Lab 1

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Is this answer *exactly* correct?

The answer is not exactly correct because we experienced numerical underflow.

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

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

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

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

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

```
##  [1] Inf  20  18  16  14  12  10   8   6   4   2   0  -2  -4  -6  -8 -10 -12 -14
## [20] -16 -18 -20
```

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

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

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

```
x
```

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

Comment on the appropriateness of the non-numeric values.

#TO-DO

- 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==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
```

- 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.

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

```
## [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] 0.49
```

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

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

```
## [1] 0.912
```

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

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

```
## [1] 0.901
```

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

```
##  [73]  TRUE FALSE  TRUE  TRUE FALSE FALSE FALSE  TRUE  TRUE  TRUE FALSE  TRUE
##  [85]  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE FALSE  TRUE  TRUE  TRUE  TRUE
##  [97] FALSE  TRUE  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"),order = TRUE)
x_3_ord
```

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

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

```
x_3_infrac = x_3 =="infraction"
x_3_misd = x_3 =="misdimeanor"
x_3_felony = x_3=="felony"

n = 100 #number of historical objects: the people
p = 3 #number of features about each

X_3_Matrix = matrix(NA, nrow = n, ncol = p)
X_3_Matrix[,1] = x_3_infrac
X_3_Matrix[,2] = x_3_misd
X_3_Matrix[,3] = x_3_felony
X_3_Matrix
```

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

```
##  [13,]  TRUE FALSE FALSE
##  [14,]  TRUE FALSE FALSE
##  [15,] FALSE FALSE FALSE
##  [16,] FALSE FALSE  TRUE
##  [17,] FALSE FALSE FALSE
##  [18,] FALSE FALSE  TRUE
##  [19,] FALSE FALSE FALSE
##  [20,] FALSE  TRUE FALSE
##  [21,] FALSE  TRUE FALSE
##  [22,]  TRUE FALSE FALSE
##  [23,] FALSE FALSE FALSE
##  [24,] FALSE FALSE FALSE
##  [25,] FALSE FALSE  TRUE
##  [26,] FALSE FALSE FALSE
##  [27,]  TRUE FALSE FALSE
##  [28,] FALSE FALSE  TRUE
##  [29,]  TRUE FALSE FALSE
##  [30,]  TRUE FALSE FALSE
##  [31,]  TRUE FALSE FALSE
##  [32,] FALSE FALSE FALSE
##  [33,] FALSE FALSE FALSE
##  [34,] FALSE FALSE  TRUE
##  [35,]  TRUE FALSE FALSE
##  [36,] FALSE FALSE  TRUE
##  [37,]  TRUE FALSE FALSE
##  [38,] FALSE  TRUE FALSE
##  [39,]  TRUE FALSE FALSE
##  [40,] FALSE FALSE FALSE
##  [41,] FALSE FALSE  TRUE
##  [42,] FALSE FALSE  TRUE
##  [43,] FALSE FALSE FALSE
##  [44,] FALSE  TRUE FALSE
##  [45,] FALSE  TRUE FALSE
##  [46,] FALSE FALSE FALSE
##  [47,] FALSE FALSE  TRUE
##  [48,] FALSE FALSE FALSE
##  [49,] FALSE FALSE  TRUE
##  [50,] FALSE FALSE FALSE
##  [51,] FALSE FALSE FALSE
##  [52,]  TRUE FALSE FALSE
##  [53,] FALSE FALSE  TRUE
##  [54,] FALSE FALSE FALSE
##  [55,] FALSE FALSE  TRUE
##  [56,] FALSE FALSE FALSE
##  [57,] FALSE  TRUE FALSE
##  [58,] FALSE FALSE  TRUE
##  [59,] FALSE  TRUE FALSE
##  [60,]  TRUE FALSE FALSE
##  [61,] FALSE FALSE FALSE
##  [62,] FALSE FALSE FALSE
##  [63,] FALSE  TRUE FALSE
##  [64,] FALSE FALSE FALSE
##  [65,] FALSE FALSE  TRUE
##  [66,] FALSE FALSE FALSE
```

```
##  [67,] FALSE  TRUE FALSE
##  [68,] FALSE FALSE FALSE
##  [69,] FALSE  TRUE FALSE
##  [70,] FALSE  TRUE FALSE
##  [71,] FALSE  TRUE FALSE
##  [72,] FALSE FALSE FALSE
##  [73,]  TRUE FALSE FALSE
##  [74,] FALSE FALSE FALSE
##  [75,] FALSE FALSE  TRUE
##  [76,]  TRUE FALSE FALSE
##  [77,] FALSE FALSE FALSE
##  [78,] FALSE FALSE FALSE
##  [79,] FALSE FALSE FALSE
##  [80,] FALSE  TRUE FALSE
##  [81,] FALSE FALSE  TRUE
##  [82,]  TRUE FALSE FALSE
##  [83,] FALSE FALSE FALSE
##  [84,] FALSE  TRUE FALSE
##  [85,] FALSE  TRUE FALSE
##  [86,]  TRUE FALSE FALSE
##  [87,]  TRUE FALSE FALSE
##  [88,]  TRUE FALSE FALSE
##  [89,] FALSE  TRUE FALSE
##  [90,] FALSE FALSE  TRUE
##  [91,] FALSE  TRUE FALSE
##  [92,] FALSE FALSE FALSE
##  [93,]  TRUE FALSE FALSE
##  [94,] FALSE FALSE  TRUE
##  [95,]  TRUE FALSE FALSE
##  [96,] FALSE FALSE  TRUE
##  [97,] FALSE FALSE FALSE
##  [98,] FALSE  TRUE FALSE
##  [99,] FALSE FALSE  TRUE
## [100,] FALSE FALSE  TRUE
```

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

Either one or zero if no criminality Verify that.

```
rowSums(X_3_Matrix)
```

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

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

The total number of people with that level of criminality

Verify that.

```
colSums(X_3_Matrix)
```

```
## [1] 22 21 22
```

- Generate a matrix with 100 rows where the first column is realization from a normal with mean 17 and variance 38, the second column is uniform between -10 and 10, the third column is poisson with mean 6, the fourth column in exponential with lambda of 9, the fifth column is binomial with n = 20 and p

= 0.12 and the sixth column is a binary variable with exactly 24% 1's dispersed randomly. Name the rows the entries of the `fake_first_names` vector.

```
fake_first_names = c(
  "Sophia", "Emma", "Olivia", "Ava", "Mia", "Isabella", "Riley",
  "Aria", "Zoe", "Charlotte", "Lily", "Layla", "Amelia", "Emily",
  "Madelyn", "Aubrey", "Adalyn", "Madison", "Chloe", "Harper",
  "Abigail", "Aaliyah", "Avery", "Evelyn", "Kaylee", "Ella", "Ellie",
  "Scarlett", "Arianna", "Hailey", "Nora", "Addison", "Brooklyn",
  "Hannah", "Mila", "Leah", "Elizabeth", "Sarah", "Eliana", "Mackenzie",
  "Peyton", "Maria", "Grace", "Adeline", "Elena", "Anna", "Victoria",
  "Camilla", "Lillian", "Natalie", "Jackson", "Aiden", "Lucas",
  "Liam", "Noah", "Ethan", "Mason", "Caden", "Oliver", "Elijah",
  "Grayson", "Jacob", "Michael", "Benjamin", "Carter", "James",
  "Jayden", "Logan", "Alexander", "Caleb", "Ryan", "Luke", "Daniel",
  "Jack", "William", "Owen", "Gabriel", "Matthew", "Connor", "Jayce",
  "Isaac", "Sebastian", "Henry", "Muhammad", "Cameron", "Wyatt",
  "Dylan", "Nathan", "Nicholas", "Julian", "Eli", "Levi", "Isaiah",
  "Landon", "David", "Christian", "Andrew", "Brayden", "John",
  "Lincoln"
)
n = 100 #number of historical objects: the people
p = 6 #number of features about each

X = matrix(NA, nrow = n, ncol = p)

X[, 1] = rnorm(n , 17, sqrt(38))
X[, 2] = runif(n ,-10, 10)
X[, 3] = rpois(n ,6)
X[, 4] = rexp(n ,9)
X[, 5] = rbinom (n ,20, 0.12)
X[, 6] = rbinom(n ,1, 0.24)
rownames(X) = fake_first_names
X
```

```
##                   [,1]           [,2] [,3]             [,4] [,5] [,6]
## Sophia    15.5123948496  3.39514894411    4 0.24296770693270    3    0
## Emma      14.6566349304 -4.03737915680   10 0.04852871891732    3    0
## Olivia    29.9860182403  7.65525081661    3 0.17322998938179    2    0
## Ava       14.0414226456 -2.79146249872    7 0.03631058418088    2    1
## Mia       19.1850852062 -7.47857928742    5 0.02573613265907    1    0
## Isabella  17.1668635577  2.07866804674    1 0.01922818533745    2    0
## Riley     14.6227533670 -0.26900858618    3 0.07048755490945    1    0
## Aria      16.0571091308 -3.36965614930    6 0.32693081732206    4    0
## Zoe        8.4940106297  3.52040128782    3 0.00264948689275    2    0
## Charlotte 15.0565055947 -8.27077508438    4 0.10673925675581    0    0
## Lily      22.9156038359 -5.84329490084    5 0.11464181345317    3    0
## Layla     11.1214570628 -0.60008181259    1 0.27804816409373    2    0
## Amelia    17.6127913873  2.05575714819    8 0.01431047893005    2    0
## Emily     17.7674963753 -0.53098186851    2 0.08000398998893    0    0
## Madelyn   26.2329444444 -9.74364424590    8 0.31544088267288    5    0
## Aubrey    10.1915038315 -3.03892144002    6 0.04249451112830    3    0
## Adalyn    16.5791548104 -6.07411171775    4 0.05393676991550    2    0
## Madison   11.5119126615 -8.43950808980    6 0.09085268930376    3    0
## Chloe     15.9774733201 -6.82510714512    4 0.21890449916217    2    0
```

```
## Harper    10.4739280918  1.72878286336    4 0.18629728719284    2    1
## Abigail   21.7070916279 -5.70805290248    8 0.14558813482470    2    0
## Aaliyah    6.0682498797  9.48494082317    9 0.11092618646814    3    0
## Avery      8.5398651622  3.46879275981    3 0.05458174294068    4    0
## Evelyn    25.4884506226 -1.36803516652    9 0.02534569479111    5    0
## Kaylee    23.4940233757  9.61170416325    5 0.01747022983101    4    0
## Ella      -3.0325339723 -8.94875853322    4 0.49599598522862    4    1
## Ellie     16.9356868695  3.86623592582    4 0.14775185224444    2    1
## Scarlett  16.0121259294  9.74279672839    9 0.58008798477594    2    0
## Arianna   13.0264798411  1.56015730929    6 0.10633517521898    2    1
## Hailey    15.6480448862  8.25111260172    6 0.07690276909206    2    0
## Nora      16.5376394077 -0.34049032722    7 0.03651589222459    3    0
## Addison    9.1746275066 -6.53836350888    6 0.03851643277027    4    0
## Brooklyn   3.9829889932 -4.13735208102    3 0.17243201546947    2    0
## Hannah    12.3310884868  1.58836048562    6 0.03954450175580    4    0
## Mila      21.6730303316 -6.12324787304    4 0.01612222786147    3    0
## Leah      15.7954034749 -3.34170852788   10 0.14388954752796    1    0
## Elizabeth 11.3237740955  0.17990447115    3 0.00569373395087    1    1
## Sarah     19.9702995795  4.46426651906    7 0.00211515102428    1    0
## Eliana    14.3733773936  4.29699413944    7 0.02966008710684    1    0
## Mackenzie  5.7285499460 -4.75345726591    5 0.04048808744611    3    1
## Peyton    16.3168460721 -6.94244007114    7 0.05000128033054    3    0
## Maria     11.3893819904  2.98184376210    5 0.02354607803540    3    0
## Grace     19.2595981121  4.99178113881   10 0.19239292177178    4    0
## Adeline   13.6752230669  8.63835441414    7 0.47746862676946    1    0
## Elena     16.2748014280 -2.27161918301    8 0.23382141504895    3    0
## Anna      24.4266296419 -3.84937701281    6 0.08892418422994    1    0
## Victoria   7.3222205526  9.77358313277    8 0.34617835446981    0    0
## Camilla   15.2397828462 -2.34727195464    4 0.00013926794809    2    0
## Lillian   23.7439987821 -8.65441722330    3 0.09768195398099    5    0
## Natalie   11.7350530655  6.51603049599    2 0.32663887654530    0    0
## Jackson   17.3446540575 -5.33492956776    1 0.12399968939056    0    0
## Aiden      8.9146582941  0.96563390456    5 0.03242189840724    3    0
## Lucas     29.9391867421 -2.22944840323    5 0.18650636593395    4    0
## Liam      26.0823489971  5.84151872434    8 0.01186309511670    3    0
## Noah      17.7951746766 -7.35933178104    7 0.06916799970592    1    1
## Ethan      9.5831559133  6.62802569568    6 0.12984392835607    4    0
## Mason     19.2918981239 -5.77064344659    4 0.22903973773844    1    0
## Caden     11.5949168736  7.91973461397    9 0.05709783044747    1    0
## Oliver    19.5599003857  5.33133334015    6 0.10479111751696    3    0
## Elijah    22.7595443276  2.25006388500    7 0.04781955935889    1    1
## Grayson   11.1247620429  8.25496210717    2 0.01617161865464    0    0
## Jacob     23.0748507654  5.16614286229    7 0.15943506234944    1    1
## Michael   19.0081675708 -2.44505085517    8 0.01504357355707    3    1
## Benjamin  11.0482798188  5.81444230396    3 0.05016945959586    3    0
## Carter    15.9316779288  9.79888943955   13 0.40583854973466    0    0
## James     18.3297925263 -4.47918335441    8 0.00996107913347    3    0
## Jayden    14.8328410991 -4.48360749055    4 0.01170950646823    1    0
## Logan     20.8497403112  6.05835883413    5 0.07382401089287    4    0
## Alexander  4.0940350585  6.48113669362    2 0.00793373490564    1    1
## Caleb     21.1397058000 -5.92269100714    5 0.03101898196878    3    1
## Ryan      23.4129898673 -5.22912057117   10 0.24233556697114    4    1
## Luke      19.7937805066  7.65500323381    7 0.00073056735305    1    0
## Daniel     6.1830114211  8.45255712513    4 0.13296203449316    4    0
```

```
## Jack      19.7530453352  4.68968774192    5 0.36117836996274    2    0
## William   21.7673887407  3.77174132969    4 0.15324037521611    3    0
## Owen      22.1628293868  6.26903261524    5 0.00280892911057    3    0
## Gabriel   20.1364259640  6.05009890627    3 0.18719717481533    3    0
## Matthew    7.3853572647 -8.68735394906    9 0.14144238322093    4    0
## Connor    15.8808170595  2.64108662494    1 0.15863614891977    3    0
## Jayce     22.3615842558 -3.05513546802    3 0.10225351764871    2    0
## Isaac     30.1224587619 -7.09135241341    4 0.02364855673578    7    0
## Sebastian 13.5889763427 -3.21353988256    2 0.02250273660239    1    0
## Henry     13.6650927255  3.54747127276    4 0.11865767655742    3    1
## Muhammad  18.6854115775  1.84807243757    3 0.07062107733347    1    0
## Cameron   20.3072446633 -2.99180550501    6 0.12640570900454    4    0
## Wyatt     20.9482961937  6.45775807556    6 0.16668974234720    2    0
## Dylan     21.1046735819  3.64000455942   11 0.29357398030914    3    0
## Nathan    14.4168464775  0.17177540809    4 0.20056258766321    0    1
## Nicholas  23.7567067948 -2.86608696915    6 0.07877880474313    3    1
## Julian    12.8086308556  4.79942964856    4 0.01741068767873    1    1
## Eli       22.3678345409 -1.96732667740    6 0.49140960513401    2    0
## Levi      13.7818898664  5.09553181473    5 0.09063709475047    4    0
## Isaiah    13.7367739803  9.31367711630   10 0.00983057916164    3    1
## Landon    14.9400453286  2.18756768852    4 0.17297542467191    3    0
## David     11.7285828772 -9.85986776650    7 0.00201122872308    3    0
## Christian 19.0997845093 -1.45769142546    7 0.01298068230972    1    0
## Andrew     7.3032475009  5.77005962841    2 0.06529642807113    3    1
## Brayden    9.7081053721 -2.31467570178    6 0.00834825438344    1    1
## John      14.7686266957  9.99820148572    3 0.13152794622246    3    0
## Lincoln   19.1537537567  1.03007489815    6 0.07082419490649    2    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("NORMAL" = rnorm(n , 17, sqrt(38)),
           "UNIFORM" = runif(n ,-10, 10),
           "POISSON" = rpois(n ,6),
           "EXPONENTIAL" = rexp(n ,9),
           "BINOMIAL" = rbinom (n ,20, 0.12),
           "D_vs_F" = sample(
    c("DOMESTIC", "FOREIGN"),
    size = n,
    replace = TRUE,
    prob = c( .76, .24)
  )
)
rownames(Y) = fake_first_names
View (Y)
```

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

```
table(Y$ D_vs_F)
```

```
##
## DOMESTIC  FOREIGN
##       77       23
```

```
prop.table(table(Y$ D_vs_F))
```

```
##
```

```
## DOMESTIC  FOREIGN
##     0.77     0.23
```

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

```
n = 50
R = matrix(sample(
    c(0,1,2),
    size = n^2,
    replace = TRUE,
    prob = c(0.50, 0.25, .25)), nrow = n, ncol = n)
R
```

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

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

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

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

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

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

30%.

```
a = matrix(rbinom(n^2, size = 1, prob = 0.7), nrow = n, ncol = n)
R[which(a==0)] = NA
R
```

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

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

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

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

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

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

```
row.sums = apply(R, 1, sum,na.rm = TRUE)
R = R[order(row.sums),]
```

- 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.

```
R_sd = apply(R, 1, sd,na.rm = TRUE)
R_sd
```

```
##  [1] 0.68588872986 0.72793204179 0.79534631298 0.76817321620 0.80321932890
##  [6] 0.91084416712 0.80229555709 0.77459666924 0.79107929540 0.68565882388
## [11] 0.77907115956 0.68882107581 0.83214969704 0.83214969704 0.72811999709
## [16] 0.92141350598 0.81649658093 0.72077702483 0.83816526318 0.83937205966
## [21] 0.85687468993 0.83937205966 0.79884051447 0.81939505146 0.83937205966
## [26] 0.89348717267 0.87008991007 0.88963130018 0.73746840551 0.77232844572
## [31] 0.84486277196 0.80229046222 0.84091786587 0.84660136485 0.86936369051
## [36] 0.85424219618 0.84334901040 0.87242971249 0.87904907299 0.94825816547
## [41] 0.84723257155 0.91919518390 0.85507438556 0.88701002632 0.83286086471
## [46] 0.79829120488 0.81809201053 0.86987613600 0.90283703394 0.89265076980
```

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

```
R_count = apply(R, 2, function(x) length(which (x == 1 | x == 2 )))
```

- 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`.

```
new_list = split(R, col(R))
```

- 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) list (min = min(x, na.rm = TRUE), max = max(x, na.rm = TRUE),
                          pct_missing =  prop.table(table (R))[1],
                          first_NA = which.min(is.na(x)) ) )
```

```
## $`1`
## $`1`$min
## [1] 0
##
## $`1`$max
## [1] 2
##
## $`1`$pct_missing
##           0
## 0.5049161365
##
## $`1`$first_NA
## [1] 2
##
##
## $`2`
## $`2`$min
## [1] 0
##
## $`2`$max
## [1] 2
##
```

```
## $`2`$pct_missing
##           0
## 0.5049161365
##
## $`2`$first_NA
## [1] 1
##
##
## $`3`
## $`3`$min
## [1] 0
##
## $`3`$max
## [1] 2
##
## $`3`$pct_missing
##           0
## 0.5049161365
##
## $`3`$first_NA
## [1] 1
##
##
## $`4`
## $`4`$min
## [1] 0
##
## $`4`$max
## [1] 2
##
## $`4`$pct_missing
##           0
## 0.5049161365
##
## $`4`$first_NA
## [1] 1
##
##
## $`5`
## $`5`$min
## [1] 0
##
## $`5`$max
## [1] 2
##
## $`5`$pct_missing
##           0
## 0.5049161365
##
## $`5`$first_NA
## [1] 1
##
##
## $`6`
```

```
## $`6`$min
## [1] 0
##
## $`6`$max
## [1] 2
##
## $`6`$pct_missing
##           0
## 0.5049161365
##
## $`6`$first_NA
## [1] 1
##
##
## $`7`
## $`7`$min
## [1] 0
##
## $`7`$max
## [1] 2
##
## $`7`$pct_missing
##           0
## 0.5049161365
##
## $`7`$first_NA
## [1] 2
##
##
## $`8`
## $`8`$min
## [1] 0
##
## $`8`$max
## [1] 2
##
## $`8`$pct_missing
##           0
## 0.5049161365
##
## $`8`$first_NA
## [1] 2
##
##
## $`9`
## $`9`$min
## [1] 0
##
## $`9`$max
## [1] 2
##
## $`9`$pct_missing
##           0
## 0.5049161365
```

```
##
## $`9`$first_NA
## [1] 3
##
##
## $`10`
## $`10`$min
## [1] 0
##
## $`10`$max
## [1] 2
##
## $`10`$pct_missing
##           0
## 0.5049161365
##
## $`10`$first_NA
## [1] 1
##
##
## $`11`
## $`11`$min
## [1] 0
##
## $`11`$max
## [1] 2
##
## $`11`$pct_missing
##           0
## 0.5049161365
##
## $`11`$first_NA
## [1] 3
##
##
## $`12`
## $`12`$min
## [1] 0
##
## $`12`$max
## [1] 2
##
## $`12`$pct_missing
##           0
## 0.5049161365
##
## $`12`$first_NA
## [1] 1
##
##
## $`13`
## $`13`$min
## [1] 0
##
```

```
## $`13`$max
## [1] 2
##
## $`13`$pct_missing
##           0
## 0.5049161365
##
## $`13`$first_NA
## [1] 3
##
##
## $`14`
## $`14`$min
## [1] 0
##
## $`14`$max
## [1] 2
##
## $`14`$pct_missing
##           0
## 0.5049161365
##
## $`14`$first_NA
## [1] 1
##
##
## $`15`
## $`15`$min
## [1] 0
##
## $`15`$max
## [1] 2
##
## $`15`$pct_missing
##           0
## 0.5049161365
##
## $`15`$first_NA
## [1] 1
##
##
## $`16`
## $`16`$min
## [1] 0
##
## $`16`$max
## [1] 2
##
## $`16`$pct_missing
##           0
## 0.5049161365
##
## $`16`$first_NA
## [1] 2
```

```
##
##
## $`17`
## $`17`$min
## [1] 0
##
## $`17`$max
## [1] 2
##
## $`17`$pct_missing
##           0
## 0.5049161365
##
## $`17`$first_NA
## [1] 1
##
##
## $`18`
## $`18`$min
## [1] 0
##
## $`18`$max
## [1] 2
##
## $`18`$pct_missing
##           0
## 0.5049161365
##
## $`18`$first_NA
## [1] 1
##
##
## $`19`
## $`19`$min
## [1] 0
##
## $`19`$max
## [1] 2
##
## $`19`$pct_missing
##           0
## 0.5049161365
##
## $`19`$first_NA
## [1] 1
##
##
## $`20`
## $`20`$min
## [1] 0
##
## $`20`$max
## [1] 2
##
```

```
## $`20`$pct_missing
##           0
## 0.5049161365
##
## $`20`$first_NA
## [1] 1
##
##
## $`21`
## $`21`$min
## [1] 0
##
## $`21`$max
## [1] 2
##
## $`21`$pct_missing
##           0
## 0.5049161365
##
## $`21`$first_NA
## [1] 3
##
##
## $`22`
## $`22`$min
## [1] 0
##
## $`22`$max
## [1] 2
##
## $`22`$pct_missing
##           0
## 0.5049161365
##
## $`22`$first_NA
## [1] 3
##
##
## $`23`
## $`23`$min
## [1] 0
##
## $`23`$max
## [1] 2
##
## $`23`$pct_missing
##           0
## 0.5049161365
##
## $`23`$first_NA
## [1] 1
##
##
## $`24`
```

```
## $`24`$min
## [1] 0
##
## $`24`$max
## [1] 2
##
## $`24`$pct_missing
##           0
## 0.5049161365
##
## $`24`$first_NA
## [1] 1
##
##
## $`25`
## $`25`$min
## [1] 0
##
## $`25`$max
## [1] 2
##
## $`25`$pct_missing
##           0
## 0.5049161365
##
## $`25`$first_NA
## [1] 3
##
##
## $`26`
## $`26`$min
## [1] 0
##
## $`26`$max
## [1] 2
##
## $`26`$pct_missing
##           0
## 0.5049161365
##
## $`26`$first_NA
## [1] 3
##
##
## $`27`
## $`27`$min
## [1] 0
##
## $`27`$max
## [1] 2
##
## $`27`$pct_missing
##           0
## 0.5049161365
```

```
##
## $`27`$first_NA
## [1] 1
##
##
## $`28`
## $`28`$min
## [1] 0
##
## $`28`$max
## [1] 2
##
## $`28`$pct_missing
##           0
## 0.5049161365
##
## $`28`$first_NA
## [1] 2
##
##
## $`29`
## $`29`$min
## [1] 0
##
## $`29`$max
## [1] 2
##
## $`29`$pct_missing
##           0
## 0.5049161365
##
## $`29`$first_NA
## [1] 2
##
##
## $`30`
## $`30`$min
## [1] 0
##
## $`30`$max
## [1] 2
##
## $`30`$pct_missing
##           0
## 0.5049161365
##
## $`30`$first_NA
## [1] 2
##
##
## $`31`
## $`31`$min
## [1] 0
##
```

```
## $`31`$max
## [1] 2
##
## $`31`$pct_missing
##           0
## 0.5049161365
##
## $`31`$first_NA
## [1] 1
##
##
## $`32`
## $`32`$min
## [1] 0
##
## $`32`$max
## [1] 2
##
## $`32`$pct_missing
##           0
## 0.5049161365
##
## $`32`$first_NA
## [1] 1
##
##
## $`33`
## $`33`$min
## [1] 0
##
## $`33`$max
## [1] 2
##
## $`33`$pct_missing
##           0
## 0.5049161365
##
## $`33`$first_NA
## [1] 2
##
##
## $`34`
## $`34`$min
## [1] 0
##
## $`34`$max
## [1] 2
##
## $`34`$pct_missing
##           0
## 0.5049161365
##
## $`34`$first_NA
## [1] 2
```

```
##
##
## $`35`
## $`35`$min
## [1] 0
##
## $`35`$max
## [1] 2
##
## $`35`$pct_missing
##           0
## 0.5049161365
##
## $`35`$first_NA
## [1] 1
##
##
## $`36`
## $`36`$min
## [1] 0
##
## $`36`$max
## [1] 2
##
## $`36`$pct_missing
##           0
## 0.5049161365
##
## $`36`$first_NA
## [1] 1
##
##
## $`37`
## $`37`$min
## [1] 0
##
## $`37`$max
## [1] 2
##
## $`37`$pct_missing
##           0
## 0.5049161365
##
## $`37`$first_NA
## [1] 2
##
##
## $`38`
## $`38`$min
## [1] 0
##
## $`38`$max
## [1] 2
##
```

```
## $`38`$pct_missing
##           0
## 0.5049161365
##
## $`38`$first_NA
## [1] 1
##
##
## $`39`
## $`39`$min
## [1] 0
##
## $`39`$max
## [1] 2
##
## $`39`$pct_missing
##           0
## 0.5049161365
##
## $`39`$first_NA
## [1] 1
##
##
## $`40`
## $`40`$min
## [1] 0
##
## $`40`$max
## [1] 2
##
## $`40`$pct_missing
##           0
## 0.5049161365
##
## $`40`$first_NA
## [1] 1
##
##
## $`41`
## $`41`$min
## [1] 0
##
## $`41`$max
## [1] 2
##
## $`41`$pct_missing
##           0
## 0.5049161365
##
## $`41`$first_NA
## [1] 4
##
##
## $`42`
```

```
## $`42`$min
## [1] 0
##
## $`42`$max
## [1] 2
##
## $`42`$pct_missing
##           0
## 0.5049161365
##
## $`42`$first_NA
## [1] 1
##
##
## $`43`
## $`43`$min
## [1] 0
##
## $`43`$max
## [1] 2
##
## $`43`$pct_missing
##           0
## 0.5049161365
##
## $`43`$first_NA
## [1] 1
##
##
## $`44`
## $`44`$min
## [1] 0
##
## $`44`$max
## [1] 2
##
## $`44`$pct_missing
##           0
## 0.5049161365
##
## $`44`$first_NA
## [1] 1
##
##
## $`45`
## $`45`$min
## [1] 0
##
## $`45`$max
## [1] 2
##
## $`45`$pct_missing
##           0
## 0.5049161365
```

```
##
## $`45`$first_NA
## [1] 1
##
##
## $`46`
## $`46`$min
## [1] 0
##
## $`46`$max
## [1] 2
##
## $`46`$pct_missing
##           0
## 0.5049161365
##
## $`46`$first_NA
## [1] 4
##
##
## $`47`
## $`47`$min
## [1] 0
##
## $`47`$max
## [1] 2
##
## $`47`$pct_missing
##           0
## 0.5049161365
##
## $`47`$first_NA
## [1] 1
##
##
## $`48`
## $`48`$min
## [1] 0
##
## $`48`$max
## [1] 2
##
## $`48`$pct_missing
##           0
## 0.5049161365
##
## $`48`$first_NA
## [1] 5
##
##
## $`49`
## $`49`$min
## [1] 0
##
```

```
## $`49`$max
## [1] 2
##
## $`49`$pct_missing
##           0
## 0.5049161365
##
## $`49`$first_NA
## [1] 2
##
##
## $`50`
## $`50`$min
## [1] 0
##
## $`50`$max
## [1] 2
##
## $`50`$pct_missing
##           0
## 0.5049161365
##
## $`50`$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(3)
v = rnorm(1000,mean = -10, sd = 10)
v
```

```
##    [1] -19.619334159199 -12.925257228785  -7.412117837587 -21.521318859151
##    [5]  -8.042171737136  -9.698760553984  -9.145822683877   1.166102127153
##    [9] -22.188574155780   2.673687220899 -17.447815961351 -21.312185708357
##   [13] -17.163584900330  -7.473476303538  -8.479542933444 -13.076564296784
##   [17] -19.530173309081 -16.482428114485   2.243136242806  -8.001883920170
##   [21] -15.784837218600 -19.423007334775 -12.037281796620 -26.664748400302
##   [25] -14.844551091510 -17.410726607216   1.606157792413   0.120671249342
##   [29] -10.720784740866 -21.367822980993  -0.993752710173  -1.482295529078
##   [33]  -2.722848258455  -2.634978543114 -13.521296169457  -2.944844865145
##   [37]   3.003579887321  -9.617479858557 -19.792837699963  -2.062387691275
##   [41]  -2.134931279906 -13.104631309593   6.988848455591 -17.945937085493
##   [45]  -6.515622838200 -32.654010735178 -11.622052790282   1.308649914589
##   [49] -14.555459762605 -18.991663155389  -2.731610982688 -18.094409018652
##   [53]  -7.329148840448 -27.372637105336 -24.114251358089 -14.535512267785
##   [57] -20.354912753681   3.621428932593  -0.825432630250 -17.851421610768
##   [61]  -4.264818268527  -0.818037922622  -7.437127270143  -6.480334440624
##   [65]   1.743373570956 -14.808463752892 -14.188297221356  -0.448871967796
##   [69] -22.890066109479  -8.138025669250 -10.313255019472  -5.329026901534
##   [73]   0.241976742046  -7.326415477656  -7.681738971398  -2.524075354776
##   [77]   2.170685105242  -6.166416548317 -19.880528215921 -11.568529101968
##   [81]   7.355352162481 -13.522983055001  -3.113599558743   2.244060958027
##   [85]  -2.057036966965 -10.064023984217  -7.808493648330 -18.864637510054
##   [89]  -5.602397086281 -18.863897506655 -18.538184543550 -19.899943307485
```

```
##   [93] -16.508777369239   0.539466604940 -13.908780334308 -10.705863936101
##   [97] -14.620508094970  -4.590917330097  -0.683650290735 -12.092743452084
##  [101]  -3.826499515279 -14.050775126934   0.531037627893  -3.977157537671
##  [105]   0.174611767962  -3.918326819880  -7.932640045535 -28.977272917940
##  [109] -16.825828316783  -5.186615845512 -14.630310380025 -12.797416957800
##  [113] -14.136901445512   6.187665209943 -17.210557108638 -14.530931573281
##  [117]  -9.857428391883  -7.842353788047  -8.111298047069 -10.501484943351
##  [121] -24.954196319188  -6.321622471664  -4.828559778244 -14.843354650510
##  [125]  -3.251443840768 -17.624486052321  -6.139262091618 -16.640033446425
##  [129] -27.243441951543   1.563190793031  -3.064934101286  -8.568436438325
##  [133]   4.928135601807 -26.321534789575  -8.721539766547 -34.036637271301
##  [137]   4.439282555670 -18.788930503079 -23.064383272157 -18.771989925869
##  [141] -21.643804594895 -29.823476800554 -19.899442348636 -11.516846011659
##  [145]  -0.874932093512  -5.923301917555 -22.421843752050 -16.426944118908
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##  [933]   4.869604274728  -1.908179766512   0.495912980797 -23.783173148779
##  [937] -21.663797316684  -5.494683374552  -4.460132607085  -8.284662147239
##  [941] -18.068814703931  -0.211471217982   1.710354977120 -12.547509988794
##  [945] -12.617794736045   3.570085370016   0.481954276737  12.288984855557
##  [949] -24.705188119154 -20.312500413812  -8.351864725618 -22.438381562496
##  [953]  -8.836918261815   1.975473701615 -16.981309875727  -7.063950518001
```

```
##  [957]  -5.627022561804  -3.722374274922 -21.605435144943 -10.207884184738
##  [961]   0.447240893840   3.115945847123 -10.824390282046  -0.807752382709
##  [965] -12.432699212984  -6.489056233583 -23.403841721078  -5.741539055199
##  [969] -18.143537334408  -3.066259193262  -2.944554440704  -7.216494611977
##  [973] -22.026921419860  -3.572381826061 -16.059739450465 -23.772576133374
##  [977] -19.259926871761  -4.327561431147  15.954812602946 -12.399845474462
##  [981]  -3.124635989125 -11.517889862396  -7.724557399724 -16.686480380507
##  [985]  -9.691709334165  -9.715704423793 -13.654550736339 -32.080121952053
##  [989]  -7.029605727864  11.297006585474   3.250411425943 -11.161714466792
##  [993] -24.701462210519 -13.792718345032 -24.650059312925   0.751482628703
##  [997] -22.261248768625 -40.563282335631   4.506577754392  -2.820231411514
```

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

```
set.seed(3)
v = rnorm(1000,mean = -10, sd = 10)
v
```

```
##    [1] -19.619334159199 -12.925257228785  -7.412117837587 -21.521318859151
##    [5]  -8.042171737136  -9.698760553984  -9.145822683877   1.166102127153
##    [9] -22.188574155780   2.673687220899 -17.447815961351 -21.312185708357
##   [13] -17.163584900330  -7.473476303538  -8.479542933444 -13.076564296784
##   [17] -19.530173309081 -16.482428114485   2.243136242806  -8.001883920170
##   [21] -15.784837218600 -19.423007334775 -12.037281796620 -26.664748400302
##   [25] -14.844551091510 -17.410726607216   1.606157792413   0.120671249342
##   [29] -10.720784740866 -21.367822980993  -0.993752710173  -1.482295529078
##   [33]  -2.722848258455  -2.634978543114 -13.521296169457  -2.944844865145
##   [37]   3.003579887321  -9.617479858557 -19.792837699963  -2.062387691275
##   [41]  -2.134931279906 -13.104631309593   6.988848455591 -17.945937085493
##   [45]  -6.515622838200 -32.654010735178 -11.622052790282   1.308649914589
##   [49] -14.555459762605 -18.991663155389  -2.731610982688 -18.094409018652
##   [53]  -7.329148840448 -27.372637105336 -24.114251358089 -14.535512267785
##   [57] -20.354912753681   3.621428932593  -0.825432630250 -17.851421610768
##   [61]  -4.264818268527  -0.818037922622  -7.437127270143  -6.480334440624
##   [65]   1.743373570956 -14.808463752892 -14.188297221356  -0.448871967796
##   [69] -22.890066109479  -8.138025669250 -10.313255019472  -5.329026901534
##   [73]   0.241976742046  -7.326415477656  -7.681738971398  -2.524075354776
##   [77]   2.170685105242  -6.166416548317 -19.880528215921 -11.568529101968
##   [81]   7.355352162481 -13.522983055001  -3.113599558743   2.244060958027
##   [85]  -2.057036966965 -10.064023984217  -7.808493648330 -18.864637510054
##   [89]  -5.602397086281 -18.863897506655 -18.538184543550 -19.899943307485
##   [93] -16.508777369239   0.539466604940 -13.908780334308 -10.705863936101
##   [97] -14.620508094970  -4.590917330097  -0.683650290735 -12.092743452084
##  [101]  -3.826499515279 -14.050775126934   0.531037627893  -3.977157537671
##  [105]   0.174611767962  -3.918326819880  -7.932640045535 -28.977272917940
##  [109] -16.825828316783  -5.186615845512 -14.630310380025 -12.797416957800
##  [113] -14.136901445512   6.187665209943 -17.210557108638 -14.530931573281
##  [117]  -9.857428391883  -7.842353788047  -8.111298047069 -10.501484943351
##  [121] -24.954196319188  -6.321622471664  -4.828559778244 -14.843354650510
##  [125]  -3.251443840768 -17.624486052321  -6.139262091618 -16.640033446425
##  [129] -27.243441951543   1.563190793031  -3.064934101286  -8.568436438325
##  [133]   4.928135601807 -26.321534789575  -8.721539766547 -34.036637271301
##  [137]   4.439282555670 -18.788930503079 -23.064383272157 -18.771989925869
##  [141] -21.643804594895 -29.823476800554 -19.899442348636 -11.516846011659
##  [145]  -0.874932093512  -5.923301917555 -22.421843752050 -16.426944118908
```

```
##  [149]   9.302436888251  -5.898006359858 -22.913493209717  16.350453747653
##  [153]  -5.129277117698  -1.461076820541   0.884427054513  -7.739860429112
##  [157]  -9.318011624379 -19.848155326560 -23.108544218437  14.640553352302
##  [161] -16.654280698611  -0.871373519774  -0.353357737106   6.080029371317
##  [165]   8.353995249022  -2.975372667555   2.178540787540 -21.236538291462
##  [169]  -3.316698844607   2.164114883365  -7.654246460518 -14.186965875024
##  [173]  -7.617799100382 -15.505881920704 -15.006027685219   1.638974920419
##  [177]  11.555369544259 -27.091570091025 -26.008226151234 -20.385534134627
##  [181]  -6.769057793887 -18.888471537352  -6.063210181149  -7.634585319331
##  [185] -14.304968134869 -15.479331263351 -23.222516588355  -3.178732506188
##  [189]  11.627894815320 -14.166696492927 -23.573178969266 -16.712264619195
##  [193]  -3.500817565471  -2.287088252289  16.766319271840 -23.708714212538
##  [197]  -9.422408545042 -11.970675081676 -22.615176255222 -16.624425616365
##  [201] -23.323523244824  -7.226763792140   0.855338489135 -26.427184894733
##  [205] -14.571802584416   4.611718454525 -26.725326023575   5.610959964386
##  [209] -24.933706478222 -21.824491405880 -13.565868809658 -19.156401246182
##  [213]  -1.505145149573 -14.896072381112  -2.720167898106 -16.193132186931
##  [217]  -6.562644570380   8.136254007118   4.532268299432  -5.875705570131
##  [221]  -7.980240406257   6.843468984371 -19.648244779343  -3.378448057553
##  [225] -15.533439939964  14.442052305831 -13.046298363917 -11.173698685216
##  [229]  -0.305712128179  -4.090603700574 -22.089584015234 -13.019284234057
##  [233]  -5.987395248469 -26.883682413982 -17.129924713780 -12.543003366598
##  [237] -20.015668284715 -19.241003535622  -5.597544310435 -13.268166109495
##  [241] -12.744758753243   2.841420588694  -6.957882234133   2.736826559013
##  [245]   0.334479322384  -3.346158438576 -13.133281085852  -5.359233146769
##  [249]  -5.213941401876  15.362357947460 -15.350630853571   3.681062220878
##  [253]  -8.581557098717 -17.828149689388   8.815187328925  -4.470771353528
##  [257] -28.448565834370 -15.503079136935 -10.260147586255 -31.592503615802
##  [261]   7.706000804296  -2.395265177401 -14.845428460113 -14.727638992701
##  [265]  -6.683279253644 -19.723007975677 -15.312442093948  -9.379632598475
##  [269]  -8.964700120039   1.697993288503  -6.058107988801 -11.341023613884
##  [273] -13.798755658155   2.786665815438 -16.993323094651  -4.357494743648
##  [277]  -6.970580441793  -7.845588432269  -0.789970006782 -18.875518923418
##  [281] -10.028930139694 -11.951736242266 -32.346789012446  -5.216770150310
##  [285]   6.226920154016 -21.960740855438   6.595091621653  -7.954545661171
##  [289]   3.859758527086 -18.578117948000  -3.141379241314 -15.816625395446
##  [293] -16.845529096189  -6.215270779043   3.129574096151  -6.859784791446
##  [297] -15.021851739205   2.521146035207 -13.031553780307  -1.887681355552
##  [301] -22.593787935409  -2.370127108045 -18.034535403280 -13.793839168024
##  [305] -23.664942854469  25.192990649636 -22.131484970229  -8.056426827022
##  [309]  -9.056343628239 -18.784914186079  -7.395641412441  -3.422929371221
##  [313]  -2.342034704849 -32.353606261072 -19.028261169045 -11.663838348314
##  [317] -10.654994166921 -15.056380209759  -4.797132853348  -9.642985169252
##  [321] -19.106895640073  -0.856568759851 -13.367091208653  -9.052371432536
##  [325]  11.272207163883  -8.034155215092 -19.676047395538 -12.848972448433
##  [329]  -8.355540029739 -21.118708105243 -29.293648192564 -14.702608566944
##  [333]  -4.656121660363 -19.210499427085  -3.156256473748   5.220787701111
##  [337]  -8.053866950632   6.972247175084  -7.219318137825 -15.710104628485
##  [341] -11.578794399908  14.883393534895   0.713690940372  -6.577809234565
##  [345]  -7.786725733542  -9.316372579400  -6.925783975895   5.086338635186
##  [349]  -3.841577608998  -9.101879819134 -33.984527302187  -9.521927092043
##  [353]  -6.638566449701  -5.651542639687  -7.889763710010  -8.892065109908
##  [357] -29.933229106959   5.050157051376  -6.458428811520  -5.651622197972
##  [361]  -2.317560851793  -5.903116313486 -29.766516010129 -20.875793634653
```

```
##  [365]   0.648639697368  11.202025368794 -15.058375334632  -5.930129194682
##  [369]  10.400257539365 -11.939353724041   3.702228952761 -15.153573477842
##  [373] -17.182328060753 -11.772422854368 -14.015764633169  -1.701164323785
##  [377] -17.858066143579 -19.385012165452  -5.821932319871  10.980978436511
##  [381] -14.488623417133 -20.952880924902 -15.289727504620 -14.847939380506
##  [385]  -8.722429579523 -10.746731068242 -13.591621355520 -30.484805589944
##  [389] -17.511800205918 -25.813830001769 -12.897760575575 -16.919545280178
##  [393] -11.719879457274 -12.225640102329  -0.807587211693 -21.100654800949
##  [397] -16.608889972063 -18.737749123100 -11.328097011326  -6.945108963913
##  [401]  11.638424847200  -1.196214951637  -4.948837474534  -8.894097947197
##  [405] -12.928585825428  -2.276800082803  11.287942290807  -4.520320297280
##  [409]   5.321292289321   6.664308537245 -14.780000492187 -13.686816252832
##  [413] -15.161661271828  -6.030623106715 -13.148717600087 -16.846898007231
##  [417]   6.322477889663 -16.845337614474 -13.130769695547 -16.400326523560
##  [421]  -3.646956422492  -9.751516340436  -7.723777884172 -12.460682463826
##  [425]  -9.757761706403 -22.445824657090 -22.059745395354  -7.269060496470
##  [429]   7.294140335842 -20.649508688608 -11.137366883434 -16.437514709292
##  [433]  -0.593515822441   9.188101759271 -20.060455500646  -4.529173695854
##  [437]  -9.661529414465 -13.158289294220  -7.114554073367 -13.443922020557
##  [441]  -8.833685649149  -4.570340320513   1.439475442835 -22.845488450952
##  [445]  -0.801882095980 -18.460901608713 -24.193042729341 -36.656975891544
##  [449]  -1.648938591958  13.774465489396  -9.860302917281 -26.334239946384
##  [453]  -5.110675267797 -20.191794091869   0.905534828730 -21.394698050146
##  [457] -10.157256350064  -7.025087177444  22.005900400366  -9.107557556393
##  [461]  -4.290276620082  -4.713143695621 -14.409047982206 -16.727933683617
##  [465]  11.543133646786  -4.061472836950 -13.840637680344  -2.802167238091
##  [469]   7.081734019592   0.752156674707  -2.225796327812  -9.477999530911
##  [473] -20.836984850360 -10.088562068557  10.306431121788 -21.133289332356
##  [477]   1.382719245775 -16.148926421488 -31.935366149424 -22.156863720830
##  [481] -10.453263615060   5.988126243780  -0.724578004789  -1.707154475790
##  [485]   0.246038758018 -14.762380683105   6.388683928811 -16.320509582575
##  [489] -23.796185760018 -12.574557480592   6.799727114113 -35.458580376782
##  [493]  -9.879212159408   9.609251111656 -13.859054811748  -0.892424520829
##  [497] -24.481307941966 -21.216145962179 -19.736179058454 -10.671869219070
##  [501] -31.398419130766 -22.634792440261  -9.166920311889  -8.116748702665
##  [505]  -8.101858065627  -7.823846476598 -16.488141417538  -7.452256169578
##  [509] -14.688300146524 -21.925100538365  -8.787717648508 -20.359326576160
##  [513] -11.918882947530 -19.705463364750  -9.422280623500 -31.106926746354
##  [517]  -0.218237260120  -6.289782632369  -2.790890694412   8.795948801955
##  [521] -13.963161120744  -8.896770525271 -15.931408812392  -5.803782301923
##  [525] -15.457387432232   1.609214994709  -3.601821656354 -11.220204431909
##  [529]  -8.153549735643 -15.178060226464  -9.320116477472 -11.847971555537
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##  [537] -12.421367936667 -10.288371963254 -13.162154742026 -14.161600874238
##  [541] -20.238959570258   0.994952751084  -1.822875295278  -8.311244903721
##  [545]  -9.613345595703   0.781748917722  -6.205727029060 -20.781745589611
##  [549]  -8.112365317051   5.831335075513 -12.501122951923  -6.570057805918
##  [553] -11.247018830407 -19.933147630009 -20.214390850685  -1.593570721449
##  [557]  -1.504268817834  -5.303810579408 -22.696552608928 -21.051202188433
##  [561] -28.979459651606  -5.082127350984 -17.047223168261   7.775761297664
##  [565] -12.453890293397 -31.112523179626 -15.853145358325 -15.179037258885
##  [569]  -4.860808547615 -16.264269188407  -8.078574048778 -24.272779916877
##  [573]  -5.990089720201   1.615649560442  -6.736531954515 -20.149822734222
##  [577]  -8.987416377173  -0.081067208551   1.026507586851  -7.196249834147
```

```
##  [581] -14.061774096875   2.864126901447 -12.540305786111 -21.444487037146
##  [585]  -7.335890898547  -3.631442516603 -24.021150926993 -25.118248270168
##  [589] -13.011928592636  -5.086388511175 -18.981564957786 -25.750548144654
##  [593] -15.032566669237 -16.229084409659 -16.848299896998 -12.215167644076
##  [597]  -6.119491673062 -18.063164557071 -15.472130543600   2.134941440868
##  [601] -14.170132300793  -8.354068148228 -25.696270072819   4.666758899016
##  [605] -24.960854494952 -21.502890189138 -30.230091439470 -16.816523950126
##  [609]  -4.929895860108  -2.528881057285  -8.240109857550 -14.375235792093
##  [613]  -0.572738464900  -1.089550398305 -26.917859576160 -17.121473927979
##  [617] -13.322688921692  -0.169665470869 -19.880417841071  -7.344535538973
##  [621] -17.281861548594   3.754050134723 -15.992643325273 -12.721732015346
##  [625]  -5.946752267101  -1.532658766078  -4.818740162577   5.794137709042
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##  [641]   6.643790270939  -6.855049136061  -3.984082412911 -24.295575357570
##  [645] -14.729991460725 -14.878888291250   0.273886491795 -20.957636862300
##  [649] -19.164456084474   0.540947792010 -24.398340349846  -4.674358907615
##  [653] -20.469287741717  -9.126141191032 -11.741116905634 -15.338263307520
##  [657]  -9.006822530691 -20.201070990736  -5.699581683909   5.028477590833
##  [661] -12.707607954566  -1.284445845554 -22.162938103986 -28.927386685519
##  [665] -18.223825706157  -2.482179848938  -2.264254818049 -27.875322577981
##  [669]  -9.111825308317 -11.800529039414 -24.717149021126  -5.099050531631
##  [673] -13.978332057372 -11.696794415160 -32.149828201759   0.081452362222
##  [677]  -4.757393046496  -7.351793645857 -13.882563543063 -13.994519195970
##  [681]  -7.728538096833 -16.111569802717  -4.593495221970  -0.900449982657
##  [685]   4.066222763532 -17.555871212665 -10.205924288417  -8.621414841537
##  [689] -19.215403924930  -4.234765686263  -7.011062804455 -18.623010366352
##  [693] -18.101380914549  -5.274441019607  -4.315009746405   4.130982693818
##  [697]  -9.411826196165 -15.834479208600  -7.298769148899   0.780464409545
##  [701] -11.465796215908 -16.352535905598  -4.759153454444   1.051460808749
##  [705] -15.010119029332  -5.758073985109 -20.773576617414 -16.258374907925
##  [709]  -1.598794292038 -10.594666093380 -10.772175456241  -5.832903725771
##  [713] -23.799143282593 -24.821499330992  -8.779285892693   1.958874459850
##  [717] -12.540624053290 -13.444073162302 -28.097991511213 -26.308950183000
##  [721] -12.719658717616 -27.909013455693 -12.284992266469   7.842409482725
##  [725] -11.663135750810  -1.909126061283 -19.723293461758 -29.525023540448
##  [729]   7.864225195296   3.129877480504   1.086747346578 -19.932007248909
##  [733]  -4.739001969808 -17.680710122345  -4.709999490219  -8.574620082522
##  [737] -25.404933130080 -17.768090988043 -40.532997907711  -1.285257098152
##  [741]  -8.090378514776  -1.504273709324 -15.634817325166   2.044169281100
##  [745]   7.044926869567 -10.580086062307  -2.291232832543 -10.276903237638
##  [749]   3.031310959971 -17.115858857299 -17.711920487548 -23.389078248123
##  [753]  -5.918393475783  -7.934624113422 -12.244763039921 -25.040281637939
##  [757]  -7.612016210712 -14.400944813518   0.859483342483  -7.120627218666
##  [761] -15.925822384620 -20.304823409248  -2.772611423582 -18.148325595500
##  [765]  -5.853648463823 -11.926365285392 -14.101086580700  -7.936384633230
##  [769]  -7.153698136536 -16.048848357475  -4.167794074200  -7.198549902518
##  [773]   3.156103420696 -24.526768213289 -21.580091458725 -10.471782849473
##  [777]  -8.370876542675  -0.590668705289 -13.928340827324 -15.623320421558
##  [781]   5.020734018666 -14.772616365075 -17.501635684538 -20.180586495226
##  [785] -20.546894909977 -16.413452540375   4.045373725882 -10.657513364810
##  [789] -10.493926166299  -4.891725427963  -7.149374068008 -10.441797416432
##  [793]  11.606194081710  -7.485621452786 -17.578027434193  10.291143237164
```

```
##  [797] -17.597541689784  -4.590011918923 -32.667650028514 -23.672182271547
##  [801]   0.460891758111  -6.544688496844   1.697036206803   6.227907457786
##  [805] -12.779611942712 -21.629676952806  -1.248488683908  -7.558047216966
##  [809] -10.254694170720 -10.770513301852 -30.505644664364  -9.386628697748
##  [813] -14.949984485481  -5.207303305748  -2.486094047916  -8.274107553695
##  [817] -10.608471939417  -3.630336467818 -24.639833199715 -18.490695920522
##  [821]  -4.910599252156  -3.675390493781   1.662447439333  -6.094208214357
##  [825] -11.369165561736 -20.938042469506 -26.697997892044   1.319465546123
##  [829]  -4.303521933432 -16.294000681253 -19.174054181642  -0.043419776036
##  [833] -18.894881758983   3.259767483239  -6.590493791052   2.620764976301
##  [837]  11.896573759000   8.667364269596  -2.649088344174 -17.863043989416
##  [841] -18.769742565026 -22.208681277632   6.166518571335  -5.019562443926
##  [845]   6.025592708658  -3.644244217312 -20.684317980659 -27.079269644933
##  [849] -20.212184191044 -12.271061222252   2.424643520905 -15.789085777253
##  [853]   0.320771577646 -11.914775064150 -14.241860982773 -33.916131097806
##  [857]   6.460653429641 -17.670603513557  -2.437290227051   4.927096668558
##  [861]  -3.440639424229  -5.052828313962 -12.531018747584 -16.629416153061
##  [865]  -4.378744358930 -17.792978920494  -1.410377291578  -0.650388552566
##  [869] -17.919525035893   3.594869518150  -9.803506229416 -21.859402915463
##  [873]  -6.563678772933  -4.145121527209 -24.302006702409   0.190293951454
##  [877]  -6.797010677610 -15.015761763340 -11.413760278171 -24.308182166015
##  [881]  -4.121423458831  -1.310364260134  -5.433450082558 -23.559595242931
##  [885]  -3.561922095536  -9.298988121354  -9.896084388177  -2.788000219939
##  [889]  -9.061850975389 -15.642570317186  -9.929763175473 -15.615374861753
##  [893]   7.559596974158  -8.295733961909   0.651952038506   5.041561305144
##  [897]  -3.400403025122 -18.382010761344  -6.053109403551 -13.796259943018
##  [901]  10.667798958086 -20.297497694303 -11.230955037009  -8.260422933721
##  [905]  -4.468093996811 -17.590686777527  -9.641704059606 -10.034950627904
##  [909] -12.201904159497 -25.576802463945 -12.380459555889  -5.750175183680
##  [913] -14.467797149752 -24.018547804707 -15.474142566073  -7.520582310342
##  [917] -23.517025392188   2.853746702425  10.966329943241 -20.757166707862
##  [921]  -3.561814448109  -1.888929140086 -13.733691622783 -11.177557024666
##  [925]  -0.604906994514 -12.235444861136 -21.888657515816  -4.000388370744
##  [929] -18.633060179970 -16.691361117331  -2.419190873591  -0.227876773458
##  [933]   4.869604274728  -1.908179766512   0.495912980797 -23.783173148779
##  [937] -21.663797316684  -5.494683374552  -4.460132607085  -8.284662147239
##  [941] -18.068814703931  -0.211471217982   1.710354977120 -12.547509988794
##  [945] -12.617794736045   3.570085370016   0.481954276737  12.288984855557
##  [949] -24.705188119154 -20.312500413812  -8.351864725618 -22.438381562496
##  [953]  -8.836918261815   1.975473701615 -16.981309875727  -7.063950518001
##  [957]  -5.627022561804  -3.722374274922 -21.605435144943 -10.207884184738
##  [961]   0.447240893840   3.115945847123 -10.824390282046  -0.807752382709
##  [965] -12.432699212984  -6.489056233583 -23.403841721078  -5.741539055199
##  [969] -18.143537334408  -3.066259193262  -2.944554440704  -7.216494611977
##  [973] -22.026921419860  -3.572381826061 -16.059739450465 -23.772576133374
##  [977] -19.259926871761  -4.327561431147  15.954812602946 -12.399845474462
##  [981]  -3.124635989125 -11.517889862396  -7.724557399724 -16.686480380507
##  [985]  -9.691709334165  -9.715704423793 -13.654550736339 -32.080121952053
##  [989]  -7.029605727864  11.297006585474   3.250411425943 -11.161714466792
##  [993] -24.701462210519 -13.792718345032 -24.650059312925   0.751482628703
##  [997] -22.261248768625 -40.563282335631   4.506577754392  -2.820231411514
```

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

```r
mean (v)
```

```
## [1] -9.9360346452
```

```r
sd(v)/sqrt(length(v))
```

```
## [1] 0.31561915962
```

- 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?

```r
quantile(v,0.05)
```

```
##           5%
## -25.753712238
```

- 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?

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

```
## [1] 0.839
```