# Lab 1

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

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

## Basic R Skills

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

```
options(digits=11)
x <- pi
x
```

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

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

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

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

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

```
prod(1/(3*(1:37)))
```

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

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

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

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

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

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

Is this answer *exactly* correct?

#TO-DO

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

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

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

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

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

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

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

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

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

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

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

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

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

Comment on the appropriateness of the non-numeric values.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

```
##  [1] NA  4  4  4  4  4  4  4  4  4  4  3  3  3  3  3  3  3  3  3  3  3  3  3
## [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)]
y
```

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

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

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

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

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

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

```
## [1] 0.48
```

- 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`.

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

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

- 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.

```
?sample
x_3 = as.factor(sample(c("none",  "infraction", "misdimeanor", "felony"), size=100, replace=TRUE))
x_3
```

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

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

```
x_3_bin = x_3 != "none"
x_3_bin
```

```
##   [1] FALSE FALSE FALSE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE
##  [13]  TRUE FALSE  TRUE  TRUE FALSE  TRUE  TRUE  TRUE FALSE  TRUE  TRUE  TRUE
##  [25]  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE FALSE FALSE FALSE FALSE  TRUE
##  [37] FALSE FALSE  TRUE  TRUE FALSE  TRUE FALSE  TRUE  TRUE  TRUE FALSE  TRUE
##  [49] FALSE  TRUE  TRUE FALSE  TRUE FALSE FALSE  TRUE  TRUE  TRUE  TRUE  TRUE
##  [61]  TRUE FALSE FALSE FALSE FALSE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE
##  [73]  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE FALSE  TRUE
##  [85] FALSE  TRUE FALSE  TRUE  TRUE  TRUE FALSE  TRUE  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] none        none        none        infraction  felony      infraction
##   [7] misdimeanor infraction  misdimeanor misdimeanor infraction  misdimeanor
##  [13] felony      none        misdimeanor infraction  none        infraction
##  [19] misdimeanor felony      none        misdimeanor felony      misdimeanor
##  [25] infraction  misdimeanor infraction  infraction  felony      infraction
##  [31] infraction  none        none        none        none        infraction
##  [37] none        none        felony      felony      none        felony
##  [43] none        infraction  felony      infraction  none        misdimeanor
```

```
##  [49] none        misdimeanor misdimeanor none        misdimeanor none
##  [55] none        felony      infraction  felony      felony      misdimeanor
##  [61] misdimeanor none        none        none        none        felony
##  [67] infraction  felony      misdimeanor misdimeanor felony      felony
##  [73] felony      infraction  infraction  misdimeanor infraction  misdimeanor
##  [79] misdimeanor infraction  infraction  felony      none        misdimeanor
##  [85] none        felony      none        misdimeanor felony      infraction
##  [91] none        infraction  misdimeanor misdimeanor felony      misdimeanor
##  [97] none        infraction  felony      misdimeanor
## Levels: none < infraction < misdimeanor < felony
```

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

```
x_3_mis = x_3 !="none" & x_3 !="infraction" & x_3 !="misdimeanor"
x_3_mis
```

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

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

#TO-DO

Verify that.

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

#TO-DO

Verify that.

```
#TO-DO
```

- 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"
)
?sample
x=array(factor(),c(100,6))
rownames(x) = fake_first_names
colnames(x) =  c("mean/var","uniform","poisson","exp","bino","binary")
x[,1]= rnorm(100,17,38)
x[,2]= sample(-10:10,100,replace = TRUE, prob=NULL)
x[,3]= rpois(100,6)
x[,4]= rexp(100,9)
x[,5]= rbinom(100,20,0.12)
x[,6]= rbinom(n=100, size=1, p=0.24)
x
```

```
##           mean/var              uniform poisson exp                   bino
## Sophia    "-4.59754880039251"   "3"     "5"     "0.0729058556155198"  "3"
## Emma      "54.7367423853293"    "0"     "4"     "0.0218525370065537"  "1"
## Olivia    "-6.87821442991235"   "-10"   "7"     "0.358712539885977"   "1"
## Ava       "4.34241933955798"    "-3"    "8"     "0.0498466467381352"  "1"
## Mia       "37.3339907722144"    "10"    "2"     "0.144359474169183"   "2"
## Isabella  "65.8454483880252"    "1"     "4"     "0.0703072510659695"  "5"
## Riley     "19.6003982853486"    "-6"    "5"     "0.0551849561743438"  "0"
## Aria      "32.2171584447996"    "2"     "7"     "0.0669759235137867"  "0"
## Zoe       "54.1337540893599"    "3"     "6"     "0.026359789065736"   "4"
## Charlotte "61.9069176985744"    "-7"    "4"     "0.0241547228975428"  "3"
## Lily      "-9.51659945503318"   "-9"    "7"     "0.082427304854295"   "4"
## Layla     "-0.469593928026022"  "-10"   "7"     "0.0302793739570512"  "2"
## Amelia    "0.750770258355526"   "10"    "11"    "0.0750053946135773"  "2"
## Emily     "-23.9640632573419"   "-9"    "2"     "0.135371451261442"   "1"
## Madelyn   "18.2419198756806"    "-7"    "8"     "0.19153761639565"    "6"
## Aubrey    "16.4299477035023"    "-6"    "11"    "0.0286637117258377"  "2"
## Adalyn    "39.9847662952449"    "-1"    "9"     "0.0880881352303439"  "3"
## Madison   "56.3787184736783"    "4"     "7"     "0.0270478498811523"  "1"
## Chloe     "-6.24503319718235"   "9"     "2"     "0.0567685800294081"  "0"
## Harper    "-11.6472763478302"   "9"     "5"     "0.0942060146505516"  "2"
## Abigail   "55.4256994158653"    "-3"    "6"     "0.00781016134553485" "1"
## Aaliyah   "53.5141498458949"    "-4"    "10"    "0.0184887535352674"  "3"
## Avery     "85.7196991686823"    "10"    "7"     "0.0165899768236392"  "3"
## Evelyn    "12.9103090605679"    "-1"    "3"     "0.148694356795286"   "0"
## Kaylee    "40.5838907920868"    "-10"   "9"     "0.0883346041617804"  "1"
## Ella      "-25.9623443898339"   "-2"    "7"     "0.0457730554044247"  "2"
## Ellie     "22.7435258106161"    "-3"    "7"     "0.0163182744728594"  "3"
## Scarlett  "-4.05489551245975"   "-2"    "3"     "0.0945913716069208"  "3"
```

```
## Arianna   "-19.0993518256222"   "10"    "10"    "0.0413496334933572"  "2"
## Hailey    "41.7359314060276"    "-2"    "2"     "0.0772944887432469"  "5"
## Nora      "15.2768673763849"    "10"    "12"    "0.00841014920216468" "3"
## Addison   "41.2210055630401"    "-4"    "3"     "0.267730908868284"   "3"
## Brooklyn  "9.35313738365935"    "-5"    "3"     "0.0986890719329"     "3"
## Hannah    "46.3364137770814"    "-7"    "7"     "0.0966775166858912"  "3"
## Mila      "-3.98014426516568"   "5"     "8"     "0.057963857996381"   "1"
## Leah      "-86.4196742275705"   "10"    "7"     "0.0478664083153709"  "4"
## Elizabeth "-24.5562639823868"   "-8"    "5"     "0.157228793318672"   "1"
## Sarah     "-44.1212589479587"   "1"     "4"     "0.0863452220495886"  "1"
## Eliana    "37.8316666686849"    "-3"    "5"     "0.0407126280120335"  "3"
## Mackenzie "-24.3827248447044"   "-8"    "6"     "0.133144857978127"   "2"
## Peyton    "-1.71425327123778"   "8"     "7"     "0.0283954199403524"  "1"
## Maria     "-64.1458095965444"   "-8"    "3"     "0.0854712939877987"  "4"
## Grace     "12.0522066024511"    "-3"    "8"     "0.464135403236753"   "2"
## Adeline   "-18.8072583316867"   "-8"    "6"     "0.0135891606720785"  "0"
## Elena     "-39.5171169539326"   "-9"    "3"     "0.0497894040826294"  "1"
## Anna      "8.94426867628393"    "-6"    "7"     "0.120095970544827"   "2"
## Victoria  "26.9360226053318"    "5"     "5"     "0.174991334054804"   "1"
## Camilla   "1.97397733650567"    "-10"   "1"     "0.0887047286725558"  "4"
## Lillian   "-11.0827893688266"   "-1"    "10"    "0.20123289400399"    "1"
## Natalie   "-48.2544388563834"   "2"     "2"     "0.0505030563929015"  "3"
## Jackson   "4.31710799867924"    "1"     "6"     "0.0364778628572822"  "1"
## Aiden     "-27.9655849655075"   "0"     "5"     "0.090606762437635"   "1"
## Lucas     "-47.4102310966142"   "-10"   "4"     "0.120969351790317"   "4"
## Liam      "24.0353920357155"    "-2"    "3"     "0.0713784518755144"  "2"
## Noah      "-15.985690160438"    "-6"    "5"     "0.173928171019592"   "3"
## Ethan     "15.2766935055091"    "-7"    "5"     "0.192233490322609"   "0"
## Mason     "32.6284657195872"    "-9"    "2"     "0.0822474638781296"  "0"
## Caden     "-18.4653862985235"   "1"     "6"     "0.0557994797635554"  "4"
## Oliver    "-22.7040714595606"   "-7"    "10"    "0.124003502225182"   "3"
## Elijah    "-28.6324990860348"   "5"     "2"     "0.037676854369541"   "5"
## Grayson   "66.8357968777066"    "-4"    "5"     "0.111911040312186"   "6"
## Jacob     "58.7428430134663"    "-6"    "7"     "0.121160482155252"   "2"
## Michael   "-3.22348627665839"   "5"     "2"     "0.0354689413727392"  "3"
## Benjamin  "24.1815710447512"    "1"     "7"     "0.130808900726638"   "3"
## Carter    "41.2141502267282"    "-9"    "6"     "0.0512512201029393"  "1"
## James     "49.8290212690634"    "1"     "9"     "0.081972882146936"   "2"
## Jayden    "-2.70914190035085"   "10"    "9"     "0.110120589736735"   "2"
## Logan     "64.7528940354762"    "7"     "8"     "0.0932871900038269"  "2"
## Alexander "54.7507495565482"    "-8"    "4"     "0.0151097865568267"  "0"
## Caleb     "26.8951660185968"    "7"     "2"     "0.0456706147847904"  "1"
## Ryan      "-69.638054967408"    "-9"    "6"     "0.0551909408532083"  "3"
## Luke      "31.3399119825961"    "-7"    "5"     "0.0370995334039132"  "2"
## Daniel    "36.1745976503482"    "7"     "4"     "0.11807523108552"    "5"
## Jack      "19.6925889080455"    "8"     "8"     "0.0882544329862479"  "2"
## William   "76.312748123355"     "5"     "5"     "0.0352110377926793"  "4"
## Owen      "95.1047244917472"    "6"     "9"     "0.0896803504844189"  "2"
## Gabriel   "34.0416788901215"    "10"    "9"     "0.231405782809758"   "2"
## Matthew   "37.1082533285836"    "-3"    "9"     "0.0103323126936124"  "3"
## Connor    "-7.07086241841673"   "9"     "5"     "0.0808455082569247"  "6"
## Jayce     "20.9882615709543"    "-3"    "2"     "0.170187043637636"   "0"
## Isaac     "-15.0356804526202"   "-1"    "9"     "0.270328033908444"   "3"
## Sebastian "57.3452512196509"    "-10"   "5"     "0.0375289884395897"  "4"
```

```
## Henry     "16.0189704438925"    "1"     "6"     "0.137988181436783"   "3"
## Muhammad  "30.6995404149716"    "7"     "6"     "0.014299835906234"   "1"
## Cameron   "2.19611950797932"    "-4"    "8"     "0.201000963431864"   "2"
## Wyatt     "-42.041832217865"    "-8"    "4"     "0.10383851653764"    "0"
## Dylan     "-0.0970355937108565" "4"     "7"     "0.0793824651134961"  "4"
## Nathan    "58.7727916913705"    "-4"    "5"     "0.00463511034669957" "2"
## Nicholas  "-34.005276350978"    "-4"    "4"     "0.14380388799588"    "4"
## Julian    "10.5576701464823"    "2"     "9"     "0.0378957934910176"  "1"
## Eli       "-9.82102771810575"   "-3"    "5"     "0.0721667066940831"  "2"
## Levi      "-27.8584472447286"   "10"    "3"     "0.0251276224541167"  "3"
## Isaiah    "35.522309152227"     "-5"    "8"     "0.174139415422018"   "2"
## Landon    "92.9873449797545"    "-6"    "5"     "0.123506617210277"   "2"
## David     "5.48678628577835"    "6"     "2"     "0.0110815984403921"  "1"
## Christian "77.4017066932999"    "-8"    "5"     "0.0868236714306487"  "5"
## Andrew    "52.5422470345286"    "-6"    "10"    "0.0989183136696211"  "2"
## Brayden   "22.4023918784284"    "2"     "5"     "0.186520442978146"   "0"
## John      "95.3664517417748"    "9"     "5"     "0.0286284459688027"  "2"
## Lincoln   "76.2471500895608"    "2"     "6"     "0.192708610237243"   "3"
##           binary
## Sophia    "0"
## Emma      "0"
## Olivia    "0"
## Ava       "0"
## Mia       "0"
## Isabella  "0"
## Riley     "0"
## Aria      "0"
## Zoe       "0"
## Charlotte "1"
## Lily      "1"
## Layla     "0"
## Amelia    "0"
## Emily     "0"
## Madelyn   "0"
## Aubrey    "0"
## Adalyn    "0"
## Madison   "0"
## Chloe     "0"
## Harper    "1"
## Abigail   "0"
## Aaliyah   "1"
## Avery     "1"
## Evelyn    "1"
## Kaylee    "1"
## Ella      "1"
## Ellie     "0"
## Scarlett  "0"
## Arianna   "1"
## Hailey    "1"
## Nora      "0"
## Addison   "0"
## Brooklyn  "0"
## Hannah    "0"
## Mila      "1"
```

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

```
## Julian    "1"
## Eli       "0"
## Levi      "0"
## Isaiah    "0"
## Landon    "0"
## David     "1"
## Christian "0"
## Andrew    "0"
## Brayden   "0"
## John      "1"
## Lincoln   "0"
```

- Create a data frame of the same data as above except make the binary variable a factor "DOMESTIC" vs "FOREIGN" for 0 and 1 respectively. Use RStudio's `View` function to ensure this worked as desired.

```
?array
x=array(factor(),c(100,6))
rownames(x) = fake_first_names
colnames(x) =  c("mean/var","uniform","poisson","exp","bino","binary")
x[,1]= rnorm(100,17,38)
x[,2]= sample(-10:10,100,replace = TRUE, prob=NULL)
x[,3]= rpois(100,6)
x[,4]= rexp(100,9)
x[,5]= rbinom(100,20,0.12)
bi_data=rbinom(n=100, size=1, p=0.24)

bi_num=array(data=bi_data,dim=100)
output= array(character(),100)
for(i in 1:length(bi_num)){
  output[i]=ifelse(bi_num[i]=="0","DOMESTIC","FOREIGN")
}

x[,6]= output
x
```

```
##           mean/var             uniform poisson exp                    bino
## Sophia    "-30.9607009388332"  "7"     "5"     "0.0274455131342014"   "3"
## Emma      "2.32540965017581"   "6"     "7"     "0.00482367822486493"  "2"
## Olivia    "46.0162309757207"   "5"     "5"     "0.00754301638031999"  "1"
## Ava       "79.3827446304768"   "-5"    "11"    "0.000592625860207622" "2"
## Mia       "31.9434521317722"   "-9"    "5"     "0.0139875946462982"   "2"
## Isabella  "69.0386220739719"   "3"     "7"     "0.189482340165909"    "5"
## Riley     "82.365432459769"    "10"    "13"    "0.00291568558249209"  "4"
## Aria      "46.8184824954403"   "-5"    "10"    "0.0240544727486041"   "4"
## Zoe       "80.6652435603783"   "-5"    "6"     "0.091065159476765"    "2"
## Charlotte "73.3935646887003"   "4"     "7"     "0.394487035540912"    "1"
## Lily      "2.55092945316984"   "-3"    "7"     "0.0681463980408865"   "5"
## Layla     "14.2464274358106"   "3"     "8"     "0.0352479965529508"   "0"
## Amelia    "-42.4225991013532"  "-2"    "4"     "0.15378395539966"     "4"
## Emily     "17.6310698070296"   "-7"    "4"     "0.147014425441922"    "1"
## Madelyn   "3.34109907111512"   "5"     "8"     "0.0174803182367757"   "5"
## Aubrey    "5.83598489568687"   "8"     "4"     "0.218764713852541"    "0"
## Adalyn    "61.6639474457965"   "-5"    "7"     "0.235373867247738"    "3"
```

```
## Madison   "-8.84538513818611"  "-2"    "5"     "0.0309332585893571"   "2"
## Chloe     "24.3679096106895"   "4"     "9"     "0.0556841212738719"   "5"
## Harper    "29.5174025654448"   "2"     "5"     "0.0633483477350738"   "2"
## Abigail   "29.903694477385"    "-10"   "7"     "0.355445266833236"    "3"
## Aaliyah   "29.3919082717281"   "-8"    "11"    "0.0935729708562029"   "2"
## Avery     "55.8782394770416"   "5"     "5"     "0.220349276222059"    "2"
## Evelyn    "60.0354283125482"   "5"     "9"     "0.020490140757627"    "1"
## Kaylee    "40.1110821332599"   "1"     "8"     "0.0279510429439445"   "2"
## Ella      "-45.3519019122207"  "3"     "7"     "0.0180300459162229"   "2"
## Ellie     "-12.9874126052013"  "-5"    "2"     "0.0470618429179821"   "1"
## Scarlett  "-5.56368546945989"  "0"     "7"     "0.116053017679487"    "2"
## Arianna   "-5.77686849547542"  "0"     "6"     "0.124681252878045"    "1"
## Hailey    "32.5972824332901"   "-8"    "6"     "0.12522268590012"     "2"
## Nora      "-28.5293291496165"  "4"     "7"     "0.0175605857123931"   "2"
## Addison   "61.8369583927261"   "6"     "8"     "0.00551811766086353"  "1"
## Brooklyn  "9.2833353606161"    "-5"    "1"     "0.063829625542793"    "3"
## Hannah    "5.94669294781602"   "-8"    "9"     "0.0967240210368912"   "3"
## Mila      "41.4225957423356"   "-1"    "3"     "0.062708570725388"    "5"
## Leah      "59.9127638221508"   "3"     "6"     "0.0121478129488726"   "2"
## Elizabeth "91.0295317144671"   "5"     "6"     "0.0604014236273037"   "1"
## Sarah     "-22.5689203015331"  "-3"    "7"     "0.119641557952068"    "1"
## Eliana    "12.8333055051243"   "-9"    "8"     "0.145085231085918"    "4"
## Mackenzie "46.832841108358"    "7"     "3"     "0.0462880542812248"   "1"
## Peyton    "-16.2370865991163"  "6"     "2"     "0.112644374262427"    "1"
## Maria     "-14.4271340634103"  "-7"    "6"     "0.070854043484562"    "2"
## Grace     "-10.9691086237724"  "-5"    "5"     "0.373824967259704"    "3"
## Adeline   "29.7481766546549"   "-1"    "5"     "0.229351948523458"    "0"
## Elena     "58.9002217909346"   "-6"    "9"     "0.0214976179930899"   "1"
## Anna      "70.8474454061464"   "3"     "4"     "0.115527675792874"    "2"
## Victoria  "40.4914948107415"   "-2"    "7"     "0.00900918329698519"  "0"
## Camilla   "-19.1427436027478"  "-2"    "11"    "0.0413007880732272"   "4"
## Lillian   "32.8343156705517"   "5"     "7"     "0.561252347471425"    "2"
## Natalie   "5.99057960888554"   "-9"    "8"     "0.0140918655662922"   "2"
## Jackson   "67.1157698055311"   "7"     "9"     "0.246317794532482"    "1"
## Aiden     "-14.3437990230654"  "-3"    "6"     "0.0201536703647839"   "4"
## Lucas     "-54.9240998544526"  "-2"    "8"     "0.0128779589716573"   "1"
## Liam      "11.6577192742494"   "-10"   "3"     "0.0611924062379532"   "1"
## Noah      "-1.33938489233738"  "-7"    "4"     "0.161579574113676"    "2"
## Ethan     "78.5625552405595"   "1"     "6"     "0.0169684287773382"   "5"
## Mason     "-28.9092148938098"  "-8"    "6"     "0.406126388842702"    "2"
## Caden     "-18.0700928699218"  "-2"    "9"     "0.00324770223556293"  "1"
## Oliver    "-44.3054689244162"  "6"     "12"    "0.0990381057637943"   "3"
## Elijah    "18.2700435211849"   "4"     "7"     "0.0691156880930066"   "4"
## Grayson   "12.3281744293593"   "-10"   "14"    "0.0727629186585546"   "4"
## Jacob     "-0.762697234915745" "4"     "12"    "0.140796415917047"    "3"
## Michael   "49.91445412366"     "-10"   "4"     "0.0303162675764826"   "2"
## Benjamin  "18.3294815239137"   "4"     "4"     "0.0336565468460321"   "2"
## Carter    "53.1456506503713"   "5"     "4"     "0.0140543422765202"   "4"
## James     "6.01104087101429"   "-1"    "7"     "0.0449942417584447"   "0"
## Jayden    "24.5425641571306"   "-10"   "8"     "0.134239642669229"    "0"
## Logan     "59.1521326460634"   "-1"    "7"     "0.425233439208574"    "3"
## Alexander "34.2313719531439"   "8"     "9"     "0.0164896661105255"   "1"
## Caleb     "-20.8044874203748"  "-10"   "8"     "0.222060021624568"    "2"
## Ryan      "8.7045837471648"    "7"     "8"     "0.190849759296182"    "1"
```

```
## Luke      "28.4208874140055"   "6"     "5"     "0.00817489432584908"  "0"
## Daniel    "-2.1205899046722"   "-7"    "9"     "0.0292770220484171"   "0"
## Jack      "-24.311472881056"   "6"     "6"     "0.0388186357191039"   "2"
## William   "-22.7834058040622"  "-1"    "5"     "0.0844378861117297"   "2"
## Owen      "-1.4385235744653"   "5"     "7"     "0.0782387607373807"   "2"
## Gabriel   "6.73006248566965"   "1"     "4"     "0.0622257098245124"   "3"
## Matthew   "57.7091765934272"   "-1"    "8"     "0.287269844970012"    "4"
## Connor    "71.6384678113443"   "-7"    "3"     "0.0795066981355747"   "4"
## Jayce     "14.5838521591644"   "-7"    "3"     "0.0499422834772203"   "2"
## Isaac     "-33.1457979240715"  "10"    "3"     "0.084473186642303"    "1"
## Sebastian "10.181872231146"    "6"     "5"     "0.106549502449203"    "3"
## Henry     "53.384986152211"    "1"     "7"     "0.0531752856430324"   "2"
## Muhammad  "-18.6712113471316"  "5"     "7"     "0.0258858733707004"   "2"
## Cameron   "36.0733839713458"   "8"     "4"     "0.0713331683331894"   "3"
## Wyatt     "1.6898455892891"    "8"     "6"     "0.0253178432273368"   "1"
## Dylan     "33.2312436360352"   "0"     "5"     "0.159786536245481"    "2"
## Nathan    "-11.4182097783937"  "-4"    "5"     "0.0256894985523317"   "2"
## Nicholas  "4.458444090015"     "6"     "13"    "0.0812176014984078"   "0"
## Julian    "12.37623860547"     "2"     "3"     "0.0431480360219547"   "3"
## Eli       "6.0773020349409"    "8"     "11"    "0.348669775842469"    "3"
## Levi      "28.8601091775599"   "5"     "9"     "0.211498717457655"    "2"
## Isaiah    "-45.6362947822597"  "-9"    "9"     "0.00550920055765245"  "3"
## Landon    "22.3858199548761"   "-3"    "9"     "0.0672207806362874"   "1"
## David     "20.1313114178469"   "4"     "8"     "0.190393742622393"    "1"
## Christian "28.4609182857611"   "4"     "4"     "0.0167506964773768"   "1"
## Andrew    "62.0948902326958"   "-9"    "8"     "0.0621142203712629"   "5"
## Brayden   "-15.1107060549216"  "1"     "8"     "0.00369825767767098"  "3"
## John      "3.76309483105057"   "10"    "5"     "0.0167902741684682"   "4"
## Lincoln   "37.1679175624727"   "-2"    "5"     "0.0589386495865054"   "3"
##           binary
## Sophia    "DOMESTIC"
## Emma      "DOMESTIC"
## Olivia    "DOMESTIC"
## Ava       "DOMESTIC"
## Mia       "DOMESTIC"
## Isabella  "DOMESTIC"
## Riley     "DOMESTIC"
## Aria      "FOREIGN"
## Zoe       "FOREIGN"
## Charlotte "DOMESTIC"
## Lily      "DOMESTIC"
## Layla     "DOMESTIC"
## Amelia    "DOMESTIC"
## Emily     "DOMESTIC"
## Madelyn   "DOMESTIC"
## Aubrey    "DOMESTIC"
## Adalyn    "FOREIGN"
## Madison   "FOREIGN"
## Chloe     "DOMESTIC"
## Harper    "DOMESTIC"
## Abigail   "DOMESTIC"
## Aaliyah   "DOMESTIC"
## Avery     "DOMESTIC"
## Evelyn    "FOREIGN"
```

```
## Kaylee    "FOREIGN"
## Ella      "DOMESTIC"
## Ellie     "DOMESTIC"
## Scarlett  "DOMESTIC"
## Arianna   "FOREIGN"
## Hailey    "DOMESTIC"
## Nora      "DOMESTIC"
## Addison   "DOMESTIC"
## Brooklyn  "DOMESTIC"
## Hannah    "DOMESTIC"
## Mila      "DOMESTIC"
## Leah      "DOMESTIC"
## Elizabeth "DOMESTIC"
## Sarah     "FOREIGN"
## Eliana    "DOMESTIC"
## Mackenzie "DOMESTIC"
## Peyton    "FOREIGN"
## Maria     "DOMESTIC"
## Grace     "FOREIGN"
## Adeline   "DOMESTIC"
## Elena     "FOREIGN"
## Anna      "DOMESTIC"
## Victoria  "DOMESTIC"
## Camilla   "DOMESTIC"
## Lillian   "DOMESTIC"
## Natalie   "DOMESTIC"
## Jackson   "DOMESTIC"
## Aiden     "DOMESTIC"
## Lucas     "DOMESTIC"
## Liam      "DOMESTIC"
## Noah      "DOMESTIC"
## Ethan     "FOREIGN"
## Mason     "FOREIGN"
## Caden     "DOMESTIC"
## Oliver    "DOMESTIC"
## Elijah    "DOMESTIC"
## Grayson   "DOMESTIC"
## Jacob     "DOMESTIC"
## Michael   "FOREIGN"
## Benjamin  "DOMESTIC"
## Carter    "DOMESTIC"
## James     "DOMESTIC"
## Jayden    "DOMESTIC"
## Logan     "FOREIGN"
## Alexander "FOREIGN"
## Caleb     "DOMESTIC"
## Ryan      "FOREIGN"
## Luke      "DOMESTIC"
## Daniel    "DOMESTIC"
## Jack      "DOMESTIC"
## William   "DOMESTIC"
## Owen      "DOMESTIC"
## Gabriel   "FOREIGN"
## Matthew   "FOREIGN"
```

```
## Connor    "FOREIGN"
## Jayce     "FOREIGN"
## Isaac     "DOMESTIC"
## Sebastian "FOREIGN"
## Henry     "DOMESTIC"
## Muhammad  "DOMESTIC"
## Cameron   "DOMESTIC"
## Wyatt     "FOREIGN"
## Dylan     "FOREIGN"
## Nathan    "DOMESTIC"
## Nicholas  "DOMESTIC"
## Julian    "DOMESTIC"
## Eli       "DOMESTIC"
## Levi      "FOREIGN"
## Isaiah    "DOMESTIC"
## Landon    "DOMESTIC"
## David     "DOMESTIC"
## Christian "DOMESTIC"
## Andrew    "FOREIGN"
## Brayden   "FOREIGN"
## John      "DOMESTIC"
## Lincoln   "FOREIGN"
```

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

```
library(MASS)
bi_variable_table=array(data=sample(c("DOMESTIC","FOREIGN"),16,replace=TRUE),dim=c(4,4),dimnames=NULL)
bi_variable_table
```

```
##      [,1]       [,2]       [,3]       [,4]
## [1,] "FOREIGN"  "DOMESTIC" "FOREIGN"  "DOMESTIC"
## [2,] "FOREIGN"  "DOMESTIC" "DOMESTIC" "DOMESTIC"
## [3,] "FOREIGN"  "DOMESTIC" "DOMESTIC" "FOREIGN"
## [4,] "DOMESTIC" "FOREIGN"  "FOREIGN"  "FOREIGN"
```

```
d=length(which(bi_variable_table=="DOMESTIC"))
f=length(which(bi_variable_table=="FOREIGN"))
pro=fractions(d/f)
pro
```

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

Print out a summary of the whole dataframe.

```
library(MASS)
bi_variable_table=array(data=sample(c("DOMESTIC","FOREIGN"),16,replace=TRUE),dim=c(4,4),dimnames=NULL)
bi_variable_table
```

```
##      [,1]       [,2]       [,3]       [,4]
## [1,] "DOMESTIC" "FOREIGN"  "DOMESTIC" "FOREIGN"
## [2,] "DOMESTIC" "FOREIGN"  "DOMESTIC" "DOMESTIC"
## [3,] "DOMESTIC" "DOMESTIC" "FOREIGN"  "DOMESTIC"
## [4,] "FOREIGN"  "DOMESTIC" "DOMESTIC" "FOREIGN"
```

```
d=length(which(bi_variable_table=="DOMESTIC"))
f=length(which(bi_variable_table=="FOREIGN"))
pro=fractions(d/f)
print(paste("there are ",d,"DOMESTIC's in the dataframe"))
```

```
## [1] "there are  10 DOMESTIC's in the dataframe"
```

```
print(paste("there are ",f,"FOREIGN's in the dataframe"))
```

```
## [1] "there are  6 FOREIGN's in the dataframe"
```

```
print(paste("the proportion of DOMESTIC vs FOREIGN in reduced fraction is",pro))
```

```
## [1] "the proportion of DOMESTIC vs FOREIGN in reduced fraction is 5/3"
```

- 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.

```
?matrix
random_data=sample(c(0,1,2),size=2500,replace=TRUE,prob=c(.50,.25,.25))
R=matrix(data=random_data,nrow=50,ncol=50,byrow=TRUE,dimnames=NULL)
options(max.print=5000)
R
```

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

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

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

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

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

```
## [39,]     0
## [40,]     0
## [41,]     0
## [42,]     0
## [43,]     2
## [44,]     0
## [45,]     0
## [46,]     0
## [47,]     0
## [48,]     2
## [49,]     1
## [50,]     0
```

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

```
random_data=sample(c(0,1,2,NA),size=2500,replace=TRUE,prob=c(.35,.175,.175,.3))
R=matrix(data=random_data,nrow=50,ncol=50,byrow=TRUE,dimnames=NULL)
options(max.print=5000)
R
```

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

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

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

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

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

```
## [44,]     0
## [45,]     0
## [46,]     0
## [47,]    NA
## [48,]     1
## [49,]    NA
## [50,]    NA
```

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

```
?sort
options(max.print=5000)
random_data=sample(c(0,1,2,NA),size=2500,replace=TRUE,prob=c(.35,.175,.175,.3))
R=matrix(data=random_data,nrow=50,ncol=50,byrow=TRUE,dimnames=NULL)
R[order(rowSums(!is.na(R)),decreasing=T),]
```

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

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

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

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

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

```
## [49,]    NA
## [50,]    NA
```

- We will now learn the `apply` function. This is a handy function that saves writing for loops which should be eschewed in R. Use the apply function to compute a vector whose entries are the standard deviation of each row. Use the apply function to compute a vector whose entries are the standard deviation of each column. Be careful about the NA's! This should be one line.

```
?apply
options(max.print=5000)
random_data=sample(c(0,1,2,NA),size=2500,replace=TRUE,prob=c(.35,.175,.175,.3))
R=matrix(data=random_data,nrow=50,ncol=50,byrow=TRUE,dimnames=NULL)
R
```

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

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

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

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

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

```
apply(!is.na(R),2,sd)
```

```
##  [1] 0.50142653642 0.40406101782 0.40406101782 0.44308749769 0.49487165931
##  [6] 0.45355736761 0.50467204950 0.46291004989 0.49031435148 0.49031435148
## [11] 0.41845195760 0.47121207150 0.44308749769 0.48487322139 0.43141911059
## [16] 0.45355736761 0.46291004989 0.40406101782 0.45355736761 0.47121207150
## [21] 0.43141911059 0.47121207150 0.43141911059 0.48487322139 0.50142653642
## [26] 0.49856938190 0.48487322139 0.46291004989 0.50507627228 0.47851812070
## [31] 0.44308749769 0.49487165931 0.45355736761 0.43141911059 0.45355736761
## [36] 0.47851812070 0.46291004989 0.47121207150 0.47121207150 0.47121207150
## [41] 0.45355736761 0.47851812070 0.45355736761 0.44308749769 0.44308749769
## [46] 0.40406101782 0.46291004989 0.47121207150 0.43141911059 0.46291004989
```

- 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.

```
options(max.print=50000)
random_data=sample(c(0,1,2,NA),size=2500,replace=TRUE,prob=c(.35,.175,.175,.3))
R=matrix(data=random_data,nrow=50,ncol=50,byrow=TRUE,dimnames=NULL)
R
```

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

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

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

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

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

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

```
apply(R,2,function(R){sum(!is.na(R))})
```

```
##  [1] 38 36 33 32 33 35 37 38 29 38 39 34 37 33 42 36 40 33 27 36 37 33 39 37 38
## [26] 34 33 36 31 33 33 36 37 40 40 33 32 31 26 34 32 41 36 28 37 31 35 35 31 43
```

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

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

```
## $`1`
##  [1]  1  2  2  1  1  0  1  0  1  1  0  1  0 NA  2  0  1 NA  2  0 NA  0  2 NA  2
## [26]  1  1  2 NA  2  1 NA  0  0  2 NA NA  2  0 NA NA  2 NA  0  1  0 NA  2  2  0
##
## $`2`
##  [1] NA  0  2  0  0 NA  2  0  0 NA  0 NA NA  0  2  0 NA  0 NA  0 NA  0  0 NA NA
## [26]  1  0  2  0  1  2 NA NA NA  2  0  1  0  2  1  1  1  0  2  2  1  0  1 NA  1
##
## $`3`
##  [1]  0  1  2  2  0 NA  2  0 NA NA  0  2  2  0  1  0  1  0 NA NA NA  1 NA NA  1
## [26]  0 NA  1  1  0 NA NA  0  2  0  2 NA NA  0 NA NA  2  2  2  1  2  1 NA NA  2
##
## $`4`
##  [1] NA  0  0  0  0 NA  0  1 NA NA NA NA  2  2  1 NA  0  2  0 NA NA  0 NA  0  0
## [26] NA  1 NA  0  2  1  2  1 NA NA NA NA  1  0  1  0 NA NA  1  0  0  0  0  1  1
##
## $`5`
##  [1]  2 NA  0 NA NA  0  0  0  0  0 NA  2 NA  1 NA  1 NA NA  1  0  0 NA  0  2 NA
## [26] NA NA  1  1  0  1 NA NA NA  0  2  2  1  2  2  0 NA  0  2  2  0  2  1  2 NA
##
## $`6`
##  [1]  2  2  0  0 NA NA  0  0 NA  1  0  1  0  0  0  0  0  1  0  1 NA  0 NA  0 NA
## [26]  2  0  0  0  0  1  2  2  0  1 NA NA NA  1 NA NA NA NA  1  2 NA  0  1  0 NA
##
## $`7`
##  [1]  1 NA  1  0  1  1 NA  0  2 NA  2  0  0  0  2  1  2  0  1  2  0 NA NA  0  1
## [26]  0 NA  2  2  0 NA  1  2 NA NA  0 NA NA  0  0  0 NA  0  0 NA  0  2  0  0  1
##
## $`8`
##  [1]  2  0 NA  0 NA  0  1  2  0  0 NA  1  0  2  2  0  2  0  2  0  2  0  1  2  2
## [26]  1 NA  0  0  0  2  0 NA NA  1  0  0  2 NA NA  0 NA  0 NA  0  1 NA  2 NA  2
##
```

```
## $`9`
##  [1]  0  0 NA NA  0  0 NA NA  1 NA NA  1 NA  0 NA  0  0 NA NA  2  0  0 NA NA  0
## [26]  1  2  2  0 NA  1  1  1  1  2  2  1  1 NA NA  2 NA NA  0 NA  2 NA  1 NA NA
##
## $`10`
##  [1]  1 NA  0  0 NA  0  1  0  0 NA NA  0  1  1  2  1  0  1  2 NA  1  0 NA  0 NA
## [26] NA  0 NA NA  0  2  2  2  0  1  1  1  0  0  0 NA  0  0  2  0  2  1 NA  1  2
##
## $`11`
##  [1]  0  0  1  0  2  2 NA  1  0 NA NA NA  0  0  0  2  1  2 NA  0  0 NA  0  2  0
## [26]  2  0 NA NA  1 NA  1  0  2  0  2  2 NA  0  2  0 NA  0  0  1  2  2  0  0  1
##
## $`12`
##  [1]  0  1 NA  1 NA  0 NA  0  1  1  0 NA NA  0  0  1  0 NA NA  2  2  1  0  2 NA
## [26]  2 NA NA  0  2  1 NA NA NA  0  2  2  1 NA  0 NA  2  1 NA  0  0  0  0  0  2
##
## $`13`
##  [1]  2 NA  1 NA NA  2  0  1 NA  1 NA  0  1  0  2 NA  2  2 NA  2  2  0  0  1 NA
## [26] NA  0  0 NA  0  2  0  0  1  1  1  0  2 NA  2  0  0  2  0  0 NA  0  0  1 NA
##
## $`14`
##  [1]  0  1  1  0  1  0  1  1 NA NA  1 NA NA  0  2 NA NA  0  0 NA NA  1 NA  2 NA
## [26]  0 NA NA  0  0  0  1 NA  0  0  2 NA  0  0  2 NA NA  1  2  2  0  2  2 NA  0
##
## $`15`
##  [1] NA  0  0  2  0  2  0  0  0  0 NA  1  2  1  2  0  2  2  2  0  2  2  0  0  0
## [26]  0 NA  2  0  0  0  0  0  0  0 NA NA NA  1 NA  0  1  2  2  0  2 NA  1  1  0
##
## $`16`
##  [1]  0  1 NA  2  1  1  0  1  0  2  0  1  2 NA  1  1 NA  0  2  0  0 NA  0 NA NA
## [26] NA NA NA  2  1  1  2  2  0  2 NA  0  2  2 NA  2 NA  0  2 NA NA  2  0  1  2
##
## $`17`
##  [1]  0  0  0  0 NA NA  0  1 NA  2  0  0  0  2  2  2  2  2  0 NA  0  2  0  1  0
## [26]  1  0 NA  0  1  0  0  1 NA  0  0  2  0 NA  2 NA  0  1 NA  0  1  2  0  0 NA
##
## $`18`
##  [1]  0  0  1  1 NA  1  0 NA NA  2  1 NA  0  0  0 NA NA  1  0  2  0  2 NA  2  0
## [26]  0  2 NA  2  2 NA  0 NA  2 NA  2 NA  0 NA NA  0 NA NA NA  2  0  0  1  1  0
##
## $`19`
##  [1]  2 NA  0 NA  0  0 NA NA  0  1 NA  0 NA  1  2  1  0  2 NA NA  2 NA NA NA  2
## [26] NA  1  2  0  2  2 NA NA NA  0 NA  1 NA NA  0  1  0 NA  0  0 NA NA NA NA  1
##
## $`20`
##  [1] NA  0 NA  1 NA  0 NA  1  0  0 NA  2  0  2  1  1  0  2  0 NA  0 NA  0 NA  0
## [26] NA  0  0  2  1 NA NA  0  1  1 NA  0  0  0  1 NA  2  0 NA  1  0  0  0  1  2
##
## $`21`
##  [1]  0  2  0  2 NA  0  0  1  2 NA NA  0 NA  0  0  0 NA NA  0  2 NA NA  1 NA  1
## [26]  0  0  1  0 NA  0  0  1  1 NA  1  2 NA  0  2  2 NA  1  1  2  0  0  0  1  2
##
## $`22`
##  [1] NA  0 NA  1 NA  2  1  0  0 NA  0  0 NA  2  1  0 NA NA NA NA NA  0  2  0  1
```

```
## [26]  2 NA  0  2  0  0 NA  0 NA  0  2 NA  0  0  1 NA  0 NA  0  1  0  0  0  0 NA
##
## $`23`
##  [1] NA  0  2  0  0  0 NA  0  1  0 NA NA NA  2  0 NA  1 NA  0 NA  0  0  1  0  1
## [26]  0  1  0  0  0 NA  0 NA  1  2  0  0  2  1  1  0  0  0  0  0 NA  2  0  0  1
##
## $`24`
##  [1]  2  2  1  1  1  0 NA  0 NA NA  1  0  0  1  0  0 NA NA  2 NA  0  0 NA  0  0
## [26]  0 NA  1  2  1  0  1  0  2  0 NA  0  1  0  2  0  2  2 NA NA  0 NA NA  2  0
##
## $`25`
##  [1]  0 NA  0  2  2 NA NA  1  0  0  2  2  2  2 NA  0  2 NA  0 NA  1  2  2  0  1
## [26]  0  1  0  0  0  0 NA  1  1  0 NA  0  1 NA  0  0  2  2  0 NA NA  1  0 NA  0
##
## $`26`
##  [1]  0  1 NA NA  2  0  0  0  1  1  2 NA  2  0 NA  0  1  0  2  2  1 NA NA  0 NA
## [26]  1 NA NA  0  1  0  1  2 NA  0  0  2  2 NA  0 NA  0 NA  0 NA  1 NA  0 NA  2
##
## $`27`
##  [1] NA NA  1  1 NA  0  2  1  2 NA  2  0  0  0  1 NA  0  2  2  0 NA  0  1  0  0
## [26] NA  2  0  0  2 NA  1  0 NA  0  2 NA NA  1 NA  0 NA NA  1 NA  2 NA  1 NA  1
##
## $`28`
##  [1]  0  0  0  1  0  2  0 NA  0 NA NA  0 NA  0 NA NA  1  0 NA NA  0  1  0  0  0
## [26]  0  2 NA  1  0  1  0  0  2 NA  0  1  2 NA  1  2  1 NA  2  0  2 NA NA  1  0
##
## $`29`
##  [1]  1 NA NA  1  1 NA  0 NA NA  2  2  2 NA  0  1 NA  0 NA  0 NA NA NA NA  2 NA
## [26]  2  0 NA  0  0  0  0  0  0  0 NA NA NA NA  2  1  0  0  0  1  0 NA  2  2  0
##
## $`30`
##  [1]  1  1 NA NA  0 NA  0 NA NA  0  0 NA  0  0 NA  0  2  0  2  1  1  2  0 NA  0
## [26]  0 NA  1 NA NA NA NA  0  1  2  2 NA  0  1  0  2  1  0 NA NA NA  1  0  1  1
##
## $`31`
##  [1]  0 NA  2  0  0  2  1  0  0 NA  2  0 NA  1 NA  1 NA  0 NA  0  1  0  0  0 NA
## [26]  0 NA  0  0  0  0  2  1  1  1 NA NA NA NA  0 NA  0  0  2  0 NA  1 NA NA NA
##
## $`32`
##  [1] NA  0  1  0  0  0  1  1  0  2  0 NA  0  0  2  2 NA  0 NA  0  0  0  2 NA NA
## [26] NA  2  0  2  2  0  2  0  2  0  2  0  0  0  0 NA NA NA  0 NA NA  0 NA  0 NA
##
## $`33`
##  [1]  1 NA  1 NA  0  2  0  1  2  0  0  1  2  0 NA  2  1  1  2 NA  0  0  1  1  1
## [26]  0  0  1  2 NA  0  2 NA NA NA  0  2 NA  2  1  0  1  0 NA  0  2 NA  2 NA NA
##
## $`34`
##  [1]  0  1  0  0  2  0  0  0  0  2  1  0  0  2  1  0  0  2  2  2  0  0 NA  0 NA
## [26] NA  0 NA  2  0  2  2 NA  0 NA  1 NA  1  1  2  1  0 NA NA  2 NA  0  0  0  1
##
## $`35`
##  [1] NA  0  1  1  1  0  2 NA  1  2 NA  0  1  0  0  2  1  1  2 NA  0  0  0  0  1
## [26]  0  0  1 NA  1  0  0  2  0  2  0  0 NA  0  0  0  0 NA  0  0  2 NA  1 NA NA
##
```

```
## $`36`
##  [1]  1 NA NA  0 NA  2  0 NA  1  2  0  1  2 NA  1 NA NA NA  2 NA  0 NA NA  2  2
## [26] NA  0  0  0  1 NA  1  1  0  0 NA NA  1  0 NA  2  2  2  2  1  1  0  2  2 NA
##
## $`37`
##  [1]  0 NA NA  2  2  0 NA NA NA NA  0  0  2 NA  2  0  0  2  1  0 NA  1  0  0  1
## [26] NA NA NA  2 NA  0  1  0  0  0  0 NA NA  0  2 NA NA  0 NA NA  0  1  1  0  2
##
## $`38`
##  [1]  0 NA  0  0 NA NA NA  0 NA NA  0  0  1 NA NA  1 NA NA  0 NA  0  2 NA  0  1
## [26] NA  2 NA  0  1  0  0  2  1 NA  2 NA NA  0  0  0  0  0  0  1  1 NA NA  2  0
##
## $`39`
##  [1]  1 NA  0 NA  1  0  0 NA  0 NA NA  0  0 NA NA NA  2 NA  1  1  2  0 NA NA NA
## [26]  0  0 NA  0  2  2 NA  2 NA  0 NA  2  2 NA NA NA NA NA NA  1  2 NA  0  0 NA
##
## $`40`
##  [1]  2 NA  1  0  2  2  2  0 NA  0  1  1  2  2 NA NA  0 NA NA  1  2 NA  1 NA  2
## [26]  0 NA  0  1  0 NA  0  0  2 NA  1 NA  2  0  0 NA  1  0 NA  2  0 NA  0  2 NA
##
## $`41`
##  [1]  0  1 NA  1  0  2  0 NA  0  2  2  1 NA  0  0  1  1  0  2 NA  2  0  0 NA  0
## [26] NA NA NA NA NA NA  0 NA  1  2 NA NA  0  0  1  0  1 NA NA  0  2  0  2 NA NA
##
## $`42`
##  [1]  2  0  0  0  0 NA  0  0  0  0  0  1  2  0  0  1  2  1  0  2  0  0 NA NA  1
## [26]  2  0  1  2  0  0 NA  2  2  0  2  0  0  2  0  2 NA  0 NA NA  0  2  2 NA NA
##
## $`43`
##  [1]  0  0  0 NA NA  1 NA NA  0  0 NA  0  0  0  0  2 NA  0  1  2 NA  0  0 NA NA
## [26]  2  0  0  1  2  1  0  0 NA  1  0  0  1 NA  0  0  0 NA  1 NA  0  1  1  0 NA
##
## $`44`
##  [1]  0  0 NA  1 NA NA  0 NA NA NA  0 NA  0 NA NA  2 NA NA  0  2  0 NA  2  0 NA
## [26]  0 NA  2 NA NA  2  2  0  0  0  0  2  1  0 NA NA NA NA  0  2 NA  1 NA  2  2
##
## $`45`
##  [1]  0  0  2  0  0  0  0  0  1 NA  2 NA  1  1 NA  2  0 NA NA  0  2  2  2  0 NA
## [26]  1  0  2  0  1 NA NA  0 NA NA  0  0  0  1  1  0  1  1  1  0  2  0 NA NA NA
##
## $`46`
##  [1] NA  2 NA  0  0  0  0  0  0  0 NA NA  2 NA  0 NA  0  0 NA NA  2  0  0  1 NA
## [26]  0  2  2  0  0  0  1  1  0  0  2 NA  2 NA NA  2 NA NA NA  2 NA NA NA  2 NA
##
## $`47`
##  [1]  2  0  2  2  1  0  0 NA NA  0  0 NA  2 NA NA  0  0 NA  2  2  0  0 NA  0  2
## [26]  2  1 NA  0  0 NA  0  1  0  0  1  1  1  0 NA  1  0 NA  1  1 NA NA  0 NA NA
##
## $`48`
##  [1]  0  1  1  0  0  1  2 NA  2  0  0 NA  1  2  1  0  0 NA  2  1  2 NA NA  0  0
## [26]  0  1  0  0  2  2  0  0 NA  0 NA  1  1 NA  0 NA  1 NA NA  0 NA NA NA NA  2
##
## $`49`
##  [1] NA NA  1 NA  2  2  0 NA  1  0  2  1  2 NA  0  0 NA NA  2  0 NA NA  0  0  0
```

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

- In one statement, use the `lapply` function to create a list whose keys are the column number and values are themselves a list with keys: "min" whose value is the minimum of the column, "max" whose value is the maximum of the column, "pct_missing" is the proportion of missingness in the column and "first_NA" whose value is the row number of the first time the NA appears.
- 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(124)
v=rnorm(1000,-10,100)
v
```

```
##    [1] -148.507061859438   -6.167681897810  -86.303016236197   11.230613552584
##    [5]  132.553796686779   64.447982233398   60.022940298623  -32.935461345173
##    [9]    9.709386189535  110.715377387226   21.833672642477 -152.379885362755
##   [13]  -50.509085804919   89.538656568402   85.881778764026   81.808789631995
##   [17]  -25.096960188161 -132.306878886620  -96.882428863779 -114.248536490429
##   [21] -120.363778306687   34.418506163659  -30.495061224772  157.563243314833
##   [25]  -23.132224993043  -29.988297793119   -4.508758456788  -78.216548854517
##   [29]  -82.770414814266  -96.190428594034  -13.752311499404 -173.142324023619
##   [33]    7.716659588745  -11.250079907818  -49.431712642590   25.156293122100
##   [37]   77.876756271992   10.465408023059  -98.738071039173  -57.721605829455
##   [41]  -36.774095335469  148.585916315174   -5.309940530204   25.649677724496
##   [45]  -22.138000532037  -13.609184209940 -108.114748672679  -53.425982765292
##   [49]  -16.748435529174   88.189456596395  -56.205239129499  -32.509928264398
##   [53]  -94.644780026189   -2.695368064115  -37.503641954615  -48.642635725802
##   [57]  -14.620314144033  -92.589372183638  -95.403423774570    1.873680940266
##   [61]   18.359690551731  183.008646624827 -124.052761804783 -142.211824286642
##   [65]  112.883160539500  -64.845603235587  -22.600749213425   58.771872163121
##   [69]   60.520037597150   70.147842909087  -56.288317916364  -98.455498410082
##   [73] -173.092757342003   46.223058791966  -42.589183462662   14.137562009856
##   [77]   98.586909945727  180.706161466008   71.292744930186   39.488878711318
##   [81]  -19.514776351738  103.878049950130   40.231462886191  -61.541405402493
##   [85] -256.839046708471  -97.255274372593   86.408807989525   81.079624870782
##   [89]  182.580883744669  -40.290694792129 -115.470705011270   31.811608518390
##   [93]   60.127282193262   14.675828235184   36.429516138673  -49.546818770101
##   [97]   61.307030515475  108.501255632763 -201.114928810344  101.493056406232
##  [101]  -56.930020625267 -124.800275339133  100.399795665775  -38.924991695188
##  [105]  -37.732862100953  -97.578263880570   -9.672084818561   16.559162537504
##  [109]  -22.402413165716  -22.892590558663   19.911231406166   -8.170078817734
##  [113] -125.006133083817  -52.939634702908   75.000297667822  -31.482949184337
##  [117]  -71.741401605354    0.942738403417  -80.651106391832  144.297581655436
##  [121]   25.080172017373  107.262057409572  -13.337353051153   26.144399565625
##  [125]   94.557563850189    0.321239241560   23.179555764504 -166.855881473891
##  [129]   34.026994419263  178.187132232449  124.910626519163 -173.508277157790
##  [133]  -81.553273217247 -101.649432288143 -246.102694467514  142.845000149248
##  [137]  -72.978722385548 -116.809202141765  114.485982420613   35.987614606552
##  [141]    6.770582831924  -37.500302260914   39.232261804539  123.975457108875
```

```
##  [145]  -57.674422430198 -159.679553654800 -130.142397064905  -50.746102820756
##  [149] -104.774809534568   75.166639841016  -68.843100917543 -146.247310369940
##  [153]  -54.963794223129  -74.332503151923  -61.074555176715   15.720201112263
##  [157]  -51.955544791465 -105.222765526726   41.239340508500 -184.426768509237
##  [161]  -59.751241156366   66.558578134751   40.139306743979   23.191117093749
##  [165]  -19.107573360713  -75.668203286103 -126.084813864839  155.593193397773
##  [169]  -84.921054764578   52.192055512935 -157.180516889463   69.819545683374
##  [173]   17.946250904833   55.787425900688   49.372632342836  -67.792651351439
##  [177]   37.606273428365 -128.763361852123   61.768804534525    3.469724498278
##  [181]  132.208034009973   -5.926908682535  -43.840975095860  -65.811538810906
##  [185]   92.781348318761  -32.547047855942 -133.163005100785  -85.824474132458
##  [189]   98.551814859004 -114.909888495924   19.039955258506  -54.757342625036
##  [193]  -31.886076643102 -170.544351246769   -2.516031413574  -62.191869938438
##  [197]  -16.490236898488   95.136996816088 -184.215826337909  163.254802805349
##  [201]  153.352914663053  -47.664969800695  -26.623821775711  -13.215227988271
##  [205]   41.315346195370  116.822734484578 -116.028265087951   51.966262290034
##  [209]  -91.962819975759  -58.774263882239  -19.108543923014   20.792734910431
##  [213]  -47.488397412193  -88.785667914597 -111.633952193432 -272.501883729794
##  [217]  -32.983210926039  -36.591735893830   26.381674640279    1.568626111320
##  [221]   65.730661713161  141.531286900488 -275.978385273457  -78.818003971352
##  [225]  -52.657864767360  -52.620544269795    4.830327616156  242.780944256064
##  [229]  -24.340008795155   93.306764284246  -45.786489327005   65.772181416416
##  [233]  219.874269671025  -17.557009541922  276.124846268148 -150.879003021918
##  [237]   -2.356224056782 -187.320909826350  -31.052808833338  -40.378763997158
##  [241]  -71.182186267685  -24.042095071790    2.135744102046   63.370617613536
##  [245]  212.609869055111   47.679199145337    6.450948886018   69.489193146142
##  [249]   93.759635653034 -155.267669585334   39.416268238971  -93.081981303835
##  [253]   70.798731117239   10.941013586235  -37.756819731141 -156.825280531585
##  [257]   39.732308144318    4.643759625719   54.159172431903   -3.102384412300
##  [261]   -8.146922997449  -37.042276299980  -33.235565744456 -104.789842330354
##  [265]   17.373967880809  -16.969703523918  -54.466289520776   -6.123045605499
##  [269]  -41.456405196341  177.285182233401 -148.933551104247   59.720901165499
##  [273] -126.192958916612 -102.774121039309   19.384110122539   10.547284097334
##  [277]   29.642192067547  -27.494699231960  -96.604266211569  -85.134841593409
##  [281] -175.980625023570 -256.311165964234   89.735936144891  110.124216671774
##  [285] -218.897425671140   90.276919435432  -30.103018668537   30.365659256117
##  [289]   18.836508985829   -9.836957141689  -77.231440520909   78.085196064302
##  [293]  -71.164722357479 -112.887012460069  186.628841835207 -137.162966680694
##  [297]   -0.694876035457   20.706149279004   -9.046738698198  -79.536923416807
##  [301]  -14.898713557396   79.052201351779  271.043143103148   22.758991591664
##  [305] -114.410733809966  -88.995906814681    9.816069902227  -25.481124979178
##  [309] -101.596060061983 -107.744017040813  145.675924414235  -16.074155062350
##  [313]  -21.171649123603 -124.866657106045  140.620940355952   92.607943756811
##  [317] -110.885854608250   40.801244573113  -28.111511158850 -130.681584337244
##  [321]   51.308846084341  154.698114639420   31.612373559078    2.011485340919
##  [325]  -44.687144020996 -175.776946561753   97.714248743375  -84.221406561358
##  [329]    7.150514740268   52.521375342177 -123.910448548980  -61.812885335798
##  [333]  193.883673389940  -96.429688060325  -91.112388982784   62.984557682961
##  [337] -148.247414107904 -214.778666800977   14.144373666929  -74.907472977147
##  [341] -176.543355572525   -1.938238619625 -116.575236749077   37.842203112296
##  [345]  126.897479423998 -197.242890153232   40.478115193193   67.597969977298
##  [349]   74.180379548595   43.484974651864  -77.643102861217 -154.946443523343
##  [353]   49.555784407134   67.871685861299  -27.283457308248   55.708476816013
##  [357]   33.526096171464  -73.530926353107  188.420727077717   56.084648424419
```

```
##  [361]  -15.916399326314    4.485118086861   -3.935978990421 -131.709639992364
##  [365]   83.130705028101 -195.128260660295   25.014999126978   -1.439089601312
##  [369]   26.764115387687   78.016196651828  -87.007481515264 -329.531352103120
##  [373] -103.799409389346   80.270162228407   48.530145995021   -3.664058047740
##  [377]  166.994543209716  -53.534467473422   42.973997246537    0.170652798810
##  [381] -163.254893622249  -20.753831014402   66.233271808041  -33.379355102459
##  [385]   61.067666574652  -11.102711737839    7.550508027368 -113.313638157536
##  [389]  195.246655537952 -137.707610524866  -40.077728893914   71.701904183822
##  [393]  -57.422693590928  -11.298939419288  -27.586213857226  -32.157615372461
##  [397]  -68.905720938647   -6.372846016292  -87.054303484423 -207.889584233633
##  [401]  -21.533064044045    2.923634204782   16.715894061899 -149.296000781875
##  [405]  -69.039350834933  202.300964442607   -2.674489471759  -48.715185268502
##  [409] -142.954651725295   24.490895035549 -111.004006806620  -11.084044914275
##  [413]  -96.510725000734  -14.341194980098  -40.897811951701  136.968331066848
##  [417]   36.592807859088   32.954675943248  130.421655762789  -64.646742745950
##  [421] -153.275533055670   27.183471154509   77.091863076572   93.639078965022
##  [425]  -20.819954357260 -206.949952519020 -149.483595540687 -106.954245477798
##  [429]  -34.367054837413  102.055829653455  -34.058605248539  -62.891061989805
##  [433] -202.646586306131  -58.307554466900  128.615554563427  -47.164610550909
##  [437]  -63.199762622604  149.731136929965 -174.812970417079   43.787667674303
##  [441]   24.767189043973 -139.534823563358 -147.438079201473   -0.317113533883
##  [445]  -32.877657135908  -64.690397161860  -53.667243584919  -19.682761589141
##  [449]  -62.966799673606  -61.911665389695  131.093991687450  -28.084256021587
##  [453]  -72.094940641428 -157.851955057745  -85.993107579150  -24.935980881989
##  [457]   27.023463863234  -92.541077175410 -155.779986506913 -184.996201088265
##  [461]   57.224629994368   77.716958163437  -44.357367594088  208.590150110836
##  [465]   96.689558470047  -41.069535877649  -57.142710360900  -30.343638995658
##  [469]   20.566085796877   66.207755885252  200.408605252160 -129.049321424832
##  [473]  105.832052623903  -45.443581666641  137.849540394242 -109.049620545812
##  [477]  -87.551401933397  123.432014555805  -45.648760610390 -156.598453133033
##  [481]  -12.278121239059   50.419926276171  -94.236724192355  -29.815544413809
##  [485]  -50.359547427930  103.865088826957  -27.050679869948 -125.200656493060
##  [489]   21.040606685401 -151.205317137952   22.097298379131  -83.935980042542
##  [493]   20.040071989406 -102.096748714505  -40.939727060258 -110.698149788778
##  [497] -132.554578446983  -94.516692593531   15.008720396328  -26.177385611810
##  [501]  -62.102739128827  -15.397577349136  176.027817649726    6.574745276635
##  [505]   70.269685814072  -79.580514718922  -97.445236597144  -26.952810860748
##  [509]   39.000799466844 -153.288072680192  -15.444476438083  -64.886351254843
##  [513]   22.129952414989  -77.071655647123  -27.282730229092   -1.023557592703
##  [517]  -66.527549637858   60.004926466164  -18.864466428859  -84.250474245110
##  [521]  116.486261929806  168.306246572576 -129.699561773610   58.171929282277
##  [525]  142.167376368485 -104.523481780568   73.695788455171  -58.064373787001
##  [529]  154.008890168785 -144.014690974289  -76.818979402594   -2.215352749910
##  [533]  -69.619171209415  -64.930774847152   79.925820669554  -82.726792518855
##  [537]  -75.743777947653  -75.665853914879   22.762022279093  -48.691126837767
##  [541]   64.747735468965  -95.335064801345  -70.624481450924  116.413955223539
##  [545]   44.202790884583    4.783172071863 -136.695056382318   35.554344836834
##  [549] -110.000440876899  -50.973491492974    2.328106295100  -72.742961051113
##  [553]  -53.879322141912 -183.349907975216  -89.477377099454  -98.959182942429
##  [557]    8.449093073868    7.344339647003   40.929817798072  -32.350188312749
##  [561]   40.667849794081  -83.533869262897  -68.295184739928   -8.959398678719
##  [565]   26.967132361460  -25.600094767627  -43.995689639020   80.298600241671
##  [569]  -45.285473639410 -115.998467327021  -20.458890319481  -72.727417891818
##  [573]   17.491585243013 -126.815943555843 -152.556046908693  144.812935083989
```

```
##  [577]  121.155954538022  -86.888819653036  123.418527903145   57.299921695795
##  [581]   96.325841051273  104.070019735248    4.916466741512    1.073017346289
##  [585]  -48.093126209078   -8.617309678019   72.671334460389  -47.454663727394
##  [589]   99.704813549879   60.133912553213  -34.197276926684   39.666924659411
##  [593]  -99.473678707180   21.505264653244 -112.074867477111  -65.525016023587
##  [597]   51.220217777564  103.989337126085  180.371400446990 -226.622358776068
##  [601]   21.668821126142   66.886859422853 -194.995929815360   39.542009532323
##  [605]  -90.851359492642    9.442177747808  155.505207185167  -21.509339672073
##  [609]   61.575811572956  -25.708025803125   90.050780305695   25.426146453299
##  [613]  -16.179704671384  -57.514359967885   56.516879152271  188.381674011010
##  [617]  -24.202525022328  -77.022481585867  -77.045272634060 -214.896014641750
##  [621]   63.597872360925  -35.308589164957  234.183791147152 -131.472933834924
##  [625]  271.565713589200  -10.110175684321  115.554826465439  -41.553723582500
##  [629]   27.672797562310  164.572563971548   48.336228961058 -120.539915350224
##  [633] -165.867451925882  -30.313223028126   13.560487353300  -11.130185520406
##  [637]   -5.946087593997  167.241674291440 -145.112775645935 -155.012907924894
##  [641]  -88.726134680243  -29.518846836815 -106.179422788338   89.070041203137
##  [645]  134.440691424567   42.024612410219  -94.639930058838 -147.477978613828
##  [649]   45.093216424273  -37.095178295597    9.930482658865   42.237417006270
##  [653] -230.969244216895 -163.594139550661 -104.827572410949   56.249227875796
##  [657]   -7.171407177849 -180.352588662889  -38.132555407140   33.906145907159
##  [661]  -71.083953323675   16.696194301755   23.256034074317  -19.890856275552
##  [665]    0.957780556198  105.773478454497   55.638051420297 -187.198127461606
##  [669]   -8.812170659263  112.455982615565  -46.594821904000  -43.130047131295
##  [673]  -84.044713267074  -63.505970282840  -20.961146448104  -90.396164784881
##  [677]  -19.490119168091   50.611913152095  -22.426226606182   48.544951794532
##  [681] -113.383236967747  126.796901818918   12.844966039447   56.411262893594
##  [685]  127.225449311660   25.611505531386   29.956298714873  109.139058343357
##  [689]   27.445987463014   26.639455824126  108.054886723298  -19.689226074197
##  [693] -102.970008119272 -168.713952819643  -29.400364405154  191.174430670972
##  [697]  130.804110900226 -124.221650250032  207.075680444498 -135.488887920108
##  [701]  -34.833068021453 -180.539386519238  -83.686903591606    1.176017469479
##  [705]   43.207633621057   56.076004781267  -97.749766548551  115.278788729168
##  [709] -106.838812375732  -53.808727848256 -156.340342562176 -289.504949334140
##  [713]  -69.901980225180 -115.701928271131   -1.452191667494 -252.967957673112
##  [717]  133.196431618411   34.368635925931 -200.492160993892   96.634099025645
##  [721]  163.213695467530  148.967887280844  -78.501584254102   67.351475996114
##  [725]  -17.476418847387   10.944636448366    1.732952952584  -47.261905552237
##  [729]   65.782995825397   44.137974994652   10.674903224605   98.227863278476
##  [733]  -20.882433945929 -121.545739787458  141.942070930207  -15.659726749645
##  [737]  145.228068707235   18.638825418945  -68.440085450043   28.419613292673
##  [741]  -19.791956168254   18.614427285747  158.649629581308   90.104844643841
##  [745]   46.981052199810 -120.142930271351    8.785433108691   34.495193282854
##  [749]  -92.072951821835  -85.922541976365   85.050692851061 -188.278593006109
##  [753] -259.567598067256  -79.421703950779  -47.814175485881  190.504941142328
##  [757]   -4.582043007903  -88.618245279136    7.853746689733 -173.468784531147
##  [761]  110.372197436532   97.732126428213   -3.099412600394   45.361046375177
##  [765]  113.546622528148  -59.294470785279    5.278186565496   37.221810701317
##  [769]    3.396229768241 -243.129801660643  -92.888970241206  -79.241741831679
##  [773]   32.286901703609   73.655189844440  -36.572956585317   89.645652647632
##  [777]  -42.913003910240 -126.611873120240 -112.147791459615  -44.798520893469
##  [781]   14.984184062407    0.371851297109 -140.653154563383  102.276594280311
##  [785]  -90.595899201676 -258.655101371883 -102.542396789275 -164.770289519107
##  [789]  -86.421669500523    3.841526233431  -78.711432863666 -191.439261314409
```

```
##  [793] -181.555951856413 -114.918219163024 -143.619274334882  -60.291616220245
##  [797]  -11.057754907361  246.846252648523   -3.008787703490 -164.876607372205
##  [801]  195.041227052776  122.221238351954  -45.932120794104   67.898959120766
##  [805]  -81.503371642705  -90.342759718435  -55.096062981233   41.927681044941
##  [809]  -28.699559862401  -58.239048250461   62.788520773436   33.884069075964
##  [813] -129.865660889060   20.530854987536  -30.228945242649   70.219818913114
##  [817]  -34.817782054405 -106.646224465488  -70.151397775798   48.661062105426
##  [821]  -17.977896972505  149.083343958912  -70.898311832258   76.634268421516
##  [825]  -12.580592680904  -56.875722867682  234.794430752207   69.920074742816
##  [829]   42.746059548161  -26.341825957415  -91.123401193684  -62.248028484733
##  [833]  -67.431693199755  -20.989271443657  -13.455928945181   33.005325078268
##  [837] -116.474882270427   48.851395296269   44.568427699875  -87.240101846454
##  [841]  -70.504505339896 -161.126483486690  154.303921251289 -213.880525423832
##  [845]   61.987606226560   45.574684652973 -144.014777248122   61.247098192849
##  [849]   21.730003207950 -111.486848833657  115.364830307834 -114.866724199383
##  [853] -108.357862857568  -67.726599068958 -297.760215221942   33.019793242446
##  [857]  -78.615043603843   64.963585026914   94.448579899136  -28.342084057902
##  [861]  107.674338769447  -90.581130917682 -105.574225806139   52.883845887572
##  [865]   -1.316159418071  -79.885347128063  -14.388726265952 -104.857602463905
##  [869] -216.405364383129   -8.304476886566  -18.659919410817    6.235030687289
##  [873]   64.967874021472   49.476106158570 -194.031365192148  233.744690254688
##  [877]   16.221169151570  -29.228820001876 -195.783051779621    7.258616817765
##  [881]   22.919126194088 -195.170824213366 -131.087835592565   54.841096371885
##  [885]   52.779001035635    8.702448974983 -185.484315121833 -241.069003810002
##  [889]  -62.462017041161  131.904685426145  136.208201330258  -54.494457952126
##  [893]   24.256059610518 -217.867895362039  106.948740438545   14.889011124536
##  [897]   54.948424570840   81.865118348204   89.136680849984 -104.881065294779
##  [901]   -6.707648672933 -112.145430801440 -215.154256612723 -111.226118676197
##  [905]  -68.986177004852   98.707314866484  116.732345132447    5.690161401489
##  [909] -134.305384192668  -15.868215739588  121.576440588626  -15.760017546371
##  [913]   21.659317580291  -17.892683045592 -195.420798495895  162.101494427297
##  [917]   38.674331615280  -92.121372987025  -18.128173413713  -27.280680107707
##  [921]   -0.026117529049   47.577970253218  -31.926577717045  -82.172325858619
##  [925]   32.594255975330  146.420764757765 -141.818265828396  -15.085095301702
##  [929]   48.744103846512   35.796455526065  -81.828928096700  -72.821765547254
##  [933]  -80.416278158409  -31.317375498376  -27.745220719072   72.747155333780
##  [937] -214.621815562293 -132.265289317013  -39.512804675238 -155.021067255700
##  [941]  -54.830970507991 -102.689942545956   -8.769748181394  -25.210066007782
##  [945]   98.721371472513  -68.266118728276  122.904697092296  198.713162688605
##  [949]  -62.551474951327 -169.090270020089  -70.116569704293   21.197376051899
##  [953]  114.897174909348  -31.314979135807   73.251737889899   13.220360965917
##  [957] -203.699319030490    9.867123672229   87.102919406986  -97.591429606439
##  [961]  -61.944604068693   70.842706952010   94.637825962067  -11.053068650804
##  [965]  135.053801785051   91.888930334469  -68.686356079985  -16.116824974278
##  [969]  -13.848845917031 -133.770094986133 -193.451633575932  -26.837002367601
##  [973]  -78.630659308685   28.042128990008  -64.386422026698  113.592605888196
##  [977]   30.780832396271  196.149730083248   23.314309485724  -61.946930252026
##  [981] -124.614541782182  -25.067272388797   81.994574971288  -34.353082915351
##  [985]   68.292236687682  -71.269455510556  -80.589564700718  -80.694220716267
##  [989]  -42.934998210308  -40.639893461726 -118.140046537623 -149.554909949192
##  [993] -152.318106121884  167.008649443922 -180.698848126230  -20.895777200183
##  [997]   63.732794969997   38.893341198724 -167.786162514542   20.913376675687
```

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

```r
set.seed(124)
v=rnorm(1000,-10,100)
v
```

```
##    [1] -148.507061859438   -6.167681897810  -86.303016236197   11.230613552584
##    [5]  132.553796686779   64.447982233398   60.022940298623  -32.935461345173
##    [9]    9.709386189535  110.715377387226   21.833672642477 -152.379885362755
##   [13]  -50.509085804919   89.538656568402   85.881778764026   81.808789631995
##   [17]  -25.096960188161 -132.306878886620  -96.882428863779 -114.248536490429
##   [21] -120.363778306687   34.418506163659  -30.495061224772  157.563243314833
##   [25]  -23.132224993043  -29.988297793119   -4.508758456788  -78.216548854517
##   [29]  -82.770414814266  -96.190428594034  -13.752311499404 -173.142324023619
##   [33]    7.716659588745  -11.250079907818  -49.431712642590   25.156293122100
##   [37]   77.876756271992   10.465408023059  -98.738071039173  -57.721605829455
##   [41]  -36.774095335469  148.585916315174   -5.309940530204   25.649677724496
##   [45]  -22.138000532037  -13.609184209940 -108.114748672679  -53.425982765292
##   [49]  -16.748435529174   88.189456596395  -56.205239129499  -32.509928264398
##   [53]  -94.644780026189   -2.695368064115  -37.503641954615  -48.642635725802
##   [57]  -14.620314144033  -92.589372183638  -95.403423774570    1.873680940266
##   [61]   18.359690551731  183.008646624827 -124.052761804783 -142.211824286642
##   [65]  112.883160539500  -64.845603235587  -22.600749213425   58.771872163121
##   [69]   60.520037597150   70.147842909087  -56.288317916364  -98.455498410082
##   [73] -173.092757342003   46.223058791966  -42.589183462662   14.137562009856
##   [77]   98.586909945727  180.706161466008   71.292744930186   39.488878711318
##   [81]  -19.514776351738  103.878049950130   40.231462886191  -61.541405402493
##   [85] -256.839046708471  -97.255274372593   86.408807989525   81.079624870782
##   [89]  182.580883744669  -40.290694792129 -115.470705011270   31.811608518390
##   [93]   60.127282193262   14.675828235184   36.429516138673  -49.546818770101
##   [97]   61.307030515475  108.501255632763 -201.114928810344  101.493056406232
##  [101]  -56.930020625267 -124.800275339133  100.399795665775  -38.924991695188
##  [105]  -37.732862100953  -97.578263880570   -9.672084818561   16.559162537504
##  [109]  -22.402413165716  -22.892590558663   19.911231406166   -8.170078817734
##  [113] -125.006133083817  -52.939634702908   75.000297667822  -31.482949184337
##  [117]  -71.741401605354    0.942738403417  -80.651106391832  144.297581655436
##  [121]   25.080172017373  107.262057409572  -13.337353051153   26.144399565625
##  [125]   94.557563850189    0.321239241560   23.179555764504 -166.855881473891
##  [129]   34.026994419263  178.187132232449  124.910626519163 -173.508277157790
##  [133]  -81.553273217247 -101.649432288143 -246.102694467514  142.845000149248
##  [137]  -72.978722385548 -116.809202141765  114.485982420613   35.987614606552
##  [141]    6.770582831924  -37.500302260914   39.232261804539  123.975457108875
##  [145]  -57.674422430198 -159.679553654800 -130.142397064905  -50.746102820756
##  [149] -104.774809534568   75.166639841016  -68.843100917543 -146.247310369940
##  [153]  -54.963794223129  -74.332503151923  -61.074555176715   15.720201112263
##  [157]  -51.955544791465 -105.222765526726   41.239340508500 -184.426768509237
##  [161]  -59.751241156366   66.558578134751   40.139306743979   23.191117093749
##  [165]  -19.107573360713  -75.668203286103 -126.084813864839  155.593193397773
##  [169]  -84.921054764578   52.192055512935 -157.180516889463   69.819545683374
##  [173]   17.946250904833   55.787425900688   49.372632342836  -67.792651351439
##  [177]   37.606273428365 -128.763361852123   61.768804534525    3.469724498278
##  [181]  132.208034009973   -5.926908682535  -43.840975095860  -65.811538810906
##  [185]   92.781348318761  -32.547047855942 -133.163005100785  -85.824474132458
##  [189]   98.551814859004 -114.909888495924   19.039955258506  -54.757342625036
##  [193]  -31.886076643102 -170.544351246769   -2.516031413574  -62.191869938438
```

```
##  [197]  -16.490236898488   95.136996816088 -184.215826337909  163.254802805349
##  [201]  153.352914663053  -47.664969800695  -26.623821775711  -13.215227988271
##  [205]   41.315346195370  116.822734484578 -116.028265087951   51.966262290034
##  [209]  -91.962819975759  -58.774263882239  -19.108543923014   20.792734910431
##  [213]  -47.488397412193  -88.785667914597 -111.633952193432 -272.501883729794
##  [217]  -32.983210926039  -36.591735893830   26.381674640279    1.568626111320
##  [221]   65.730661713161  141.531286900488 -275.978385273457  -78.818003971352
##  [225]  -52.657864767360  -52.620544269795    4.830327616156  242.780944256064
##  [229]  -24.340008795155   93.306764284246  -45.786489327005   65.772181416416
##  [233]  219.874269671025  -17.557009541922  276.124846268148 -150.879003021918
##  [237]   -2.356224056782 -187.320909826350  -31.052808833338  -40.378763997158
##  [241]  -71.182186267685  -24.042095071790    2.135744102046   63.370617613536
##  [245]  212.609869055111   47.679199145337    6.450948886018   69.489193146142
##  [249]   93.759635653034 -155.267669585334   39.416268238971  -93.081981303835
##  [253]   70.798731117239   10.941013586235  -37.756819731141 -156.825280531585
##  [257]   39.732308144318    4.643759625719   54.159172431903   -3.102384412300
##  [261]   -8.146922997449  -37.042276299980  -33.235565744456 -104.789842330354
##  [265]   17.373967880809  -16.969703523918  -54.466289520776   -6.123045605499
##  [269]  -41.456405196341  177.285182233401 -148.933551104247   59.720901165499
##  [273] -126.192958916612 -102.774121039309   19.384110122539   10.547284097334
##  [277]   29.642192067547  -27.494699231960  -96.604266211569  -85.134841593409
##  [281] -175.980625023570 -256.311165964234   89.735936144891  110.124216671774
##  [285] -218.897425671140   90.276919435432  -30.103018668537   30.365659256117
##  [289]   18.836508985829   -9.836957141689  -77.231440520909   78.085196064302
##  [293]  -71.164722357479 -112.887012460069  186.628841835207 -137.162966680694
##  [297]   -0.694876035457   20.706149279004   -9.046738698198  -79.536923416807
##  [301]  -14.898713557396   79.052201351779  271.043143103148   22.758991591664
##  [305] -114.410733809966  -88.995906814681    9.816069902227  -25.481124979178
##  [309] -101.596060061983 -107.744017040813  145.675924414235  -16.074155062350
##  [313]  -21.171649123603 -124.866657106045  140.620940355952   92.607943756811
##  [317] -110.885854608250   40.801244573113  -28.111511158850 -130.681584337244
##  [321]   51.308846084341  154.698114639420   31.612373559078    2.011485340919
##  [325]  -44.687144020996 -175.776946561753   97.714248743375  -84.221406561358
##  [329]    7.150514740268   52.521375342177 -123.910448548980  -61.812885335798
##  [333]  193.883673389940  -96.429688060325  -91.112388982784   62.984557682961
##  [337] -148.247414107904 -214.778666800977   14.144373666929  -74.907472977147
##  [341] -176.543355572525   -1.938238619625 -116.575236749077   37.842203112296
##  [345]  126.897479423998 -197.242890153232   40.478115193193   67.597969977298
##  [349]   74.180379548595   43.484974651864  -77.643102861217 -154.946443523343
##  [353]   49.555784407134   67.871685861299  -27.283457308248   55.708476816013
##  [357]   33.526096171464  -73.530926353107  188.420727077717   56.084648424419
##  [361]  -15.916399326314    4.485118086861   -3.935978990421 -131.709639992364
##  [365]   83.130705028101 -195.128260660295   25.014999126978   -1.439089601312
##  [369]   26.764115387687   78.016196651828  -87.007481515264 -329.531352103120
##  [373] -103.799409389346   80.270162228407   48.530145995021   -3.664058047740
##  [377]  166.994543209716  -53.534467473422   42.973997246537    0.170652798810
##  [381] -163.254893622249  -20.753831014402   66.233271808041  -33.379355102459
##  [385]   61.067666574652  -11.102711737839    7.550508027368 -113.313638157536
##  [389]  195.246655537952 -137.707610524866  -40.077728893914   71.701904183822
##  [393]  -57.422693590928  -11.298939419288  -27.586213857226  -32.157615372461
##  [397]  -68.905720938647   -6.372846016292  -87.054303484423 -207.889584233633
##  [401]  -21.533064044045    2.923634204782   16.715894061899 -149.296000781875
##  [405]  -69.039350834933  202.300964442607   -2.674489471759  -48.715185268502
##  [409] -142.954651725295   24.490895035549 -111.004006806620  -11.084044914275
```

```
##  [413]  -96.510725000734  -14.341194980098  -40.897811951701  136.968331066848
##  [417]   36.592807859088   32.954675943248  130.421655762789  -64.646742745950
##  [421] -153.275533055670   27.183471154509   77.091863076572   93.639078965022
##  [425]  -20.819954357260 -206.949952519020 -149.483595540687 -106.954245477798
##  [429]  -34.367054837413  102.055829653455  -34.058605248539  -62.891061989805
##  [433] -202.646586306131  -58.307554466900  128.615554563427  -47.164610550909
##  [437]  -63.199762622604  149.731136929965 -174.812970417079   43.787667674303
##  [441]   24.767189043973 -139.534823563358 -147.438079201473   -0.317113533883
##  [445]  -32.877657135908  -64.690397161860  -53.667243584919  -19.682761589141
##  [449]  -62.966799673606  -61.911665389695  131.093991687450  -28.084256021587
##  [453]  -72.094940641428 -157.851955057745  -85.993107579150  -24.935980881989
##  [457]   27.023463863234  -92.541077175410 -155.779986506913 -184.996201088265
##  [461]   57.224629994368   77.716958163437  -44.357367594088  208.590150110836
##  [465]   96.689558470047  -41.069535877649  -57.142710360900  -30.343638995658
##  [469]   20.566085796877   66.207755885252  200.408605252160 -129.049321424832
##  [473]  105.832052623903  -45.443581666641  137.849540394242 -109.049620545812
##  [477]  -87.551401933397  123.432014555805  -45.648760610390 -156.598453133033
##  [481]  -12.278121239059   50.419926276171  -94.236724192355  -29.815544413809
##  [485]  -50.359547427930  103.865088826957  -27.050679869948 -125.200656493060
##  [489]   21.040606685401 -151.205317137952   22.097298379131  -83.935980042542
##  [493]   20.040071989406 -102.096748714505  -40.939727060258 -110.698149788778
##  [497] -132.554578446983  -94.516692593531   15.008720396328  -26.177385611810
##  [501]  -62.102739128827  -15.397577349136  176.027817649726    6.574745276635
##  [505]   70.269685814072  -79.580514718922  -97.445236597144  -26.952810860748
##  [509]   39.000799466844 -153.288072680192  -15.444476438083  -64.886351254843
##  [513]   22.129952414989  -77.071655647123  -27.282730229092   -1.023557592703
##  [517]  -66.527549637858   60.004926466164  -18.864466428859  -84.250474245110
##  [521]  116.486261929806  168.306246572576 -129.699561773610   58.171929282277
##  [525]  142.167376368485 -104.523481780568   73.695788455171  -58.064373787001
##  [529]  154.008890168785 -144.014690974289  -76.818979402594   -2.215352749910
##  [533]  -69.619171209415  -64.930774847152   79.925820669554  -82.726792518855
##  [537]  -75.743777947653  -75.665853914879   22.762022279093  -48.691126837767
##  [541]   64.747735468965  -95.335064801345  -70.624481450924  116.413955223539
##  [545]   44.202790884583    4.783172071863 -136.695056382318   35.554344836834
##  [549] -110.000440876899  -50.973491492974    2.328106295100  -72.742961051113
##  [553]  -53.879322141912 -183.349907975216  -89.477377099454  -98.959182942429
##  [557]    8.449093073868    7.344339647003   40.929817798072  -32.350188312749
##  [561]   40.667849794081  -83.533869262897  -68.295184739928   -8.959398678719
##  [565]   26.967132361460  -25.600094767627  -43.995689639020   80.298600241671
##  [569]  -45.285473639410 -115.998467327021  -20.458890319481  -72.727417891818
##  [573]   17.491585243013 -126.815943555843 -152.556046908693  144.812935083989
##  [577]  121.155954538022  -86.888819653036  123.418527903145   57.299921695795
##  [581]   96.325841051273  104.070019735248    4.916466741512    1.073017346289
##  [585]  -48.093126209078   -8.617309678019   72.671334460389  -47.454663727394
##  [589]   99.704813549879   60.133912553213  -34.197276926684   39.666924659411
##  [593]  -99.473678707180   21.505264653244 -112.074867477111  -65.525016023587
##  [597]   51.220217777564  103.989337126085  180.371400446990 -226.622358776068
##  [601]   21.668821126142   66.886859422853 -194.995929815360   39.542009532323
##  [605]  -90.851359492642    9.442177747808  155.505207185167  -21.509339672073
##  [609]   61.575811572956  -25.708025803125   90.050780305695   25.426146453299
##  [613]  -16.179704671384  -57.514359967885   56.516879152271  188.381674011010
##  [617]  -24.202525022328  -77.022481585867  -77.045272634060 -214.896014641750
##  [621]   63.597872360925  -35.308589164957  234.183791147152 -131.472933834924
##  [625]  271.565713589200  -10.110175684321  115.554826465439  -41.553723582500
```

```
##  [629]   27.672797562310  164.572563971548   48.336228961058 -120.539915350224
##  [633] -165.867451925882  -30.313223028126   13.560487353300  -11.130185520406
##  [637]   -5.946087593997  167.241674291440 -145.112775645935 -155.012907924894
##  [641]  -88.726134680243  -29.518846836815 -106.179422788338   89.070041203137
##  [645]  134.440691424567   42.024612410219  -94.639930058838 -147.477978613828
##  [649]   45.093216424273  -37.095178295597    9.930482658865   42.237417006270
##  [653] -230.969244216895 -163.594139550661 -104.827572410949   56.249227875796
##  [657]   -7.171407177849 -180.352588662889  -38.132555407140   33.906145907159
##  [661]  -71.083953323675   16.696194301755   23.256034074317  -19.890856275552
##  [665]    0.957780556198  105.773478454497   55.638051420297 -187.198127461606
##  [669]   -8.812170659263  112.455982615565  -46.594821904000  -43.130047131295
##  [673]  -84.044713267074  -63.505970282840  -20.961146448104  -90.396164784881
##  [677]  -19.490119168091   50.611913152095  -22.426226606182   48.544951794532
##  [681] -113.383236967747  126.796901818918   12.844966039447   56.411262893594
##  [685]  127.225449311660   25.611505531386   29.956298714873  109.139058343357
##  [689]   27.445987463014   26.639455824126  108.054886723298  -19.689226074197
##  [693] -102.970008119272 -168.713952819643  -29.400364405154  191.174430670972
##  [697]  130.804110900226 -124.221650250032  207.075680444498 -135.488887920108
##  [701]  -34.833068021453 -180.539386519238  -83.686903591606    1.176017469479
##  [705]   43.207633621057   56.076004781267  -97.749766548551  115.278788729168
##  [709] -106.838812375732  -53.808727848256 -156.340342562176 -289.504949334140
##  [713]  -69.901980225180 -115.701928271131   -1.452191667494 -252.967957673112
##  [717]  133.196431618411   34.368635925931 -200.492160993892   96.634099025645
##  [721]  163.213695467530  148.967887280844  -78.501584254102   67.351475996114
##  [725]  -17.476418847387   10.944636448366    1.732952952584  -47.261905552237
##  [729]   65.782995825397   44.137974994652   10.674903224605   98.227863278476
##  [733]  -20.882433945929 -121.545739787458  141.942070930207  -15.659726749645
##  [737]  145.228068707235   18.638825418945  -68.440085450043   28.419613292673
##  [741]  -19.791956168254   18.614427285747  158.649629581308   90.104844643841
##  [745]   46.981052199810 -120.142930271351    8.785433108691   34.495193282854
##  [749]  -92.072951821835  -85.922541976365   85.050692851061 -188.278593006109
##  [753] -259.567598067256  -79.421703950779  -47.814175485881  190.504941142328
##  [757]   -4.582043007903  -88.618245279136    7.853746689733 -173.468784531147
##  [761]  110.372197436532   97.732126428213   -3.099412600394   45.361046375177
##  [765]  113.546622528148  -59.294470785279    5.278186565496   37.221810701317
##  [769]    3.396229768241 -243.129801660643  -92.888970241206  -79.241741831679
##  [773]   32.286901703609   73.655189844440  -36.572956585317   89.645652647632
##  [777]  -42.913003910240 -126.611873120240 -112.147791459615  -44.798520893469
##  [781]   14.984184062407    0.371851297109 -140.653154563383  102.276594280311
##  [785]  -90.595899201676 -258.655101371883 -102.542396789275 -164.770289519107
##  [789]  -86.421669500523    3.841526233431  -78.711432863666 -191.439261314409
##  [793] -181.555951856413 -114.918219163024 -143.619274334882  -60.291616220245
##  [797]  -11.057754907361  246.846252648523   -3.008787703490 -164.876607372205
##  [801]  195.041227052776  122.221238351954  -45.932120794104   67.898959120766
##  [805]  -81.503371642705  -90.342759718435  -55.096062981233   41.927681044941
##  [809]  -28.699559862401  -58.239048250461   62.788520773436   33.884069075964
##  [813] -129.865660889060   20.530854987536  -30.228945242649   70.219818913114
##  [817]  -34.817782054405 -106.646224465488  -70.151397775798   48.661062105426
##  [821]  -17.977896972505  149.083343958912  -70.898311832258   76.634268421516
##  [825]  -12.580592680904  -56.875722867682  234.794430752207   69.920074742816
##  [829]   42.746059548161  -26.341825957415  -91.123401193684  -62.248028484733
##  [833]  -67.431693199755  -20.989271443657  -13.455928945181   33.005325078268
##  [837] -116.474882270427   48.851395296269   44.568427699875  -87.240101846454
##  [841]  -70.504505339896 -161.126483486690  154.303921251289 -213.880525423832
```

```
##  [845]   61.987606226560   45.574684652973 -144.014777248122   61.247098192849
##  [849]   21.730003207950 -111.486848833657  115.364830307834 -114.866724199383
##  [853] -108.357862857568  -67.726599068958 -297.760215221942   33.019793242446
##  [857]  -78.615043603843   64.963585026914   94.448579899136  -28.342084057902
##  [861]  107.674338769447  -90.581130917682 -105.574225806139   52.883845887572
##  [865]   -1.316159418071  -79.885347128063  -14.388726265952 -104.857602463905
##  [869] -216.405364383129   -8.304476886566  -18.659919410817    6.235030687289
##  [873]   64.967874021472   49.476106158570 -194.031365192148  233.744690254688
##  [877]   16.221169151570  -29.228820001876 -195.783051779621    7.258616817765
##  [881]   22.919126194088 -195.170824213366 -131.087835592565   54.841096371885
##  [885]   52.779001035635    8.702448974983 -185.484315121833 -241.069003810002
##  [889]  -62.462017041161  131.904685426145  136.208201330258  -54.494457952126
##  [893]   24.256059610518 -217.867895362039  106.948740438545   14.889011124536
##  [897]   54.948424570840   81.865118348204   89.136680849984 -104.881065294779
##  [901]   -6.707648672933 -112.145430801440 -215.154256612723 -111.226118676197
##  [905]  -68.986177004852   98.707314866484  116.732345132447    5.690161401489
##  [909] -134.305384192668  -15.868215739588  121.576440588626  -15.760017546371
##  [913]   21.659317580291  -17.892683045592 -195.420798495895  162.101494427297
##  [917]   38.674331615280  -92.121372987025  -18.128173413713  -27.280680107707
##  [921]   -0.026117529049   47.577970253218  -31.926577717045  -82.172325858619
##  [925]   32.594255975330  146.420764757765 -141.818265828396  -15.085095301702
##  [929]   48.744103846512   35.796455526065  -81.828928096700  -72.821765547254
##  [933]  -80.416278158409  -31.317375498376  -27.745220719072   72.747155333780
##  [937] -214.621815562293 -132.265289317013  -39.512804675238 -155.021067255700
##  [941]  -54.830970507991 -102.689942545956   -8.769748181394  -25.210066007782
##  [945]   98.721371472513  -68.266118728276  122.904697092296  198.713162688605
##  [949]  -62.551474951327 -169.090270020089  -70.116569704293   21.197376051899
##  [953]  114.897174909348  -31.314979135807   73.251737889899   13.220360965917
##  [957] -203.699319030490    9.867123672229   87.102919406986  -97.591429606439
##  [961]  -61.944604068693   70.842706952010   94.637825962067  -11.053068650804
##  [965]  135.053801785051   91.888930334469  -68.686356079985  -16.116824974278
##  [969]  -13.848845917031 -133.770094986133 -193.451633575932  -26.837002367601
##  [973]  -78.630659308685   28.042128990008  -64.386422026698  113.592605888196
##  [977]   30.780832396271  196.149730083248   23.314309485724  -61.946930252026
##  [981] -124.614541782182  -25.067272388797   81.994574971288  -34.353082915351
##  [985]   68.292236687682  -71.269455510556  -80.589564700718  -80.694220716267
##  [989]  -42.934998210308  -40.639893461726 -118.140046537623 -149.554909949192
##  [993] -152.318106121884  167.008649443922 -180.698848126230  -20.895777200183
##  [997]   63.732794969997   38.893341198724 -167.786162514542   20.913376675687
```

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

```
set.seed(124)
v=rnorm(1000,-10,100)
print(sd(v)/sqrt(length(v)))
```

```
## [1] 3.0934284574
```

```
print(mean(v))
```

```
## [1] -16.53551982
```

- 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?

```
?qnorm
set.seed(124)
v=rnorm(1000,-10,100)
print(quantile(v,.05))
```

```
##           5%
## -176.73381723
```

```
qnorm(v,-10,100,lower.tail=TRUE,log.p=FALSE)
```

```
## Warning in qnorm(v, -10, 100, lower.tail = TRUE, log.p = FALSE): NaNs produced
```

```
##    [1]            NaN            NaN            NaN            NaN
##    [5]            NaN            NaN            NaN            NaN
##    [9]            NaN            NaN            NaN            NaN
##   [13]            NaN            NaN            NaN            NaN
##   [17]            NaN            NaN            NaN            NaN
##   [21]            NaN            NaN            NaN            NaN
##   [25]            NaN            NaN            NaN            NaN
##   [29]            NaN            NaN            NaN            NaN
##   [33]            NaN            NaN            NaN            NaN
##   [37]            NaN            NaN            NaN            NaN
##   [41]            NaN            NaN            NaN            NaN
##   [45]            NaN            NaN            NaN            NaN
##   [49]            NaN            NaN            NaN            NaN
##   [53]            NaN            NaN            NaN            NaN
##   [57]            NaN            NaN            NaN            NaN
##   [61]            NaN            NaN            NaN            NaN
##   [65]            NaN            NaN            NaN            NaN
##   [69]            NaN            NaN            NaN            NaN
##   [73]            NaN            NaN            NaN            NaN
##   [77]            NaN            NaN            NaN            NaN
##   [81]            NaN            NaN            NaN            NaN
##   [85]            NaN            NaN            NaN            NaN
##   [89]            NaN            NaN            NaN            NaN
##   [93]            NaN            NaN            NaN            NaN
##   [97]            NaN            NaN            NaN            NaN
##  [101]            NaN            NaN            NaN            NaN
##  [105]            NaN            NaN            NaN            NaN
##  [109]            NaN            NaN            NaN            NaN
##  [113]            NaN            NaN            NaN            NaN
##  [117]            NaN  147.818466064            NaN            NaN
##  [121]            NaN            NaN            NaN            NaN
##  [125]            NaN -56.423626286            NaN            NaN
##  [129]            NaN            NaN            NaN            NaN
##  [133]            NaN            NaN            NaN            NaN
##  [137]            NaN            NaN            NaN            NaN
##  [141]            NaN            NaN            NaN            NaN
##  [145]            NaN            NaN            NaN            NaN
```

```
##  [149]          NaN          NaN          NaN          NaN
##  [153]          NaN          NaN          NaN          NaN
##  [157]          NaN          NaN          NaN          NaN
##  [161]          NaN          NaN          NaN          NaN
##  [165]          NaN          NaN          NaN          NaN
##  [169]          NaN          NaN          NaN          NaN
##  [173]          NaN          NaN          NaN          NaN
##  [177]          NaN          NaN          NaN          NaN
##  [181]          NaN          NaN          NaN          NaN
##  [185]          NaN          NaN          NaN          NaN
##  [189]          NaN          NaN          NaN          NaN
##  [193]          NaN          NaN          NaN          NaN
##  [197]          NaN          NaN          NaN          NaN
##  [201]          NaN          NaN          NaN          NaN
##  [205]          NaN          NaN          NaN          NaN
##  [209]          NaN          NaN          NaN          NaN
##  [213]          NaN          NaN          NaN          NaN
##  [217]          NaN          NaN          NaN          NaN
##  [221]          NaN          NaN          NaN          NaN
##  [225]          NaN          NaN          NaN          NaN
##  [229]          NaN          NaN          NaN          NaN
##  [233]          NaN          NaN          NaN          NaN
##  [237]          NaN          NaN          NaN          NaN
##  [241]          NaN          NaN          NaN          NaN
##  [245]          NaN          NaN          NaN          NaN
##  [249]          NaN          NaN          NaN          NaN
##  [253]          NaN          NaN          NaN          NaN
##  [257]          NaN          NaN          NaN          NaN
##  [261]          NaN          NaN          NaN          NaN
##  [265]          NaN          NaN          NaN          NaN
##  [269]          NaN          NaN          NaN          NaN
##  [273]          NaN          NaN          NaN          NaN
##  [277]          NaN          NaN          NaN          NaN
##  [281]          NaN          NaN          NaN          NaN
##  [285]          NaN          NaN          NaN          NaN
##  [289]          NaN          NaN          NaN          NaN
##  [293]          NaN          NaN          NaN          NaN
##  [297]          NaN          NaN          NaN          NaN
##  [301]          NaN          NaN          NaN          NaN
##  [305]          NaN          NaN          NaN          NaN
##  [309]          NaN          NaN          NaN          NaN
##  [313]          NaN          NaN          NaN          NaN
##  [317]          NaN          NaN          NaN          NaN
##  [321]          NaN          NaN          NaN          NaN
##  [325]          NaN          NaN          NaN          NaN
##  [329]          NaN          NaN          NaN          NaN
##  [333]          NaN          NaN          NaN          NaN
##  [337]          NaN          NaN          NaN          NaN
##  [341]          NaN          NaN          NaN          NaN
##  [345]          NaN          NaN          NaN          NaN
##  [349]          NaN          NaN          NaN          NaN
##  [353]          NaN          NaN          NaN          NaN
##  [357]          NaN          NaN          NaN          NaN
##  [361]          NaN          NaN          NaN          NaN
```

```
##  [365]           NaN           NaN           NaN           NaN
##  [369]           NaN           NaN           NaN           NaN
##  [373]           NaN           NaN           NaN           NaN
##  [377]           NaN           NaN           NaN -105.158873343
##  [381]           NaN           NaN           NaN           NaN
##  [385]           NaN           NaN           NaN           NaN
##  [389]           NaN           NaN           NaN           NaN
##  [393]           NaN           NaN           NaN           NaN
##  [397]           NaN           NaN           NaN           NaN
##  [401]           NaN           NaN           NaN           NaN
##  [405]           NaN           NaN           NaN           NaN
##  [409]           NaN           NaN           NaN           NaN
##  [413]           NaN           NaN           NaN           NaN
##  [417]           NaN           NaN           NaN           NaN
##  [421]           NaN           NaN           NaN           NaN
##  [425]           NaN           NaN           NaN           NaN
##  [429]           NaN           NaN           NaN           NaN
##  [433]           NaN           NaN           NaN           NaN
##  [437]           NaN           NaN           NaN           NaN
##  [441]           NaN           NaN           NaN           NaN
##  [445]           NaN           NaN           NaN           NaN
##  [449]           NaN           NaN           NaN           NaN
##  [453]           NaN           NaN           NaN           NaN
##  [457]           NaN           NaN           NaN           NaN
##  [461]           NaN           NaN           NaN           NaN
##  [465]           NaN           NaN           NaN           NaN
##  [469]           NaN           NaN           NaN           NaN
##  [473]           NaN           NaN           NaN           NaN
##  [477]           NaN           NaN           NaN           NaN
##  [481]           NaN           NaN           NaN           NaN
##  [485]           NaN           NaN           NaN           NaN
##  [489]           NaN           NaN           NaN           NaN
##  [493]           NaN           NaN           NaN           NaN
##  [497]           NaN           NaN           NaN           NaN
##  [501]           NaN           NaN           NaN           NaN
##  [505]           NaN           NaN           NaN           NaN
##  [509]           NaN           NaN           NaN           NaN
##  [513]           NaN           NaN           NaN           NaN
##  [517]           NaN           NaN           NaN           NaN
##  [521]           NaN           NaN           NaN           NaN
##  [525]           NaN           NaN           NaN           NaN
##  [529]           NaN           NaN           NaN           NaN
##  [533]           NaN           NaN           NaN           NaN
##  [537]           NaN           NaN           NaN           NaN
##  [541]           NaN           NaN           NaN           NaN
##  [545]           NaN           NaN           NaN           NaN
##  [549]           NaN           NaN           NaN           NaN
##  [553]           NaN           NaN           NaN           NaN
##  [557]           NaN           NaN           NaN           NaN
##  [561]           NaN           NaN           NaN           NaN
##  [565]           NaN           NaN           NaN           NaN
##  [569]           NaN           NaN           NaN           NaN
##  [573]           NaN           NaN           NaN           NaN
##  [577]           NaN           NaN           NaN           NaN
```

```
##  [581]             NaN             NaN             NaN             NaN
##  [585]             NaN             NaN             NaN             NaN
##  [589]             NaN             NaN             NaN             NaN
##  [593]             NaN             NaN             NaN             NaN
##  [597]             NaN             NaN             NaN             NaN
##  [601]             NaN             NaN             NaN             NaN
##  [605]             NaN             NaN             NaN             NaN
##  [609]             NaN             NaN             NaN             NaN
##  [613]             NaN             NaN             NaN             NaN
##  [617]             NaN             NaN             NaN             NaN
##  [621]             NaN             NaN             NaN             NaN
##  [625]             NaN             NaN             NaN             NaN
##  [629]             NaN             NaN             NaN             NaN
##  [633]             NaN             NaN             NaN             NaN
##  [637]             NaN             NaN             NaN             NaN
##  [641]             NaN             NaN             NaN             NaN
##  [645]             NaN             NaN             NaN             NaN
##  [649]             NaN             NaN             NaN             NaN
##  [653]             NaN             NaN             NaN             NaN
##  [657]             NaN             NaN             NaN             NaN
##  [661]             NaN             NaN             NaN             NaN
##  [665] 162.549175939             NaN             NaN             NaN
##  [669]             NaN             NaN             NaN             NaN
##  [673]             NaN             NaN             NaN             NaN
##  [677]             NaN             NaN             NaN             NaN
##  [681]             NaN             NaN             NaN             NaN
##  [685]             NaN             NaN             NaN             NaN
##  [689]             NaN             NaN             NaN             NaN
##  [693]             NaN             NaN             NaN             NaN
##  [697]             NaN             NaN             NaN             NaN
##  [701]             NaN             NaN             NaN             NaN
##  [705]             NaN             NaN             NaN             NaN
##  [709]             NaN             NaN             NaN             NaN
##  [713]             NaN             NaN             NaN             NaN
##  [717]             NaN             NaN             NaN             NaN
##  [721]             NaN             NaN             NaN             NaN
##  [725]             NaN             NaN             NaN             NaN
##  [729]             NaN             NaN             NaN             NaN
##  [733]             NaN             NaN             NaN             NaN
##  [737]             NaN             NaN             NaN             NaN
##  [741]             NaN             NaN             NaN             NaN
##  [745]             NaN             NaN             NaN             NaN
##  [749]             NaN             NaN             NaN             NaN
##  [753]             NaN             NaN             NaN             NaN
##  [757]             NaN             NaN             NaN             NaN
##  [761]             NaN             NaN             NaN             NaN
##  [765]             NaN             NaN             NaN             NaN
##  [769]             NaN             NaN             NaN             NaN
##  [773]             NaN             NaN             NaN             NaN
##  [777]             NaN             NaN             NaN             NaN
##  [781]             NaN -42.695410999             NaN             NaN
##  [785]             NaN             NaN             NaN             NaN
##  [789]             NaN             NaN             NaN             NaN
##  [793]             NaN             NaN             NaN             NaN
```

```
##  [797]          NaN          NaN          NaN          NaN
##  [801]          NaN          NaN          NaN          NaN
##  [805]          NaN          NaN          NaN          NaN
##  [809]          NaN          NaN          NaN          NaN
##  [813]          NaN          NaN          NaN          NaN
##  [817]          NaN          NaN          NaN          NaN
##  [821]          NaN          NaN          NaN          NaN
##  [825]          NaN          NaN          NaN          NaN
##  [829]          NaN          NaN          NaN          NaN
##  [833]          NaN          NaN          NaN          NaN
##  [837]          NaN          NaN          NaN          NaN
##  [841]          NaN          NaN          NaN          NaN
##  [845]          NaN          NaN          NaN          NaN
##  [849]          NaN          NaN          NaN          NaN
##  [853]          NaN          NaN          NaN          NaN
##  [857]          NaN          NaN          NaN          NaN
##  [861]          NaN          NaN          NaN          NaN
##  [865]          NaN          NaN          NaN          NaN
##  [869]          NaN          NaN          NaN          NaN
##  [873]          NaN          NaN          NaN          NaN
##  [877]          NaN          NaN          NaN          NaN
##  [881]          NaN          NaN          NaN          NaN
##  [885]          NaN          NaN          NaN          NaN
##  [889]          NaN          NaN          NaN          NaN
##  [893]          NaN          NaN          NaN          NaN
##  [897]          NaN          NaN          NaN          NaN
##  [901]          NaN          NaN          NaN          NaN
##  [905]          NaN          NaN          NaN          NaN
##  [909]          NaN          NaN          NaN          NaN
##  [913]          NaN          NaN          NaN          NaN
##  [917]          NaN          NaN          NaN          NaN
##  [921]          NaN          NaN          NaN          NaN
##  [925]          NaN          NaN          NaN          NaN
##  [929]          NaN          NaN          NaN          NaN
##  [933]          NaN          NaN          NaN          NaN
##  [937]          NaN          NaN          NaN          NaN
##  [941]          NaN          NaN          NaN          NaN
##  [945]          NaN          NaN          NaN          NaN
##  [949]          NaN          NaN          NaN          NaN
##  [953]          NaN          NaN          NaN          NaN
##  [957]          NaN          NaN          NaN          NaN
##  [961]          NaN          NaN          NaN          NaN
##  [965]          NaN          NaN          NaN          NaN
##  [969]          NaN          NaN          NaN          NaN
##  [973]          NaN          NaN          NaN          NaN
##  [977]          NaN          NaN          NaN          NaN
##  [981]          NaN          NaN          NaN          NaN
##  [985]          NaN          NaN          NaN          NaN
##  [989]          NaN          NaN          NaN          NaN
##  [993]          NaN          NaN          NaN          NaN
##  [997]          NaN          NaN          NaN          NaN
```

- 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?