
## Mia                     1
## Isabella                1
## Riley                   0
## Aria                    0
## Zoe                     0
## Charlotte               0
## Lily                    1
## Layla                   0
## Amelia                  0
## Emily                   0
## Madelyn                 1
## Aubrey                  0
## Adalyn                  0
## Madison                 0
## Chloe                   0
## Harper                  0
## Abigail                 0
## Aaliyah                 0
## Avery                   0
## Evelyn                  0
## Kaylee                  0
## Ella                    0
## Ellie                   1
## Scarlett                0
## Arianna                 0
## Hailey                  0
## Nora                    1
## Addison                 1
```

```
## Brooklyn              0
## Hannah                1
## Mila                  0
## Leah                  0
## Elizabeth             0
## Sarah                 0
## Eliana                1
## Mackenzie             0
## Peyton                0
## Maria                 1
## Grace                 0
## Adeline               0
## Elena                 0
## Anna                  0
## Victoria              1
## Camilla               0
## Lillian               0
## Natalie               0
## Jackson               0
## Aiden                 0
## Lucas                 0
## Liam                  0
## Noah                  0
## Ethan                 1
## Mason                 0
## Caden                 0
## Oliver                0
## Elijah                0
## Grayson               0
## Jacob                 0
## Michael               0
## Benjamin              0
## Carter                0
## James                 1
## Jayden                0
## Logan                 1
## Alexander             0
## Caleb                 0
## Ryan                  0
## Luke                  0
## Daniel                0
## Jack                  1
## William               0
## Owen                  0
## Gabriel               0
## Matthew               0
## Connor                0
## Jayce                 0
## Isaac                 0
## Sebastian             1
## Henry                 0
## Muhammad              1
## Cameron               0
## Wyatt                 0
```

```
## Dylan                   1
## Nathan                  0
## Nicholas                0
## Julian                  0
## Eli                     1
## Levi                    1
## Isaiah                  0
## Landon                  1
## David                   0
## Christian               1
## Andrew                  0
## Brayden                 0
## John                    0
## Lincoln                 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.

```
Y <- data.frame(X)
Y$binary_variable <- factor(Y$binary_variable, labels = c("DOMESTIC", "FOREIGN") , levels = c(0,1))
View(Y)
```

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

```
table(Y$binary_variable)
```

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

```
table(Y$binary_variable) / 100
```

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

Print out a summary of the whole dataframe.

```
summary(Y)
```

```
##   realization           uniform             poisson
##  Min.   :-3.4082931   Min.   :-9.9669812   Min.   : 1.00
##  1st Qu.:10.9940958   1st Qu.:-3.0020058   1st Qu.: 4.00
##  Median :16.6123851   Median : 1.1998313   Median : 6.00
##  Mean   :16.3173889   Mean   : 1.0637930   Mean   : 5.88
##  3rd Qu.:21.5041170   3rd Qu.: 5.6803267   3rd Qu.: 7.00
##  Max.   :33.0959453   Max.   : 9.7087696   Max.   :13.00
##   exponential              binomial   binary_variable
##  Min.   :0.00036354592   Min.   :0.0   DOMESTIC:76
##  1st Qu.:0.02594090751   1st Qu.:1.0   FOREIGN :24
```

```
##  Median :0.06770893398   Median :2.0
##  Mean   :0.10363930555   Mean   :2.1
##  3rd Qu.:0.14933583139   3rd Qu.:3.0
##  Max.   :0.52164398964   Max.   :7.0
```

- 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
c = 50
R = matrix(nrow = n, ncol = c, sample(c(rep(0, n*c*0.5), rep(1, n*c*0.25), rep(2, n*c*0.25))))
R
```

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

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

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

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

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

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

```
punch_holes = matrix(nrow = n, ncol = c, sample(c(rep(1, n*c*0.70), rep(30, n*c*.30))))

for(nRow in 1:n){
  for(nCol in 1:c){
    if(punch_holes[nRow,nCol] == 30){
      R[nRow, nCol] = NA
    }
  }
}
R
```

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

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

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

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

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

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

- 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.

```
rows = apply(R, MARGIN = 1, sd, na.rm = TRUE)
columns = apply(R, MARGIN = 2, sd, na.rm = TRUE)
```

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

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

```
##  [1] 14 27 21 15 18 19 18 19 18 17 13 21 20 18 14 16 16 16 13 24 19 18 20 26 17
## [26] 14 15 18 19 17 16 23 18 16 16 21 19 19 16 15 16 18 18 16 17 16 13 14  8 18
```

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

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

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

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

```
## $`20`
##  [1]  0  0  2  0  0 NA  0  2  2  2 NA  0  2 NA  2  1 NA  1  0 NA  1  1  2  1  0
## [26] NA NA  2  1 NA NA  2  2  0  1  2 NA  2  0  2 NA NA NA  2  0  0  2  2  1  0
##
## $`21`
##  [1]  0 NA NA  0  1  0  0 NA  0 NA  1  1 NA  1  2  1  2  1  1  2  0  0  0 NA NA
## [26]  2  0  0 NA NA  2  0  1  1  1 NA NA  2 NA NA  2  0  1  0  0  1 NA NA  0 NA
##
## $`22`
##  [1]  0  0  0  0 NA  0  2  2  0  1  2  0  0 NA  1 NA  0  0  2  1 NA  1  1  0 NA
## [26]  0  1  2  1  0  0  1 NA  0 NA  0  0  0  2  0  0  0  1  0  1 NA  0  1  0  1
##
## $`23`
##  [1] NA  0 NA NA  0  1 NA NA  0  1  0 NA NA  1 NA  0  2  1 NA  0  1 NA  2  2  0
## [26]  2  2  1  1 NA  1 NA  1 NA NA NA  1  0 NA  0 NA  0  1  0  1  2  0  2  1  0
##
## $`24`
##  [1]  1  0  0  2  0  1  2  1  0  1  0 NA NA NA  2  2  1  0  2  2  1  0 NA NA  0
## [26]  1  0  1  0  2  0  1  1  2  0  0  0  0  0  2  1 NA  0  1  2  0  1  1  2  1
##
## $`25`
##  [1]  0  1 NA  0  0 NA  0 NA  0  0 NA  0  1  0  0  2  0  0 NA  2  2  0  1  0  2
## [26] NA  1 NA  2 NA NA NA  1  1  2  1  1  2  2  1 NA  0  0 NA  0 NA NA  0 NA  0
##
## $`26`
##  [1] NA  0  0  0 NA NA  1  1  0  0  2  0  0 NA  2  0  1 NA NA  2  2  1  2  0 NA
## [26]  0  0 NA  0  2  2 NA NA  0  0  0 NA  0  0 NA  0  0  0  1 NA NA NA  1  1 NA
##
## $`27`
##  [1]  2  0  0 NA  2  1  0 NA NA  0 NA NA  0 NA  0 NA  1  0  0  2  0  0  0 NA  2
## [26]  2  0  1  0  2  0 NA  2  0  1  0  1  1  1  0  0  0  0  0  0 NA  0  0  1  0
##
## $`28`
##  [1]  1  2  1 NA  0  2  2 NA NA  0  2 NA  0 NA  0 NA  0  0  0  2  0  1  2  2 NA
## [26]  0  1  0  0  0  0  0  1 NA  0  0  1 NA  1  2  2  1 NA  0 NA NA  0  1  0 NA
##
## $`29`
##  [1]  2 NA  0  2 NA  1  0  1 NA NA NA  0  0  0  2  2 NA  1  0  2 NA  1  1 NA NA
## [26] NA NA  0  2  2  1 NA  2  0 NA  1  0  0 NA NA  0  2  1 NA  0  1 NA NA NA  1
##
## $`30`
##  [1]  2  1  0 NA NA  1 NA  2  0  1  0 NA NA NA NA NA NA  0 NA  2  1  0 NA NA NA
## [26]  0  0  2  0  2 NA  0 NA NA  0  0  1  1  0 NA  0  0  2  2  2  1 NA  2 NA  1
##
## $`31`
##  [1]  0  0 NA NA  1  0  1  0  0  1  0  1  2  0  0 NA NA NA  0  2  0 NA NA  1 NA
## [26]  1  2 NA NA  0  0  0 NA NA  1  0  2 NA  2  1  2  0  0 NA  0 NA NA  2  1  0
##
## $`32`
##  [1]  0  2  0  1  1 NA  2 NA  2  1  0  2  0  0 NA  0  2  1  2  1  2  0 NA  2 NA
## [26]  2  0  2 NA  0  0  2  0  1  1  2 NA NA  0 NA  0 NA NA  2  0  2  1  0 NA  2
##
## $`33`
##  [1] NA  0 NA NA  1  0  1  1  2  0 NA NA  0  1  0  2  0  2  0 NA NA  0 NA  1  2
```

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

```
## $`47`
##  [1]  0  0  0 NA  0 NA NA  0 NA  2  0  2  2  0  0  2  0  2  1 NA NA  0  1  2  0
## [26] NA  0  0 NA  0  2 NA  0  1  0  0  0  2  1  0 NA NA NA  2  0  0  0 NA  0  0
##
## $`48`
##  [1]  0 NA  0  1 NA  2  1 NA  1  0  2  2 NA  2 NA  2 NA  0  0 NA  0  2  2 NA  0
## [26]  0 NA  0  1 NA  2  0 NA NA NA  0  0  0  0 NA  2 NA  1  0  0  0  0  0  0 NA
##
## $`49`
##  [1] NA NA  2  0  0 NA NA NA  1  0  0 NA NA  0  0  2 NA  0  0  0 NA  1  0 NA NA
## [26] NA  1  2 NA NA  0  0  0  0  0  0  0  0  0 NA NA  1  0  0 NA  2 NA NA  0  0
##
## $`50`
##  [1]  0  2  0  0  1  1  2 NA  0 NA  2  0  0  0 NA  0 NA  0  0  1 NA NA  2 NA NA
## [26]  2  0  2  2 NA  0  1  0  0  0  2 NA  1  1  2 NA  2 NA NA  0 NA  1  1 NA NA
```

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

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

```
## $`1`
## $`1`$min
## [1] 0
##
## $`1`$max
## [1] 2
##
## $`1`$pct_missing
## [1] 0.42
##
## $`1`$first_NA
## [1] 3
##
##
## $`2`
## $`2`$min
## [1] 0
##
## $`2`$max
## [1] 2
##
## $`2`$pct_missing
## [1] 0.22
##
## $`2`$first_NA
```

```
## [1] 3
##
##
## $`3`
## $`3`$min
## [1] 0
##
## $`3`$max
## [1] 2
##
## $`3`$pct_missing
## [1] 0.34
##
## $`3`$first_NA
## [1] 3
##
##
## $`4`
## $`4`$min
## [1] 0
##
## $`4`$max
## [1] 2
##
## $`4`$pct_missing
## [1] 0.3
##
## $`4`$first_NA
## [1] 1
##
##
## $`5`
## $`5`$min
## [1] 0
##
## $`5`$max
## [1] 2
##
## $`5`$pct_missing
## [1] 0.2
##
## $`5`$first_NA
## [1] 2
##
##
## $`6`
## $`6`$min
## [1] 0
##
## $`6`$max
## [1] 2
##
## $`6`$pct_missing
## [1] 0.22
```

```
##
## $`6`$first_NA
## [1] 1
##
##
## $`7`
## $`7`$min
## [1] 0
##
## $`7`$max
## [1] 2
##
## $`7`$pct_missing
## [1] 0.3
##
## $`7`$first_NA
## [1] 1
##
##
## $`8`
## $`8`$min
## [1] 0
##
## $`8`$max
## [1] 2
##
## $`8`$pct_missing
## [1] 0.32
##
## $`8`$first_NA
## [1] 1
##
##
## $`9`
## $`9`$min
## [1] 0
##
## $`9`$max
## [1] 2
##
## $`9`$pct_missing
## [1] 0.36
##
## $`9`$first_NA
## [1] 1
##
##
## $`10`
## $`10`$min
## [1] 0
##
## $`10`$max
## [1] 2
##
```

```
## $`10`$pct_missing
## [1] 0.28
##
## $`10`$first_NA
## [1] 1
##
##
## $`11`
## $`11`$min
## [1] 0
##
## $`11`$max
## [1] 2
##
## $`11`$pct_missing
## [1] 0.36
##
## $`11`$first_NA
## [1] 2
##
##
## $`12`
## $`12`$min
## [1] 0
##
## $`12`$max
## [1] 2
##
## $`12`$pct_missing
## [1] 0.22
##
## $`12`$first_NA
## [1] 1
##
##
## $`13`
## $`13`$min
## [1] 0
##
## $`13`$max
## [1] 2
##
## $`13`$pct_missing
## [1] 0.22
##
## $`13`$first_NA
## [1] 2
##
##
## $`14`
## $`14`$min
## [1] 0
##
## $`14`$max
```

```
## [1] 2
##
## $`14`$pct_missing
## [1] 0.36
##
## $`14`$first_NA
## [1] 1
##
##
## $`15`
## $`15`$min
## [1] 0
##
## $`15`$max
## [1] 2
##
## $`15`$pct_missing
## [1] 0.46
##
## $`15`$first_NA
## [1] 1
##
##
## $`16`
## $`16`$min
## [1] 0
##
## $`16`$max
## [1] 2
##
## $`16`$pct_missing
## [1] 0.32
##
## $`16`$first_NA
## [1] 1
##
##
## $`17`
## $`17`$min
## [1] 0
##
## $`17`$max
## [1] 2
##
## $`17`$pct_missing
## [1] 0.28
##
## $`17`$first_NA
## [1] 1
##
##
## $`18`
## $`18`$min
## [1] 0
```

```
##
## $`18`$max
## [1] 2
##
## $`18`$pct_missing
## [1] 0.36
##
## $`18`$first_NA
## [1] 1
##
##
## $`19`
## $`19`$min
## [1] 0
##
## $`19`$max
## [1] 2
##
## $`19`$pct_missing
## [1] 0.36
##
## $`19`$first_NA
## [1] 1
##
##
## $`20`
## $`20`$min
## [1] 0
##
## $`20`$max
## [1] 2
##
## $`20`$pct_missing
## [1] 0.26
##
## $`20`$first_NA
## [1] 1
##
##
## $`21`
## $`21`$min
## [1] 0
##
## $`21`$max
## [1] 2
##
## $`21`$pct_missing
## [1] 0.32
##
## $`21`$first_NA
## [1] 1
##
##
## $`22`
```

```
## $`22`$min
## [1] 0
##
## $`22`$max
## [1] 2
##
## $`22`$pct_missing
## [1] 0.16
##
## $`22`$first_NA
## [1] 1
##
##
## $`23`
## $`23`$min
## [1] 0
##
## $`23`$max
## [1] 2
##
## $`23`$pct_missing
## [1] 0.34
##
## $`23`$first_NA
## [1] 2
##
##
## $`24`
## $`24`$min
## [1] 0
##
## $`24`$max
## [1] 2
##
## $`24`$pct_missing
## [1] 0.12
##
## $`24`$first_NA
## [1] 1
##
##
## $`25`
## $`25`$min
## [1] 0
##
## $`25`$max
## [1] 2
##
## $`25`$pct_missing
## [1] 0.3
##
## $`25`$first_NA
## [1] 1
##
```

```
##
## $`26`
## $`26`$min
## [1] 0
##
## $`26`$max
## [1] 2
##
## $`26`$pct_missing
## [1] 0.32
##
## $`26`$first_NA
## [1] 2
##
##
## $`27`
## $`27`$min
## [1] 0
##
## $`27`$max
## [1] 2
##
## $`27`$pct_missing
## [1] 0.2
##
## $`27`$first_NA
## [1] 1
##
##
## $`28`
## $`28`$min
## [1] 0
##
## $`28`$max
## [1] 2
##
## $`28`$pct_missing
## [1] 0.26
##
## $`28`$first_NA
## [1] 1
##
##
## $`29`
## $`29`$min
## [1] 0
##
## $`29`$max
## [1] 2
##
## $`29`$pct_missing
## [1] 0.38
##
## $`29`$first_NA
```

```
## [1] 1
##
##
## $`30`
## $`30`$min
## [1] 0
##
## $`30`$max
## [1] 2
##
## $`30`$pct_missing
## [1] 0.38
##
## $`30`$first_NA
## [1] 1
##
##
## $`31`
## $`31`$min
## [1] 0
##
## $`31`$max
## [1] 2
##
## $`31`$pct_missing
## [1] 0.32
##
## $`31`$first_NA
## [1] 1
##
##
## $`32`
## $`32`$min
## [1] 0
##
## $`32`$max
## [1] 2
##
## $`32`$pct_missing
## [1] 0.24
##
## $`32`$first_NA
## [1] 1
##
##
## $`33`
## $`33`$min
## [1] 0
##
## $`33`$max
## [1] 2
##
## $`33`$pct_missing
## [1] 0.34
```

```
##
## $`33`$first_NA
## [1] 2
##
##
## $`34`
## $`34`$min
## [1] 0
##
## $`34`$max
## [1] 2
##
## $`34`$pct_missing
## [1] 0.3
##
## $`34`$first_NA
## [1] 3
##
##
## $`35`
## $`35`$min
## [1] 0
##
## $`35`$max
## [1] 2
##
## $`35`$pct_missing
## [1] 0.26
##
## $`35`$first_NA
## [1] 1
##
##
## $`36`
## $`36`$min
## [1] 0
##
## $`36`$max
## [1] 2
##
## $`36`$pct_missing
## [1] 0.26
##
## $`36`$first_NA
## [1] 1
##
##
## $`37`
## $`37`$min
## [1] 0
##
## $`37`$max
## [1] 2
##
```

```
## $`37`$pct_missing
## [1] 0.26
##
## $`37`$first_NA
## [1] 1
##
##
## $`38`
## $`38`$min
## [1] 0
##
## $`38`$max
## [1] 2
##
## $`38`$pct_missing
## [1] 0.36
##
## $`38`$first_NA
## [1] 3
##
##
## $`39`
## $`39`$min
## [1] 0
##
## $`39`$max
## [1] 2
##
## $`39`$pct_missing
## [1] 0.34
##
## $`39`$first_NA
## [1] 4
##
##
## $`40`
## $`40`$min
## [1] 0
##
## $`40`$max
## [1] 2
##
## $`40`$pct_missing
## [1] 0.32
##
## $`40`$first_NA
## [1] 1
##
##
## $`41`
## $`41`$min
## [1] 0
##
## $`41`$max
```

```
## [1] 2
##
## $`41`$pct_missing
## [1] 0.38
##
## $`41`$first_NA
## [1] 2
##
##
## $`42`
## $`42`$min
## [1] 0
##
## $`42`$max
## [1] 2
##
## $`42`$pct_missing
## [1] 0.3
##
## $`42`$first_NA
## [1] 2
##
##
## $`43`
## $`43`$min
## [1] 0
##
## $`43`$max
## [1] 2
##
## $`43`$pct_missing
## [1] 0.24
##
## $`43`$first_NA
## [1] 2
##
##
## $`44`
## $`44`$min
## [1] 0
##
## $`44`$max
## [1] 2
##
## $`44`$pct_missing
## [1] 0.24
##
## $`44`$first_NA
## [1] 1
##
##
## $`45`
## $`45`$min
## [1] 0
```

```
##
## $`45`$max
## [1] 2
##
## $`45`$pct_missing
## [1] 0.26
##
## $`45`$first_NA
## [1] 1
##
##
## $`46`
## $`46`$min
## [1] 0
##
## $`46`$max
## [1] 2
##
## $`46`$pct_missing
## [1] 0.36
##
## $`46`$first_NA
## [1] 1
##
##
## $`47`
## $`47`$min
## [1] 0
##
## $`47`$max
## [1] 2
##
## $`47`$pct_missing
## [1] 0.26
##
## $`47`$first_NA
## [1] 1
##
##
## $`48`
## $`48`$min
## [1] 0
##
## $`48`$max
## [1] 2
##
## $`48`$pct_missing
## [1] 0.32
##
## $`48`$first_NA
## [1] 1
##
##
## $`49`
```

```
## $`49`$min
## [1] 0
##
## $`49`$max
## [1] 2
##
## $`49`$pct_missing
## [1] 0.38
##
## $`49`$first_NA
## [1] 3
##
##
## $`50`
## $`50`$min
## [1] 0
##
## $`50`$max
## [1] 2
##
## $`50`$pct_missing
## [1] 0.32
##
## $`50`$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(17)
v = rnorm(1000, mean = -10, sd = 10)
v
```

```
##    [1] -20.150087164606 -10.796367371298 -12.329870219576 -18.172679336760
##    [5]  -2.279091607998 -11.656119353208  -0.271255738956   7.165339792337
##    [9]  -7.447629955043  -6.334188796694   1.807892362525  -3.568079310350
##   [13]   2.953218674674  -8.120819265693   5.912050979204 -10.551790569080
##   [17]  -1.615288793602  -8.406298748866  -3.740455984547  -3.664152749544
##   [21]  -3.189723513515 -16.820333658735 -17.232567368032   6.735259648821
##   [25] -15.957556324548   1.598438441624  -8.825775887198  -7.407786130781
##   [29]  -6.176378961527 -17.114817352893 -21.775695693615 -19.601665095796
##   [33] -18.789522376094 -45.561364807598 -24.167498427741 -14.487692659921
##   [37] -17.759677056052 -18.318280520826  -9.481698836068 -16.165513114254
##   [41]  -7.456032490741 -13.315204614358 -12.063193144728   2.153370863674
##   [45]   8.920564188355  -9.258064788643   7.516961694392 -12.314874367570
##   [49]  -4.565475152387 -19.890014011738  -6.844685361532  14.423274642231
##   [53]  -4.503071384786 -10.292433673210 -18.307833776807   2.464343861616
##   [57] -23.757552911897 -13.311084475208  -0.190885138923  11.907705641411
##   [61]  -9.694542532498 -17.855174057500  -6.745594438846 -18.808435499429
##   [65]  -7.906740569310  -8.489670475658 -13.434787944798  -0.941224038384
##   [69]  -0.810451461853 -15.559874920389  -4.397651586960 -27.924177958063
##   [73] -25.654168650876 -43.203188807403  -8.452784286989 -13.646266604177
##   [77] -34.336838537121  -6.635356945899 -16.404528199244   8.211204171977
```

```
##   [81] -28.467234543039  -3.582831634573   1.855248692710 -11.776880298423
##   [85] -22.861259241344  -5.365493559067  -1.193337263893  -8.605780452935
##   [89] -13.750548278468  -9.574609663882  -3.661197093177 -27.074884595758
##   [93]  -9.803134540601 -12.987963670316 -14.417628254521  -4.090246841595
##   [97] -21.343208083025 -14.387445878050  -6.550986312876 -14.494003701153
##  [101]  -9.561797784699 -15.679915859886   8.248603076018  -5.669974304900
##  [105] -23.539662768983   1.544659056455  -0.792630522186 -14.486574634379
##  [109]  10.705737160584 -11.995561285572 -21.291284952426 -22.955548649107
##  [113]   2.404188769534   6.950587232336  -4.976990609021  -6.663683504420
##  [117] -15.082026301443 -13.706323521689   5.086429518830 -10.496257860441
##  [121]   3.817566246549  -5.510675732733 -11.523099552261  -7.407060241716
##  [125] -26.114016652319 -30.089559907747 -29.993712411363  -8.789593236451
##  [129] -12.299948004472 -31.991020759838 -27.104085681050  -7.737408052839
##  [133]  -0.491497416377  11.084155438169 -16.212261929764   0.546474612717
##  [137] -26.390094548616  -1.590168064422 -15.254750050586  -9.361414545904
##  [141] -14.636523700405  -3.389552655258 -14.399860908692 -12.881595388270
##  [145] -23.159483125297   7.102272563645 -13.275400420816 -28.384576832215
##  [149]   3.194120227038  -6.511179152240  19.160722452752  -9.000835440000
##  [153]   3.131607900763  -3.105762199224 -14.017258387460   0.363085231176
##  [157] -21.102520572674 -11.577273904295   5.766081350439 -21.808354039249
##  [161] -19.299823536500 -16.908916648018 -34.547725776377 -21.698518376339
##  [165] -19.685190949892  -4.993972410263   8.383551968649  -9.865657189571
##  [169] -10.648761547638 -11.789986215057 -14.904717557651 -14.990264084565
##  [173]   0.929635165934 -10.026669913515 -17.382113503663  -6.427859162531
##  [177]  -0.025034807594  -5.927632781470 -20.539798688377 -22.224878812404
##  [181] -24.000669010716 -22.185265835887 -22.006359621512  13.932156120132
##  [185] -28.882548913982  -4.559633013625 -17.848715904338   3.983754753986
##  [189]  -1.637650911403 -21.866980509862 -22.462202426578 -20.355656090095
##  [193] -24.042089541743 -15.550872218348 -13.515558933798  -3.331678832248
##  [197] -14.161366841871 -15.901437570224 -22.774785043692  -7.505690732704
##  [201] -13.800461376076  -1.858939160188 -12.667060612416   3.669155317650
##  [205]  -6.525074826865  -6.596034269454   2.775329548409 -13.602721012489
##  [209]  -4.153011456618   2.566028639582 -13.445275273569 -22.622645401660
##  [213]  -3.131587444980 -10.479069048194 -13.610719201748   1.425584509393
##  [217]   1.078064181763  -8.242684391424  -8.341699833574 -10.380770501185
##  [221]   4.680777401936 -13.300040863871 -14.820845783016 -14.822042730414
##  [225]  13.795241008475   3.023955380350 -14.773233912385  -0.400772048171
##  [229]  -7.925300411389 -27.090955631374 -13.041131104726 -26.765663149030
##  [233]  -5.928071649098 -25.489410306593   5.849564455827 -26.182811584380
##  [237] -21.315725903742 -18.096711567468   9.585687443292 -19.698597773379
##  [241] -11.619897453580 -17.650727978200 -10.997260400098  -9.608706701961
##  [245] -16.397615271838 -15.663537367593 -20.003416026337   3.527055069011
##  [249]  -8.708025192560 -14.218445579701   1.660813814172  -8.385328810044
##  [253] -15.253772295599   3.231574162078  10.943249778490 -15.025035222849
##  [257]  -7.596600920330 -11.292764272128 -17.557725813983 -16.954102489914
##  [261]  -9.864294392935   1.677762669465 -17.320115786088   1.023522961425
##  [265]  -9.985149049743 -10.513433272683  -6.052748676702   0.497687712742
##  [269]   3.081660256728 -10.539591047191  -3.146291921970  -5.422661970712
##  [273]   8.467923835692 -44.012241405389  -9.735576353509  -6.296801941593
##  [277] -18.013411695279  -9.976878775209 -20.752949519889  -0.778962534115
##  [281]  -8.198155292723  12.636966257171  -6.902612356258  -0.254706767606
##  [285] -12.833816555657  -9.543039366639  -2.933073307999  -4.577368711270
##  [289]  -2.220894828923 -10.091765108069 -25.425372836317  -6.576335486065
##  [293] -12.955572499828   0.472604624516 -13.695157319660  -8.048041732671
```

```
##  [297] -19.357449899575  -3.295813715689 -11.019597436975 -24.442605113744
##  [301]  -5.640985124071  -9.784244815082 -13.227678878323   9.694138518804
##  [305] -10.084808263179  -8.574109786015   3.616351014299  -9.289070676276
##  [309]  -2.339304397242  -5.511025957426   7.861284560505  -8.283965365636
##  [313]  -6.143446800354 -11.413739859139   1.767490321543 -22.237204824534
##  [317] -13.307245495639  -0.689586761677 -17.080664589167 -16.415168323065
##  [321] -26.123888231916 -10.513631808498  -6.111121916267 -29.594867946274
##  [325] -12.844214607600 -11.899158711606 -21.284033382868  -4.214476743378
##  [329] -11.631894361894 -10.493594107813 -25.310307738148 -22.216069303143
##  [333] -12.539509476670 -13.776977491200 -24.820040308448  -7.334207667726
##  [337]   6.286262310536  -7.820771010080  -7.198209099332 -25.083154850974
##  [341] -12.090929019277  -0.409786744973 -18.243861492002   2.457522382041
##  [345] -16.806068189774 -11.162478913532 -17.310539525452 -19.189474314744
##  [349]  -3.642982405976  -7.141294045703  -6.348300046128  -9.285162518828
##  [353] -12.899120775406 -10.267539828798 -12.590079669235 -12.645522890496
##  [357]  -8.489021658569  -8.612735740713  -9.692337095103 -13.650433188668
##  [361]   4.348323712478   2.018891294434  -4.011242055415  -1.938184120617
##  [365]  -2.176605728090  -9.283905240447 -20.072996268914 -15.569154830653
##  [369] -37.863749069468 -13.569002567416  -6.358801366712  -1.278628772910
##  [373]  20.917324312786 -22.661342835262  -0.429067755261  -6.140923790551
##  [377]  -2.878947336670 -12.720128997583   4.575945494298 -22.112206188247
##  [381]  -8.610705837098   0.466417292449   0.492967301801 -24.366361898889
##  [385] -17.742168639044 -20.523658425373   1.929930136788   3.537156533696
##  [389] -22.869989278622 -12.571399514378 -26.868163055295 -25.243278211356
##  [393] -23.841514244100   3.787583092552 -26.424558079462  -1.740812744956
##  [397] -10.823772473166 -17.767611918572  -6.577269644868  -3.049472110570
##  [401]  -7.624880406307  -8.211316005312 -29.009896303533   5.901963289603
##  [405]   5.462582236307 -33.390491812907 -21.360281997634 -19.131867114131
##  [409] -25.877374636903 -17.980568628746 -35.518529158487   1.419324758310
##  [413]  -4.521063909959  23.301530539802  -2.630059258859  -2.302907386031
##  [417] -14.714594681452  -9.389818951298 -18.365778782842 -14.536159714223
##  [421] -15.199902574295 -15.236857517028 -18.699265226994 -25.411607549879
##  [425] -15.693698973649 -26.100535118828   4.427544054476 -19.850168208073
##  [429] -16.625266710710 -13.894710630525 -10.293322140913 -15.671832866362
##  [433]  -5.237339713629 -17.221533392725 -19.152072088138 -20.810138930061
##  [437]   0.192402722752 -13.471674554245  -9.534262648905  -7.958471621273
##  [441]  -9.105319255221  -7.693615454039 -10.117797711005  -1.148445752939
##  [445]  -5.312305205700 -19.780926206240  -3.688132282300 -15.090050260649
##  [449]  -7.683429486854 -26.385733497347   2.394208410222   8.395457830672
##  [453]  12.353609606067 -25.375271644504 -23.994403186647  -2.618911971933
##  [457]  -4.741070086413  -8.273219541799  -0.917153858316 -27.857873560544
##  [461] -30.190558470660 -29.111911010741 -27.729647760498  -8.244870542941
##  [465]  -0.848641853272   1.200737655282 -18.036519665548 -12.996140301144
##  [469]  -4.457750063169  -5.908391794831 -44.942738603128   5.164618201913
##  [473] -25.045104533044  -2.838661914640   2.822619936633  -8.522635460200
##  [477] -16.409640611011  -8.929443236329  -6.956455045668   3.696833432628
##  [481] -16.074357951956 -15.441577784035   0.730659689580  -9.878526379852
##  [485] -20.035830537920 -27.226282004851 -22.296714646247 -18.851868275263
##  [489]   0.045133456279 -13.386922634633  -4.072228916837 -15.558489480642
##  [493]   1.084026911879 -14.195713576746 -11.739230537416  -5.455978278008
##  [497]  -4.282523900801  -7.737095297849   3.235841506182 -15.348904787312
##  [501]   9.462448858843 -12.388696179009 -12.137865528110   6.314029067685
##  [505]  -3.772306350077  -2.548336048704  29.397455037747 -11.673700992585
##  [509]   1.186082316827  -4.961693511058   0.346971207140 -10.656877746946
```

```
##  [513] -17.169523498638 -16.329403521879 -12.885994436490 -16.273684608782
##  [517]  -5.881121337059  -0.271240606956   3.445110089674 -20.878243801130
##  [521]  -5.715818541919  -9.064330278191  13.566797856454  -6.055261812310
##  [525] -19.730268972463  10.299043484064 -19.791069858193 -17.688522138629
##  [529] -26.088550793842 -12.445908893961 -26.707311648419  -1.014871176743
##  [533]  -0.760531478347 -20.187890259729 -14.059940367582  -4.942817805473
##  [537] -13.556406387215  16.506430746286  -2.568600889196 -22.703326894580
##  [541] -17.923558754766 -16.459619995407 -16.381931660219 -11.066699465552
##  [545] -11.962232168180  -2.550358904834  -1.706510796410  -2.133258617679
##  [549] -16.083472542800 -11.173449516254   1.627066770732 -20.493449427060
##  [553]  -8.773518858183   7.953858972383  -6.295657830601  -6.398424824464
##  [557] -16.870402549675  13.989723098875  -9.599543012731 -19.325718757353
##  [561] -18.001634150210 -27.435121602238 -14.373464975724 -25.000831581362
##  [565] -25.018271008944 -17.390367848777 -20.482397718042  -8.863005034967
##  [569]  -9.686738531355  -7.306120050459  -2.971944362567  10.210736433629
##  [573]  -4.048228354600 -10.711440866517  -4.984848867414  -0.887779348173
##  [577]  -2.771593975223 -15.302004164080 -19.046162717343 -10.558218416841
##  [581] -28.195580235937 -16.581476482236 -10.232481987613   2.757661467562
##  [585]   7.761050756432 -23.740023739742 -14.810870554018 -11.000994277162
##  [589]  -5.956748956090 -24.715699851684  -2.923993672530 -12.122797447773
##  [593]  -7.902175059199 -25.545041692250 -32.429946386642 -19.949752520479
##  [597]  -5.274136813788 -12.959832491640 -23.595410709769  -1.077414398899
##  [601] -25.396303578633 -11.071327925224 -10.097007920893 -19.801885582207
##  [605] -19.698263930918  -1.666205458984   2.264110115453  -0.364264387106
##  [609]  -4.741469382882 -13.902578000311   4.256369376273  -0.238202506888
##  [613] -11.129916355246  -8.442551601381  -3.920558175715 -12.845510285031
##  [617]  -8.695908701256 -15.385139466763 -12.147034690068   5.920151935935
##  [621]  -6.952054666633 -15.640462092349  -9.763464196479 -13.146718881058
##  [625] -15.947086992638  -3.957928628452  -3.524720590400  -3.701753228703
##  [629]  -6.269823789514  -8.680904684820  -0.963782800282 -12.571361872379
##  [633] -14.313750128974  -6.259716322050 -24.487557457686 -14.963103916541
##  [637]   5.394136017790   7.391835182319  -7.443997131473 -30.032630724271
##  [641] -17.209884145823 -10.940854688677 -20.403566541262 -14.333727006514
##  [645]   1.129154307565 -13.071353637399 -14.141237558303  -7.802755749097
##  [649] -20.977375285081  -8.607481084645 -24.643243969914  -4.355115564552
##  [653]   1.386941676272 -15.951901422623  -7.998286966947 -15.801625643468
##  [657]  -1.504869683969 -18.994778453885  14.770592702425  -7.485332126471
##  [661]  -7.097639794220  -4.185912699907 -11.410332435354  -5.374226732003
##  [665] -17.812185819045 -18.466881225098 -12.569262187436  -9.789533680471
##  [669] -17.022337123751 -18.703339854025  -8.709068586495 -13.617846128321
##  [673] -12.516739110646  -3.468213585094  -3.273306175012 -26.869586328486
##  [677]  -1.194592125147 -18.631695812317  -7.579982388822  14.910518373322
##  [681]  13.805797068096  -3.178946318600  -9.615788292973   3.358763159065
##  [685] -26.002082515831  -8.972771848411 -24.211778276220 -32.227518069744
##  [689]  -5.200925418583 -10.814500249380  -5.203990072475  -2.702150174330
##  [693]  -4.158190476241  -9.460928423299 -13.338212952986 -25.827944298116
##  [697]  -2.869538181698 -10.808675815927  -7.092953604808   9.095673866964
##  [701]  -8.764311624905 -26.198784150147 -15.433289890440  -7.863832538835
##  [705]  -7.903114557392  -4.709944061610 -26.156904958544 -11.693183854407
##  [709]  -8.921330335824 -14.542033307619 -12.779819049241 -12.768076714843
##  [713] -23.020277861299 -18.809014307038 -32.971136646671 -25.715311436757
##  [717]  -7.748940213004 -12.460637677872  -9.308246335115  -5.557189673371
##  [721]  -2.665038419903 -14.266361599085  -8.715082920717  -7.550240537173
##  [725] -16.464962001986  -1.318195201245 -11.593418422676  -2.960950730050
```

```
##  [729]  -5.781813399473 -12.251817934278  -7.449332572619  -0.798929125663
##  [733]  -9.631788114179  -3.152280798046   2.574567131606 -20.944727494111
##  [737]  -2.377905679380   9.793474718754 -24.656510258505  -1.188155126436
##  [741]  -5.687557007698  -5.655124776902 -14.252196883700  -3.490037293898
##  [745]  -6.713020815318 -12.372568207788  -9.767377894920 -10.627225006766
##  [749]  -9.673824320820   6.838725059059 -25.516752634555  -5.365299504600
##  [753] -16.713356477036 -16.237904788750  -7.097289743527  11.445286438814
##  [757]   2.525315822474   4.744906000852  11.386303674048 -23.004159913922
##  [761] -19.795522453367 -18.631334544538   1.672609994885  -2.868022791475
##  [765] -11.391749514200 -11.400159513713   5.445540677886 -16.570601820528
##  [769]   5.751767952362  -4.242700782690  -1.591206860795 -20.739915705941
##  [773] -12.314436089019  -2.244525592042 -27.592780404539 -22.354001166307
##  [777]  -5.308412883614 -17.218797634613 -21.173935390786  -2.307823957401
##  [781]  -3.768950218422 -12.518247154996 -11.586606688954 -18.728462511682
##  [785]  -4.815775657640 -15.913800637234  -2.084884521908 -15.152997533075
##  [789] -17.689933944248  -6.934397291694 -14.589053393716 -17.164852915792
##  [793]  15.949935737420  -0.066932053425   1.896027714433  10.279337178203
##  [797]  -3.457809985991 -18.960926660046  -6.347764365375  -7.892662282539
##  [801]  -2.615726486884 -16.583758038387  -1.597664977105  -8.394015802297
##  [805]   3.862943189042 -10.911953493860  19.664874334287  -0.102693461620
##  [809]  -6.444854520462 -19.267340754427  -3.151624220732   7.867409502604
##  [813] -13.151874202187 -15.048788472986  -3.916306866729   6.012244726546
##  [817] -24.425981103427 -16.209129907992   9.223776206668 -11.873498634510
##  [821] -20.255196361114  -8.995631559302 -17.055203536561  -0.500787058387
##  [825] -11.552485989717  -1.411230356217   2.935802963096 -18.644853645516
##  [829]  -9.730081749247   1.286842313817  -2.591167148544 -18.245730891678
##  [833] -11.391218187606 -16.501180768594 -26.040766398507  -9.563798294750
##  [837] -25.176764367109   8.782845007128 -19.867718519030 -12.441226815444
##  [841] -36.112550573799 -16.919958205779   6.146044370200  -5.622519158529
##  [845]  -6.351376882686   6.300905959341  -3.807388462220  -4.363976079646
##  [849] -18.526334426613  -2.734700458592 -10.286158337355 -13.044027229839
##  [853] -32.095790491522   5.515143699352  -5.194033046985  -8.959777315429
##  [857]  -3.968290518551 -16.609652171151 -20.794950093561   3.120201810730
##  [861]  -8.326930236109  -2.927154509386 -11.207003004663 -24.124869723848
##  [865] -12.705603654313  17.274561637794 -19.337293934265  -2.228730127127
##  [869]  -6.041152221169  -7.632633016285 -16.361723459856   5.679940560468
##  [873]  -3.182742137179 -11.914989695571 -16.511360089155 -24.741487828465
##  [877]  -7.353597042759  -3.379171647337  -9.610686380989  -6.438360769176
##  [881]  -6.264403989342 -11.169310366996 -22.556153834341 -16.480951375995
##  [885] -22.379148894672  -5.806652661548 -20.522507868558 -27.511872910767
##  [889]  -7.426040094502 -21.225151151510  -5.459681145381  -8.130844621406
##  [893] -19.642864158694  -9.261598480917  -0.062525170678  -9.986489910162
##  [897] -14.138421426081 -19.032826461350  -3.280117397660 -23.721622649421
##  [901]  -1.600810541618  -9.682907789443  -7.735405682937  -7.183289713087
##  [905] -16.105163551538 -14.109462038671 -15.575646441348   5.356275028766
##  [909] -13.429174668694 -21.312382709331  -2.282399135633 -21.485412171017
##  [913] -10.155951447911  16.813810371471 -10.637548818922 -13.664390926322
##  [917]  -2.338289403452  -1.780058568792   7.992865782309   0.622755241055
##  [921] -10.870845514986 -26.426661409248 -10.647338950886  -9.309719862540
##  [925]  -8.324210705666 -16.668392428985  -8.863757667022 -13.011873094718
##  [929] -15.959224584519  -4.228701632290  -7.304990635246  -3.669709754249
##  [933] -16.331027747712 -13.007085054813 -14.027871941604  -4.286854681792
##  [937] -11.130777930562  -3.382901532820 -11.513206429842 -26.776254996835
##  [941]  -5.097096589930  -7.090581517000 -14.689893258642 -18.778633472873
```

```
##  [945]  -7.021690132849   0.096290877803  -5.463475877881 -21.242929284071
##  [949] -11.294964823759 -10.599230666617  -8.838991484889  -6.676984120490
##  [953]   4.101030061355  -2.324379667788  -1.211781874290  -7.958091459899
##  [957] -18.027837222519 -14.591896370080  -5.544403520200 -11.304673300288
##  [961]  -4.697687176266  -8.614113645753 -21.017040195292 -15.540833411153
##  [965] -17.468328633006 -14.131495854636 -13.480707824792  -5.044312725839
##  [969] -12.531692378638 -18.602511128904 -11.579713928631 -11.471420018537
##  [973] -17.384990061620 -13.259082064427 -14.962499218085  -5.304671681053
##  [977]   6.330967733924  -5.048218710973 -25.114478473088  -5.711931998872
##  [981]  11.302874153101  -2.251055734527  10.680893189389   5.328428671773
##  [985]  -0.665338426636  -2.405250861900 -19.238067105465   0.627512201034
##  [989] -15.989684022778 -18.169190721536 -15.341802673733 -18.824032736991
##  [993]  -4.781169932785   0.157562845250  -3.619826360590 -22.558923456626
##  [997]  -5.572754687726 -15.410426740657  -3.654387666413  -4.165628532915
```

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

```
set.seed(17)
v = rnorm(1000, mean = -10, sd = 10)
v
```

```
##    [1] -20.150087164606 -10.796367371298 -12.329870219576 -18.172679336760
##    [5]  -2.279091607998 -11.656119353208  -0.271255738956   7.165339792337
##    [9]  -7.447629955043  -6.334188796694   1.807892362525  -3.568079310350
##   [13]   2.953218674674  -8.120819265693   5.912050979204 -10.551790569080
##   [17]  -1.615288793602  -8.406298748866  -3.740455984547  -3.664152749544
##   [21]  -3.189723513515 -16.820333658735 -17.232567368032   6.735259648821
##   [25] -15.957556324548   1.598438441624  -8.825775887198  -7.407786130781
##   [29]  -6.176378961527 -17.114817352893 -21.775695693615 -19.601665095796
##   [33] -18.789522376094 -45.561364807598 -24.167498427741 -14.487692659921
##   [37] -17.759677056052 -18.318280520826  -9.481698836068 -16.165513114254
##   [41]  -7.456032490741 -13.315204614358 -12.063193144728   2.153370863674
##   [45]   8.920564188355  -9.258064788643   7.516961694392 -12.314874367570
##   [49]  -4.565475152387 -19.890014011738  -6.844685361532  14.423274642231
##   [53]  -4.503071384786 -10.292433673210 -18.307833776807   2.464343861616
##   [57] -23.757552911897 -13.311084475208  -0.190885138923  11.907705641411
##   [61]  -9.694542532498 -17.855174057500  -6.745594438846 -18.808435499429
##   [65]  -7.906740569310  -8.489670475658 -13.434787944798  -0.941224038384
##   [69]  -0.810451461853 -15.559874920389  -4.397651586960 -27.924177958063
##   [73] -25.654168650876 -43.203188807403  -8.452784286989 -13.646266604177
##   [77] -34.336838537121  -6.635356945899 -16.404528199244   8.211204171977
##   [81] -28.467234543039  -3.582831634573   1.855248692710 -11.776880298423
##   [85] -22.861259241344  -5.365493559067  -1.193337263893  -8.605780452935
##   [89] -13.750548278468  -9.574609663882  -3.661197093177 -27.074884595758
##   [93]  -9.803134540601 -12.987963670316 -14.417628254521  -4.090246841595
##   [97] -21.343208083025 -14.387445878050  -6.550986312876 -14.494003701153
##  [101]  -9.561797784699 -15.679915859886   8.248603076018  -5.669974304900
##  [105] -23.539662768983   1.544659056455  -0.792630522186 -14.486574634379
##  [109]  10.705737160584 -11.995561285572 -21.291284952426 -22.955548649107
##  [113]   2.404188769534   6.950587232336  -4.976990609021  -6.663683504420
##  [117] -15.082026301443 -13.706323521689   5.086429518830 -10.496257860441
##  [121]   3.817566246549  -5.510675732733 -11.523099552261  -7.407060241716
##  [125] -26.114016652319 -30.089559907747 -29.993712411363  -8.789593236451
```

```
##  [129] -12.299948004472 -31.991020759838 -27.104085681050  -7.737408052839
##  [133]  -0.491497416377  11.084155438169 -16.212261929764   0.546474612717
##  [137] -26.390094548616  -1.590168064422 -15.254750050586  -9.361414545904
##  [141] -14.636523700405  -3.389552655258 -14.399860908692 -12.881595388270
##  [145] -23.159483125297   7.102272563645 -13.275400420816 -28.384576832215
##  [149]   3.194120227038  -6.511179152240  19.160722452752  -9.000835440000
##  [153]   3.131607900763  -3.105762199224 -14.017258387460   0.363085231176
##  [157] -21.102520572674 -11.577273904295   5.766081350439 -21.808354039249
##  [161] -19.299823536500 -16.908916648018 -34.547725776377 -21.698518376339
##  [165] -19.685190949892  -4.993972410263   8.383551968649  -9.865657189571
##  [169] -10.648761547638 -11.789986215057 -14.904717557651 -14.990264084565
##  [173]   0.929635165934 -10.026669913515 -17.382113503663  -6.427859162531
##  [177]  -0.025034807594  -5.927632781470 -20.539798688377 -22.224878812404
##  [181] -24.000669010716 -22.185265835887 -22.006359621512  13.932156120132
##  [185] -28.882548913982  -4.559633013625 -17.848715904338   3.983754753986
##  [189]  -1.637650911403 -21.866980509862 -22.462202426578 -20.355656090095
##  [193] -24.042089541743 -15.550872218348 -13.515558933798  -3.331678832248
##  [197] -14.161366841871 -15.901437570224 -22.774785043692  -7.505690732704
##  [201] -13.800461376076  -1.858939160188 -12.667060612416   3.669155317650
##  [205]  -6.525074826865  -6.596034269454   2.775329548409 -13.602721012489
##  [209]  -4.153011456618   2.566028639582 -13.445275273569 -22.622645401660
##  [213]  -3.131587444980 -10.479069048194 -13.610719201748   1.425584509393
##  [217]   1.078064181763  -8.242684391424  -8.341699833574 -10.380770501185
##  [221]   4.680777401936 -13.300040863871 -14.820845783016 -14.822042730414
##  [225]  13.795241008475   3.023955380350 -14.773233912385  -0.400772048171
##  [229]  -7.925300411389 -27.090955631374 -13.041131104726 -26.765663149030
##  [233]  -5.928071649098 -25.489410306593   5.849564455827 -26.182811584380
##  [237] -21.315725903742 -18.096711567468   9.585687443292 -19.698597773379
##  [241] -11.619897453580 -17.650727978200 -10.997260400098  -9.608706701961
##  [245] -16.397615271838 -15.663537367593 -20.003416026337   3.527055069011
##  [249]  -8.708025192560 -14.218445579701   1.660813814172  -8.385328810044
##  [253] -15.253772295599   3.231574162078  10.943249778490 -15.025035222849
##  [257]  -7.596600920330 -11.292764272128 -17.557725813983 -16.954102489914
##  [261]  -9.864294392935   1.677762669465 -17.320115786088   1.023522961425
##  [265]  -9.985149049743 -10.513433272683  -6.052748676702   0.497687712742
##  [269]   3.081660256728 -10.539591047191  -3.146291921970  -5.422661970712
##  [273]   8.467923835692 -44.012241405389  -9.735576353509  -6.296801941593
##  [277] -18.013411695279  -9.976878775209 -20.752949519889  -0.778962534115
##  [281]  -8.198155292723  12.636966257171  -6.902612356258  -0.254706767606
##  [285] -12.833816555657  -9.543039366639  -2.933073307999  -4.577368711270
##  [289]  -2.220894828923 -10.091765108069 -25.425372836317  -6.576335486065
##  [293] -12.955572499828   0.472604624516 -13.695157319660  -8.048041732671
##  [297] -19.357449899575  -3.295813715689 -11.019597436975 -24.442605113744
##  [301]  -5.640985124071  -9.784244815082 -13.227678878323   9.694138518804
##  [305] -10.084808263179  -8.574109786015   3.616351014299  -9.289070676276
##  [309]  -2.339304397242  -5.511025957426   7.861284560505  -8.283965365636
##  [313]  -6.143446800354 -11.413739859139   1.767490321543 -22.237204824534
##  [317] -13.307245495639  -0.689586761677 -17.080664589167 -16.415168323065
##  [321] -26.123888231916 -10.513631808498  -6.111121916267 -29.594867946274
##  [325] -12.844214607600 -11.899158711606 -21.284033382868  -4.214476743378
##  [329] -11.631894361894 -10.493594107813 -25.310307738148 -22.216069303143
##  [333] -12.539509476670 -13.776977491200 -24.820040308448  -7.334207667726
##  [337]   6.286262310536  -7.820771010080  -7.198209099332 -25.083154850974
##  [341] -12.090929019277  -0.409786744973 -18.243861492002   2.457522382041
```

```
##  [345] -16.806068189774 -11.162478913532 -17.310539525452 -19.189474314744
##  [349]  -3.642982405976  -7.141294045703  -6.348300046128  -9.285162518828
##  [353] -12.899120775406 -10.267539828798 -12.590079669235 -12.645522890496
##  [357]  -8.489021658569  -8.612735740713  -9.692337095103 -13.650433188668
##  [361]   4.348323712478   2.018891294434  -4.011242055415  -1.938184120617
##  [365]  -2.176605728090  -9.283905240447 -20.072996268914 -15.569154830653
##  [369] -37.863749069468 -13.569002567416  -6.358801366712  -1.278628772910
##  [373]  20.917324312786 -22.661342835262  -0.429067755261  -6.140923790551
##  [377]  -2.878947336670 -12.720128997583   4.575945494298 -22.112206188247
##  [381]  -8.610705837098   0.466417292449   0.492967301801 -24.366361898889
##  [385] -17.742168639044 -20.523658425373   1.929930136788   3.537156533696
##  [389] -22.869989278622 -12.571399514378 -26.868163055295 -25.243278211356
##  [393] -23.841514244100   3.787583092552 -26.424558079462  -1.740812744956
##  [397] -10.823772473166 -17.767611918572  -6.577269644868  -3.049472110570
##  [401]  -7.624880406307  -8.211316005312 -29.009896303533   5.901963289603
##  [405]   5.462582236307 -33.390491812907 -21.360281997634 -19.131867114131
##  [409] -25.877374636903 -17.980568628746 -35.518529158487   1.419324758310
##  [413]  -4.521063909959  23.301530539802  -2.630059258859  -2.302907386031
##  [417] -14.714594681452  -9.389818951298 -18.365778782842 -14.536159714223
##  [421] -15.199902574295 -15.236857517028 -18.699265226994 -25.411607549879
##  [425] -15.693698973649 -26.100535118828   4.427544054476 -19.850168208073
##  [429] -16.625266710710 -13.894710630525 -10.293322140913 -15.671832866362
##  [433]  -5.237339713629 -17.221533392725 -19.152072088138 -20.810138930061
##  [437]   0.192402722752 -13.471674554245  -9.534262648905  -7.958471621273
##  [441]  -9.105319255221  -7.693615454039 -10.117797711005  -1.148445752939
##  [445]  -5.312305205700 -19.780926206240  -3.688132282300 -15.090050260649
##  [449]  -7.683429486854 -26.385733497347   2.394208410222   8.395457830672
##  [453]  12.353609606067 -25.375271644504 -23.994403186647  -2.618911971933
##  [457]  -4.741070086413  -8.273219541799  -0.917153858316 -27.857873560544
##  [461] -30.190558470660 -29.111911010741 -27.729647760498  -8.244870542941
##  [465]  -0.848641853272   1.200737655282 -18.036519665548 -12.996140301144
##  [469]  -4.457750063169  -5.908391794831 -44.942738603128   5.164618201913
##  [473] -25.045104533044  -2.838661914640   2.822619936633  -8.522635460200
##  [477] -16.409640611011  -8.929443236329  -6.956455045668   3.696833432628
##  [481] -16.074357951956 -15.441577784035   0.730659689580  -9.878526379852
##  [485] -20.035830537920 -27.226282004851 -22.296714646247 -18.851868275263
##  [489]   0.045133456279 -13.386922634633  -4.072228916837 -15.558489480642
##  [493]   1.084026911879 -14.195713576746 -11.739230537416  -5.455978278008
##  [497]  -4.282523900801  -7.737095297849   3.235841506182 -15.348904787312
##  [501]   9.462448858843 -12.388696179009 -12.137865528110   6.314029067685
##  [505]  -3.772306350077  -2.548336048704  29.397455037747 -11.673700992585
##  [509]   1.186082316827  -4.961693511058   0.346971207140 -10.656877746946
##  [513] -17.169523498638 -16.329403521879 -12.885994436490 -16.273684608782
##  [517]  -5.881121337059  -0.271240606956   3.445110089674 -20.878243801130
##  [521]  -5.715818541919  -9.064330278191  13.566797856454  -6.055261812310
##  [525] -19.730268972463  10.299043484064 -19.791069858193 -17.688522138629
##  [529] -26.088550793842 -12.445908893961 -26.707311648419  -1.014871176743
##  [533]  -0.760531478347 -20.187890259729 -14.059940367582  -4.942817805473
##  [537] -13.556406387215  16.506430746286  -2.568600889196 -22.703326894580
##  [541] -17.923558754766 -16.459619995407 -16.381931660219 -11.066699465552
##  [545] -11.962232168180  -2.550358904834  -1.706510796410  -2.133258617679
##  [549] -16.083472542800 -11.173449516254   1.627066770732 -20.493449427060
##  [553]  -8.773518858183   7.953858972383  -6.295657830601  -6.398424824464
##  [557] -16.870402549675  13.989723098875  -9.599543012731 -19.325718757353
```

```
##  [561] -18.001634150210 -27.435121602238 -14.373464975724 -25.000831581362
##  [565] -25.018271008944 -17.390367848777 -20.482397718042  -8.863005034967
##  [569]  -9.686738531355  -7.306120050459  -2.971944362567  10.210736433629
##  [573]  -4.048228354600 -10.711440866517  -4.984848867414  -0.887779348173
##  [577]  -2.771593975223 -15.302004164080 -19.046162717343 -10.558218416841
##  [581] -28.195580235937 -16.581476482236 -10.232481987613   2.757661467562
##  [585]   7.761050756432 -23.740023739742 -14.810870554018 -11.000994277162
##  [589]  -5.956748956090 -24.715699851684  -2.923993672530 -12.122797447773
##  [593]  -7.902175059199 -25.545041692250 -32.429946386642 -19.949752520479
##  [597]  -5.274136813788 -12.959832491640 -23.595410709769  -1.077414398899
##  [601] -25.396303578633 -11.071327925224 -10.097007920893 -19.801885582207
##  [605] -19.698263930918  -1.666205458984   2.264110115453  -0.364264387106
##  [609]  -4.741469382882 -13.902578000311   4.256369376273  -0.238202506888
##  [613] -11.129916355246  -8.442551601381  -3.920558175715 -12.845510285031
##  [617]  -8.695908701256 -15.385139466763 -12.147034690068   5.920151935935
##  [621]  -6.952054666633 -15.640462092349  -9.763464196479 -13.146718881058
##  [625] -15.947086992638  -3.957928628452  -3.524720590400  -3.701753228703
##  [629]  -6.269823789514  -8.680904684820  -0.963782800282 -12.571361872379
##  [633] -14.313750128974  -6.259716322050 -24.487557457686 -14.963103916541
##  [637]   5.394136017790   7.391835182319  -7.443997131473 -30.032630724271
##  [641] -17.209884145823 -10.940854688677 -20.403566541262 -14.333727006514
##  [645]   1.129154307565 -13.071353637399 -14.141237558303  -7.802755749097
##  [649] -20.977375285081  -8.607481084645 -24.643243969914  -4.355115564552
##  [653]   1.386941676272 -15.951901422623  -7.998286966947 -15.801625643468
##  [657]  -1.504869683969 -18.994778453885  14.770592702425  -7.485332126471
##  [661]  -7.097639794220  -4.185912699907 -11.410332435354  -5.374226732003
##  [665] -17.812185819045 -18.466881225098 -12.569262187436  -9.789533680471
##  [669] -17.022337123751 -18.703339854025  -8.709068586495 -13.617846128321
##  [673] -12.516739110646  -3.468213585094  -3.273306175012 -26.869586328486
##  [677]  -1.194592125147 -18.631695812317  -7.579982388822  14.910518373322
##  [681]  13.805797068096  -3.178946318600  -9.615788292973   3.358763159065
##  [685] -26.002082515831  -8.972771848411 -24.211778276220 -32.227518069744
##  [689]  -5.200925418583 -10.814500249380  -5.203990072475  -2.702150174330
##  [693]  -4.158190476241  -9.460928423299 -13.338212952986 -25.827944298116
##  [697]  -2.869538181698 -10.808675815927  -7.092953604808   9.095673866964
##  [701]  -8.764311624905 -26.198784150147 -15.433289890440  -7.863832538835
##  [705]  -7.903114557392  -4.709944061610 -26.156904958544 -11.693183854407
##  [709]  -8.921330335824 -14.542033307619 -12.779819049241 -12.768076714843
##  [713] -23.020277861299 -18.809014307038 -32.971136646671 -25.715311436757
##  [717]  -7.748940213004 -12.460637677872  -9.308246335115  -5.557189673371
##  [721]  -2.665038419903 -14.266361599085  -8.715082920717  -7.550240537173
##  [725] -16.464962001986  -1.318195201245 -11.593418422676  -2.960950730050
##  [729]  -5.781813399473 -12.251817934278  -7.449332572619  -0.798929125663
##  [733]  -9.631788114179  -3.152280798046   2.574567131606 -20.944727494111
##  [737]  -2.377905679380   9.793474718754 -24.656510258505  -1.188155126436
##  [741]  -5.687557007698  -5.655124776902 -14.252196883700  -3.490037293898
##  [745]  -6.713020815318 -12.372568207788  -9.767377894920 -10.627225006766
##  [749]  -9.673824320820   6.838725059059 -25.516752634555  -5.365299504600
##  [753] -16.713356477036 -16.237904788750  -7.097289743527  11.445286438814
##  [757]   2.525315822474   4.744906000852  11.386303674048 -23.004159913922
##  [761] -19.795522453367 -18.631334544538   1.672609994885  -2.868022791475
##  [765] -11.391749514200 -11.400159513713   5.445540677886 -16.570601820528
##  [769]   5.751767952362  -4.242700782690  -1.591206860795 -20.739915705941
##  [773] -12.314436089019  -2.244525592042 -27.592780404539 -22.354001166307
```

```
##  [777]  -5.308412883614 -17.218797634613 -21.173935390786  -2.307823957401
##  [781]  -3.768950218422 -12.518247154996 -11.586606688954 -18.728462511682
##  [785]  -4.815775657640 -15.913800637234  -2.084884521908 -15.152997533075
##  [789] -17.689933944248  -6.934397291694 -14.589053393716 -17.164852915792
##  [793]  15.949935737420  -0.066932053425   1.896027714433  10.279337178203
##  [797]  -3.457809985991 -18.960926660046  -6.347764365375  -7.892662282539
##  [801]  -2.615726486884 -16.583758038387  -1.597664977105  -8.394015802297
##  [805]   3.862943189042 -10.911953493860  19.664874334287  -0.102693461620
##  [809]  -6.444854520462 -19.267340754427  -3.151624220732   7.867409502604
##  [813] -13.151874202187 -15.048788472986  -3.916306866729   6.012244726546
##  [817] -24.425981103427 -16.209129907992   9.223776206668 -11.873498634510
##  [821] -20.255196361114  -8.995631559302 -17.055203536561  -0.500787058387
##  [825] -11.552485989717  -1.411230356217   2.935802963096 -18.644853645516
##  [829]  -9.730081749247   1.286842313817  -2.591167148544 -18.245730891678
##  [833] -11.391218187606 -16.501180768594 -26.040766398507  -9.563798294750
##  [837] -25.176764367109   8.782845007128 -19.867718519030 -12.441226815444
##  [841] -36.112550573799 -16.919958205779   6.146044370200  -5.622519158529
##  [845]  -6.351376882686   6.300905959341  -3.807388462220  -4.363976079646
##  [849] -18.526334426613  -2.734700458592 -10.286158337355 -13.044027229839
##  [853] -32.095790491522   5.515143699352  -5.194033046985  -8.959777315429
##  [857]  -3.968290518551 -16.609652171151 -20.794950093561   3.120201810730
##  [861]  -8.326930236109  -2.927154509386 -11.207003004663 -24.124869723848
##  [865] -12.705603654313  17.274561637794 -19.337293934265  -2.228730127127
##  [869]  -6.041152221169  -7.632633016285 -16.361723459856   5.679940560468
##  [873]  -3.182742137179 -11.914989695571 -16.511360089155 -24.741487828465
##  [877]  -7.353597042759  -3.379171647337  -9.610686380989  -6.438360769176
##  [881]  -6.264403989342 -11.169310366996 -22.556153834341 -16.480951375995
##  [885] -22.379148894672  -5.806652661548 -20.522507868558 -27.511872910767
##  [889]  -7.426040094502 -21.225151151510  -5.459681145381  -8.130844621406
##  [893] -19.642864158694  -9.261598480917  -0.062525170678  -9.986489910162
##  [897] -14.138421426081 -19.032826461350  -3.280117397660 -23.721622649421
##  [901]  -1.600810541618  -9.682907789443  -7.735405682937  -7.183289713087
##  [905] -16.105163551538 -14.109462038671 -15.575646441348   5.356275028766
##  [909] -13.429174668694 -21.312382709331  -2.282399135633 -21.485412171017
##  [913] -10.155951447911  16.813810371471 -10.637548818922 -13.664390926322
##  [917]  -2.338289403452  -1.780058568792   7.992865782309   0.622755241055
##  [921] -10.870845514986 -26.426661409248 -10.647338950886  -9.309719862540
##  [925]  -8.324210705666 -16.668392428985  -8.863757667022 -13.011873094718
##  [929] -15.959224584519  -4.228701632290  -7.304990635246  -3.669709754249
##  [933] -16.331027747712 -13.007085054813 -14.027871941604  -4.286854681792
##  [937] -11.130777930562  -3.382901532820 -11.513206429842 -26.776254996835
##  [941]  -5.097096589930  -7.090581517000 -14.689893258642 -18.778633472873
##  [945]  -7.021690132849   0.096290877803  -5.463475877881 -21.242929284071
##  [949] -11.294964823759 -10.599230666617  -8.838991484889  -6.676984120490
##  [953]   4.101030061355  -2.324379667788  -1.211781874290  -7.958091459899
##  [957] -18.027837222519 -14.591896370080  -5.544403520200 -11.304673300288
##  [961]  -4.697687176266  -8.614113645753 -21.017040195292 -15.540833411153
##  [965] -17.468328633006 -14.131495854636 -13.480707824792  -5.044312725839
##  [969] -12.531692378638 -18.602511128904 -11.579713928631 -11.471420018537
##  [973] -17.384990061620 -13.259082064427 -14.962499218085  -5.304671681053
##  [977]   6.330967733924  -5.048218710973 -25.114478473088  -5.711931998872
##  [981]  11.302874153101  -2.251055734527  10.680893189389   5.328428671773
##  [985]  -0.665338426636  -2.405250861900 -19.238067105465   0.627512201034
##  [989] -15.989684022778 -18.169190721536 -15.341802673733 -18.824032736991
```

```
##  [993]  -4.781169932785   0.157562845250  -3.619826360590 -22.558923456626
##  [997]  -5.572754687726 -15.410426740657  -3.654387666413  -4.165628532915
```

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

```
mean(v)
```

```
## [1] -9.8259967761
```

```
SEV = sd(v)/sqrt(1000)
SEV
```

```
## [1] 0.3218524474
```

- 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?

```
#The 5% ile
fifth = quantile(v, probs = 0.05)
fifth
```

```
##           5%
## -26.101209196
```

```
#Theoretically
qnorm(.05, mean(v), sd(v))
```

```
## [1] -26.567099941
```

```
#Yes because v is the random realization from mean that is -10 and sd = 10
```

- 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?

```
#Theoretically
ecdf(v)(0)
```

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

```
#estimate
pnorm(0, mean(v), sd(v))
```

```
## [1] 0.83283470917
```

```
#Yes because v is the random realization we have set and comparing it between the two result.
```