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

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

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

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

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

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

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

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

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

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

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

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

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

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

Is this answer *exactly* correct?

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

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

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

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

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

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

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

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

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

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

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

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

Comment on the appropriateness of the non-numeric values.

Log is undefined for negative numbers and the log of infinity is infinity.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

```
##  [1] NA  4  4  4  4  4  4  4  4  4  4  3  3  3  3  3  3  3  3  3  3  3  3  3  3
## [26]  3  3  3  3  3  3  3  3  3  3  3  3  3  2  2  2  2  2  2  2  2  2  1  1  1
```

```
## [51]  0 NA NA NA NA NA NA NA NA NA NA NA
```

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

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

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

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

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

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

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

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

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

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

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

```
## [1] 0.896
```

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

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

```
## [1] 0.882
```

- In class we considered a variable `x_3` which measured "criminality". We imagined $L = 4$ levels "none", "infraction", "misdimeanor" and "felony". Create a variable `x_3` here with 100 random elements (equally probable). Create it as a nominal (i.e. unordered) factor.

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

```
##  [1] felony      felony      none        none        none        misdimeanor
##  [7] misdimeanor felony      none        misdimeanor none        infraction
## [13] infraction  none        none        misdimeanor infraction  felony
## [19] infraction  none        misdimeanor infraction  misdimeanor felony
## [25] felony      felony      infraction  misdimeanor none        infraction
## [31] none        felony      infraction  infraction  infraction  infraction
## [37] none        none        none        infraction  misdimeanor none
## [43] misdimeanor infraction  felony      infraction  none        none
## [49] none        misdimeanor none        misdimeanor misdimeanor misdimeanor
```

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

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

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

```
##    [1]  TRUE  TRUE FALSE FALSE FALSE  TRUE  TRUE  TRUE FALSE  TRUE FALSE  TRUE
##   [13]  TRUE FALSE FALSE  TRUE  TRUE  TRUE  TRUE FALSE  TRUE  TRUE  TRUE  TRUE
##   [25]  TRUE  TRUE  TRUE  TRUE FALSE  TRUE FALSE  TRUE  TRUE  TRUE  TRUE  TRUE
##   [37] FALSE FALSE FALSE  TRUE  TRUE FALSE  TRUE  TRUE  TRUE  TRUE FALSE FALSE
##   [49] FALSE  TRUE FALSE  TRUE  TRUE  TRUE FALSE FALSE  TRUE FALSE  TRUE  TRUE
##   [61] FALSE  TRUE  TRUE  TRUE FALSE  TRUE  TRUE FALSE FALSE  TRUE FALSE  TRUE
##   [73] FALSE  TRUE FALSE FALSE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE
##   [85]  TRUE FALSE FALSE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE FALSE FALSE
##   [97]  TRUE  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"),ordered=TRUE)
x_3_ord
```

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

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

```
x_binary1=x_3_ord=="infraction"
x_binary2=x_3_ord=="misdimeanor"
x_binary3=x_3_ord=="felony"
x_3_ord_bin=matrix(data=c(x_binary1,x_binary2,x_binary3),nrow=3,ncol=100,byrow=TRUE,dimnames=NULL)
x_3_ord_bin
```

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

- What should the sum of each row be (in English)? The sum of the first row should be the total number of infractions. The sum of the second row should be the total number of misdemeanors. The sum of the third row should be the total number of felonies.

Verify that.

```
rowSums(x_3_ord_bin)
```

```
## [1] 24 24 19
```

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

  The column sums should either be zero or one because only one option occurred or none occurred.

  Verify that.

```
colSums(x_3_ord_bin)
```

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

- 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"
)

names=c(rnorm(n=100,mean=17,sqrt(38)),runif(n=100,min=-10,max=10),rpois(n=100,lambda=6),rexp(n=100,rate=
matrix_fake_first_names=matrix(data=names,nrow=100,ncol=6,byrow=FALSE,dimnames=list(fake_first_names))
matrix_fake_first_names
```

```
##                     [,1]            [,2] [,3]            [,4] [,5] [,6]
## Sophia       15.7488359911   2.993334364146    2 0.07412788075291    3    0
## Emma         20.9289067003   9.221343141980    7 0.15860706918664    2    0
## Olivia       20.7256256925  -9.835995608009    9 0.10481979593996    1    1
## Ava          22.3073938689  -3.338282601908    6 0.01394931868547    0    1
## Mia          21.0366541415  -2.191735901870    6 0.21494635669616    4    1
## Isabella     14.9034737415   1.260038926266    5 0.01355085822029    4    0
## Riley        15.2527314409   9.829947371036    7 0.00734196235943    0    0
## Aria          9.4017173615   5.134957712144    5 0.06678041826106    1    1
## Zoe          18.3403738979  -1.872462490574    7 0.02585682722347    1    0
## Charlotte    11.4088935400  -7.694312073290    6 0.11801437733021    3    0
## Lily          7.4612095969   0.458280392922    5 0.01251620018414    2    1
## Layla         9.5860827516  -4.322810573503    7 0.19728223283142    4    0
## Amelia        9.5900698339   5.540532558225    6 0.16804778492179    2    0
## Emily        17.0811764036   4.427702883258    7 0.12470764076491    4    0
## Madelyn      12.5899004858  -1.453248523176    5 0.02819869020540    1    0
## Aubrey       17.5170253237  -9.085109466687    2 0.04739595582295    2    1
## Adalyn       16.1529049756   8.740805252455    5 0.04275506641716    0    0
## Madison       6.7119279922   3.380242334679    8 0.05731924836672    2    0
## Chloe         9.5268880873   1.889655892737    6 0.05292445767878    1    1
## Harper        9.2569978634   7.209460604936    6 0.05163498724707    0    1
## Abigail      27.3518637305  -6.295257685706    3 0.05687556883901    1    1
## Aaliyah      20.5297671226  -8.559501348063    1 0.11665906435861    4    0
## Avery        23.7385250147  -9.054029677063    8 0.09498550007688    3    0
## Evelyn       27.8181781439   7.395980055444    6 0.19713141497832    2    0
## Kaylee       21.0210318185   8.038634913974    9 0.29099973848552    3    0
```

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```
## Ella      9.6170475545  3.171285171993   7 0.05054311847521  5   0
## Ellie     9.4041028672 -0.825090226717   5 0.00585836373890  4   1
## Scarlett 15.9944188934 -6.882613790222   7 0.05326422537897  1   0
## Arianna  26.8754457882 -2.906945659779   9 0.02313189317162  2   0
## Hailey   18.2252347456  9.132722900249   9 0.14284297430214  1   0
## Nora      6.8887993130  3.297373717651   6 0.13979942818907  1   0
## Addison   8.9606626026  1.932508642785   7 0.13050103528579  1   0
## Brooklyn 15.7450454006 -8.518074946478   5 0.18730470102589  5   0
## Hannah   22.6860392676  0.833838116378   9 0.01230108263632  4   0
## Mila     18.0184660478  4.197558998130   7 0.04856717345459  4   0
## Leah     29.4731015779  5.287653384730   5 0.07397661839301  2   0
## Elizabeth 20.1494621904 3.423080514185   8 0.21481892548396  1   0
## Sarah    24.9149753550  4.869227497838   5 0.20159499681884  4   0
## Eliana   27.8005246654  4.233981864527   7 0.01305597648025  0   0
## Mackenzie 18.1421208729 -8.737052977085  3 0.11634337849862  2   0
## Peyton   21.1976025806  2.374891350046   4 0.19691791881184  4   1
## Maria    11.3838485718  9.355569151230   9 0.33498000351708  3   0
## Grace     6.5825296933  1.179763260297   5 0.39384115795444  2   0
## Adeline  20.5867930147  7.113605593331   3 0.23699099507024  4   0
## Elena    19.0115711163  0.589409205131   9 0.08500440511386  1   0
## Anna     19.3322263430  9.208539663814   3 0.02585492779811  2   1
## Victoria -1.3401403567 -1.036413819529   9 0.10738020783030  3   0
## Camilla  16.3750253196 -5.327127608471   7 0.00751319564200  2   0
## Lillian  12.2986091072  7.937766094692  11 0.10015297537019  2   0
## Natalie  11.2718710167 -6.016859193332   3 0.37764302722070  2   0
## Jackson  20.4654417607  6.466320329346   7 0.04966104121368  2   0
## Aiden     2.0035103636  0.044288556091   5 0.06988047803235  0   0
## Lucas    27.1513113676 -1.277925618924   6 0.06671382735173  3   0
## Liam     14.1179872172  9.009472853504   7 0.17225741469920  4   0
## Noah     18.3999998388 -5.298306117766   5 0.07520516604806  3   0
## Ethan    23.2375398360 -8.381794602610   2 0.10748658649571  2   0
## Mason    26.8756908065 -4.906081897207  11 0.10101817040755  3   1
## Caden     7.2959091130 -3.327881423756   6 0.01104864687851  5   0
## Oliver   16.2361485340  8.996103531681   6 0.01608651053781  5   0
## Elijah    9.9286821288  5.925150318071   3 0.26003930778395  1   0
## Grayson  21.0779704597  6.039019585587   6 0.00479523179234  4   0
## Jacob    13.3499196240 -5.554351331666   6 0.02300416248747  2   0
## Michael  23.1032186581  5.140760978684   5 0.02402574707601  0   0
## Benjamin  8.7686562810  3.662848463282   4 0.04503165382064  2   1
## Carter   23.0423037802 -0.323464735411   7 0.00852398760617  1   1
## James    30.6775260622  0.727832261473   4 0.20323046192421  2   1
## Jayden   14.0143011881 -1.889815437607   7 0.00877242856167  3   0
## Logan    11.3609079123 -0.808941456489   7 0.01143784146699  2   0
## Alexander 11.8802700527  3.021263536066  10 0.05113154277205  2   0
## Caleb    25.2016090247  6.239500404336   4 0.00189407076687  1   0
## Ryan     19.5152648425  9.149114792235  11 0.05656963597155  1   0
## Luke     32.6805542665 -0.792511315085   6 0.04988047857800  2   0
## Daniel   18.7636592264  9.578678039834   5 0.00888972279305  1   0
## Jack     13.4204384886 -9.829255244695   5 0.08087623010801  3   1
## William   7.0340430149 -9.339245008305   5 0.04916144679818  0   0
## Owen      1.0923849185 -6.371544501744   7 0.13724527486858  5   0
## Gabriel  10.5183832371  0.449582743458   2 0.04502933177476  3   0
## Matthew  19.2749720040  0.486286384985   6 0.14231792071160  1   0
## Connor   17.4337834195  6.750956517644   7 0.00069341401128  2   0
```

```
## Jayce     25.3887147491 -3.973977006972  6 0.06171809167912  1  1
## Isaac     21.9411383750  9.913750924170  4 0.11365824099163  1  0
## Sebastian 13.5706002720  5.543367271312  5 0.08992718594303  3  0
## Henry      9.8469126729  0.811731265858  5 0.21198296690875  0  0
## Muhammad  22.5547235471 -0.791070200503  9 0.10361639349669  1  0
## Cameron    9.1412014607  7.123930850066  7 0.00746894870988  3  1
## Wyatt     23.4697835083  8.215136942454  3 0.00071852705959  3  0
## Dylan     21.8592481366  5.448319064453  5 0.26777704120766  4  0
## Nathan    15.9622565254  8.859179294668  6 0.00623394114276  3  0
## Nicholas  14.9431229964 -3.782155923545  7 0.13475610687862  2  1
## Julian    11.7159413859  9.876922997646  1 0.06732882792130  4  1
## Eli       16.7813810780 -4.015083936974  9 0.13879786400279  2  0
## Levi      16.9444361441  5.684761065058  8 0.00806690550720  6  1
## Isaiah    18.9350416393  1.464875508100  3 0.14545895552003  4  0
## Landon    15.5555725919 -8.569849198684  8 0.02616881299764  1  0
## David     18.6655555835 -5.116261625662  4 0.00067885321912  3  0
## Christian 11.1496134509 -4.553827419877  5 0.11147624615941  0  0
## Andrew    16.7662030927  2.718090941198  6 0.12016604892029  0  0
## Brayden    4.0201644693 -4.481565901078  9 0.48373850390826  4  1
## John      16.8453169616 -6.629325649701  7 0.32361155745933  4  1
## Lincoln   12.4903377917  7.780601638369  5 0.01700789686577  2  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.

```
z=as.data.frame(matrix_fake_first_names,row.names=fake_first_names)
z
```

```
##                     V1            V2 V3             V4 V5 V6
## Sophia    15.7488359911  2.993334364146  2 0.07412788075291  3  0
## Emma      20.9289067003  9.221343141980  7 0.15860706918664  2  0
## Olivia    20.7256256925 -9.835995608009  9 0.10481979593996  1  1
## Ava       22.3073938689 -3.338282601908  6 0.01394931868547  0  1
## Mia       21.0366541415 -2.191735901870  6 0.21494635669616  4  1
## Isabella  14.9034737415  1.260038926266  5 0.01355085822029  4  0
## Riley     15.2527314409  9.829947371036  7 0.00734196235943  0  0
## Aria       9.4017173615  5.134957712144  5 0.06678041826106  1  1
## Zoe       18.3403738979 -1.872462490574  7 0.02585682722347  1  0
## Charlotte 11.4088935400 -7.694312073290  6 0.11801437733021  3  0
## Lily       7.4612095969  0.458280392922  5 0.01251620018414  2  1
## Layla      9.5860827516 -4.322810573503  7 0.19728223283142  4  0
## Amelia     9.5900698339  5.540532558225  6 0.16804778492179  2  0
## Emily     17.0811764036  4.427702883258  7 0.12470764076491  4  0
## Madelyn   12.5899004858 -1.453248523176  5 0.02819869020540  1  0
## Aubrey    17.5170253237 -9.085109466687  2 0.04739595582295  2  1
## Adalyn    16.1529049756  8.740805252455  5 0.04275506641716  0  0
## Madison    6.7119279922  3.380242334679  8 0.05731924836672  2  0
## Chloe      9.5268880873  1.889655892737  6 0.05292445767878  1  1
## Harper     9.2569978634  7.209460604936  6 0.05163498724707  0  1
## Abigail   27.3518637305 -6.295257685706  3 0.05687556883901  1  1
## Aaliyah   20.5297671226 -8.559501348063  1 0.11665906435861  4  0
## Avery     23.7385250147 -9.054029677063  8 0.09498550007688  3  0
## Evelyn    27.8181781439  7.395980055444  6 0.19713141497832  2  0
## Kaylee    21.0210318185  8.038634913974  9 0.29099973848552  3  0
## Ella       9.6170475545  3.171285171993  7 0.05054311847521  5  0
```

```
## Ellie       9.4041028672 -0.825090226717   5 0.00585836373890  4  1
## Scarlett   15.9944188934 -6.882613790222    7 0.05326422537897  1  0
## Arianna    26.8754457882 -2.906945659779    9 0.02313189317162  2  0
## Hailey     18.2252347456  9.132722900249    9 0.14284297430214  1  0
## Nora        6.8887993130  3.297373717651    6 0.13979942818907  1  0
## Addison     8.9606626026  1.932508642785    7 0.13050103528579  1  0
## Brooklyn   15.7450454006 -8.518074946478    5 0.18730470102589  5  0
## Hannah     22.6860392676  0.833838116378    9 0.01230108263632  4  0
## Mila       18.0184660478  4.197558998130    7 0.04856717345459  4  0
## Leah       29.4731015779  5.287653384730    5 0.07397661839301  2  0
## Elizabeth  20.1494621904  3.423080514185    8 0.21481892548396  1  0
## Sarah      24.9149753550  4.869227497838    5 0.20159499681884  4  0
## Eliana     27.8005246654  4.233981864527    7 0.01305597648025  0  0
## Mackenzie  18.1421208729 -8.737052977085    3 0.11634337849862  2  0
## Peyton     21.1976025806  2.374891350046    4 0.19691791881184  4  1
## Maria      11.3838485718  9.355569151230    9 0.33498000351708  3  0
## Grace       6.5825296933  1.179763260297    5 0.39384115795444  2  0
## Adeline    20.5867930147  7.113605593331    3 0.23699099507024  4  0
## Elena      19.0115711163  0.589409205131    9 0.08500440511386  1  0
## Anna       19.3322263430  9.208539663814    3 0.02585492779811  2  1
## Victoria   -1.3401403567 -1.036413819529    9 0.10738020783030  3  0
## Camilla    16.3750253196 -5.327127608471    7 0.00751319564200  2  0
## Lillian    12.2986091072  7.937766094692   11 0.10015297537019  2  0
## Natalie    11.2718710167 -6.016859193332    3 0.37764302722070  2  0
## Jackson    20.4654417607  6.466320329346    7 0.04966104121368  2  0
## Aiden       2.0035103636  0.044288556091    5 0.06988047803235  0  0
## Lucas      27.1513113676 -1.277925618924    6 0.06671382735173  3  0
## Liam       14.1179872172  9.009472853504    7 0.17225741469920  4  0
## Noah       18.3999998388 -5.298306117766    5 0.07520516604806  3  0
## Ethan      23.2375398360 -8.381794602610    2 0.10748658649571  2  0
## Mason      26.8756908065 -4.906081897207   11 0.10101817040755  3  1
## Caden       7.2959091130 -3.327881423756    6 0.01104864687851  5  0
## Oliver     16.2361485340  8.996103531681    6 0.01608651053781  5  0
## Elijah      9.9286821288  5.925150318071    3 0.26003930778395  1  0
## Grayson    21.0779704597  6.039019585587    6 0.00479523179234  4  0
## Jacob      13.3499196240 -5.554351331666    6 0.02300416248747  2  0
## Michael    23.1032186581  5.140760978684    5 0.02402574707601  0  0
## Benjamin    8.7686562810  3.662848463282    4 0.04503165382064  2  1
## Carter     23.0423037802 -0.323464735411    7 0.00852398760617  1  1
## James      30.6775260622  0.727832261473    4 0.20323046192421  2  1
## Jayden     14.0143011881 -1.889815437607    7 0.00877242856167  3  0
## Logan      11.3609079123 -0.808941456489    7 0.01143784146699  2  0
## Alexander  11.8802700527  3.021263536066   10 0.05113154277205  2  0
## Caleb      25.2016090247  6.239500404336    4 0.00189407076687  1  0
## Ryan       19.5152648425  9.149114792235   11 0.05656963597155  1  0
## Luke       32.6805542665 -0.792511315085    6 0.04988047857800  2  0
## Daniel     18.7636592264  9.578678039834    5 0.00888972279305  1  0
## Jack       13.4204384886 -9.829255244695    5 0.08087623010801  3  1
## William     7.0340430149 -9.339245008305    5 0.04916144679818  0  0
## Owen        1.0923849185 -6.371544501744    7 0.13724527486858  5  0
## Gabriel    10.5183832371  0.449582743458    2 0.04502933177476  3  0
## Matthew    19.2749720040  0.486286384985    6 0.14231792071160  1  0
## Connor     17.4337834195  6.750956517644    7 0.00069341401128  2  0
## Jayce      25.3887147491 -3.973977006972    6 0.06171809167912  1  1
```

```
## Isaac       21.9411383750  9.913750924170  4 0.11365824099163  1  0
## Sebastian 13.5706002720  5.543367271312  5 0.08992718594303  3  0
## Henry        9.8469126729  0.811731265858  5 0.21198296690875  0  0
## Muhammad  22.5547235471 -0.791070200503  9 0.10361639349669  1  0
## Cameron      9.1412014607  7.123930850066  7 0.00746894870988  3  1
## Wyatt       23.4697835083  8.215136942454  3 0.00071852705959  3  0
## Dylan       21.8592481366  5.448319064453  5 0.26777704120766  4  0
## Nathan      15.9622565254  8.859179294668  6 0.00623394114276  3  0
## Nicholas    14.9431229964 -3.782155923545  7 0.13475610687862  2  1
## Julian      11.7159413859  9.876922997646  1 0.06732882792130  4  1
## Eli         16.7813810780 -4.015083936974  9 0.13879786400279  2  0
## Levi        16.9444361441  5.684761065058  8 0.00806690550720  6  1
## Isaiah      18.9350416393  1.464875508100  3 0.14545895552003  4  0
## Landon      15.5555725919 -8.569849198684  8 0.02616881299764  1  0
## David       18.6655555835 -5.116261625662  4 0.00067885321912  3  0
## Christian 11.1496134509 -4.553827419877  5 0.11147624615941  0  0
## Andrew      16.7662030927  2.718090941198  6 0.12016604892029  0  0
## Brayden      4.0201644693 -4.481565901078  9 0.48373850390826  4  1
## John        16.8453169616 -6.629325649701  7 0.32361155745933  4  1
## Lincoln     12.4903377917  7.780601638369  5 0.01700789686577  2  0
```

```r
z[ ,6]=factor(x=(z[ ,6]),c(0,1),labels=c("domestic","foreign"))
z
```

```
##                          V1             V2 V3                V4 V5        V6
## Sophia     15.7488359911   2.993334364146  2 0.07412788075291  3 domestic
## Emma       20.9289067003   9.221343141980  7 0.15860706918664  2 domestic
## Olivia     20.7256256925  -9.835995608009  9 0.10481979593996  1  foreign
## Ava        22.3073938689  -3.338282601908  6 0.01394931868547  0  foreign
## Mia        21.0366541415  -2.191735901870  6 0.21494635669616  4  foreign
## Isabella   14.9034737415   1.260038926266  5 0.01355085822029  4 domestic
## Riley      15.2527314409   9.829947371036  7 0.00734196235943  0 domestic
## Aria        9.4017173615   5.134957712144  5 0.06678041826106  1  foreign
## Zoe        18.3403738979  -1.872462490574  7 0.02585682722347  1 domestic
## Charlotte 11.4088935400  -7.694312073290  6 0.11801437733021  3 domestic
## Lily        7.4612095969   0.458280392922  5 0.01251620018414  2  foreign
## Layla       9.5860827516  -4.322810573503  7 0.19728223283142  4 domestic
## Amelia      9.5900698339   5.540532558225  6 0.16804778492179  2 domestic
## Emily      17.0811764036   4.427702883258  7 0.12470764076491  4 domestic
## Madelyn    12.5899004858  -1.453248523176  5 0.02819869020540  1 domestic
## Aubrey     17.5170253237  -9.085109466687  2 0.04739595582295  2  foreign
## Adalyn     16.1529049756   8.740805252455  5 0.04275506641716  0 domestic
## Madison     6.7119279922   3.380242334679  8 0.05731924836672  2 domestic
## Chloe       9.5268880873   1.889655892737  6 0.05292445767878  1  foreign
## Harper      9.2569978634   7.209460604936  6 0.05163498724707  0  foreign
## Abigail    27.3518637305  -6.295257685706  3 0.05687556883901  1  foreign
## Aaliyah    20.5297671226  -8.559501348063  1 0.11665906435861  4 domestic
## Avery      23.7385250147  -9.054029677063  8 0.09498550007688  3 domestic
## Evelyn     27.8181781439   7.395980055444  6 0.19713141497832  2 domestic
## Kaylee     21.0210318185   8.038634913974  9 0.29099973848552  3 domestic
## Ella        9.6170475545   3.171285171993  7 0.05054311847521  5 domestic
## Ellie       9.4041028672  -0.825090226717  5 0.00585836373890  4  foreign
## Scarlett   15.9944188934  -6.882613790222  7 0.05326422537897  1 domestic
## Arianna    26.8754457882  -2.906945659779  9 0.02313189317162  2 domestic
## Hailey     18.2252347456   9.132722900249  9 0.14284297430214  1 domestic
```

```
## Nora       6.8887993130   3.297373717651   6 0.13979942818907   1 domestic
## Addison    8.9606626026   1.932508642785   7 0.13050103528579   1 domestic
## Brooklyn  15.7450454006  -8.518074946478   5 0.18730470102589   5 domestic
## Hannah    22.6860392676   0.833838116378   9 0.01230108263632   4 domestic
## Mila      18.0184660478   4.197558998130   7 0.04856717345459   4 domestic
## Leah      29.4731015779   5.287653384730   5 0.07397661839301   2 domestic
## Elizabeth 20.1494621904   3.423080514185   8 0.21481892548396   1 domestic
## Sarah     24.9149753550   4.869227497838   5 0.20159499681884   4 domestic
## Eliana    27.8005246654   4.233981864527   7 0.01305597648025   0 domestic
## Mackenzie 18.1421208729  -8.737052977085   3 0.11634337849862   2 domestic
## Peyton    21.1976025806   2.374891350046   4 0.19691791881184   4  foreign
## Maria     11.3838485718   9.355569151230   9 0.33498000351708   3 domestic
## Grace      6.5825296933   1.179763260297   5 0.39384115795444   2 domestic
## Adeline   20.5867930147   7.113605593331   3 0.23699099507024   4 domestic
## Elena     19.0115711163   0.589409205131   9 0.08500440511386   1 domestic
## Anna      19.3322263430   9.208539663814   3 0.02585492779811   2  foreign
## Victoria  -1.3401403567  -1.036413819529   9 0.10738020783030   3 domestic
## Camilla   16.3750253196  -5.327127608471   7 0.00751319564200   2 domestic
## Lillian   12.2986091072   7.937766094692  11 0.10015297537019   2 domestic
## Natalie   11.2718710167  -6.016859193332   3 0.37764302722070   2 domestic
## Jackson   20.4654417607   6.466320329346   7 0.04966104121368   2 domestic
## Aiden      2.0035103636   0.044288556091   5 0.06988047803235   0 domestic
## Lucas     27.1513113676  -1.277925618924   6 0.06671382735173   3 domestic
## Liam      14.1179872172   9.009472853504   7 0.17225741469920   4 domestic
## Noah      18.3999998388  -5.298306117766   5 0.07520516604806   3 domestic
## Ethan     23.2375398360  -8.381794602610   2 0.10748658649571   2 domestic
## Mason     26.8756908065  -4.906081897207  11 0.10101817040755   3  foreign
## Caden      7.2959091130  -3.327881423756   6 0.01104864687851   5 domestic
## Oliver    16.2361485340   8.996103531681   6 0.01608651053781   5 domestic
## Elijah     9.9286821288   5.925150318071   3 0.26003930778395   1 domestic
## Grayson   21.0779704597   6.039019585587   6 0.00479523179234   4 domestic
## Jacob     13.3499196240  -5.554351331666   6 0.02300416248747   2 domestic
## Michael   23.1032186581   5.140760978684   5 0.02402574707601   0 domestic
## Benjamin   8.7686562810   3.662848463282   4 0.04503165382064   2  foreign
## Carter    23.0423037802  -0.323464735411   7 0.00852398760617   1  foreign
## James     30.6775260622   0.727832261473   4 0.20323046192421   2  foreign
## Jayden    14.0143011881  -1.889815437607   7 0.00877242856167   3 domestic
## Logan     11.3609079123  -0.808941456489   7 0.01143784146699   2 domestic
## Alexander 11.8802700527   3.021263536066  10 0.05113154277205   2 domestic
## Caleb     25.2016090247   6.239500404336   4 0.00189407076687   1 domestic
## Ryan      19.5152648425   9.149114792235  11 0.05656963597155   1 domestic
## Luke      32.6805542665  -0.792511315085   6 0.04988047857800   2 domestic
## Daniel    18.7636592264   9.578678039834   5 0.00888972279305   1 domestic
## Jack      13.4204384886  -9.829255244695   5 0.08087623010801   3  foreign
## William    7.0340430149  -9.339245008305   5 0.04916144679818   0 domestic
## Owen       1.0923849185  -6.371544501744   7 0.13724527486858   5 domestic
## Gabriel   10.5183832371   0.449582743458   2 0.04502933177476   3 domestic
## Matthew   19.2749720040   0.486286384985   6 0.14231792071160   1 domestic
## Connor    17.4337834195   6.750956517644   7 0.00069341401128   2 domestic
## Jayce     25.3887147491  -3.973977006972   6 0.06171809167912   1  foreign
## Isaac     21.9411383750   9.913750924170   4 0.11365824099163   1 domestic
## Sebastian 13.5706002720   5.543367271312   5 0.08992718594303   3 domestic
## Henry      9.8469126729   0.811731265858   5 0.21198296690875   0 domestic
## Muhammad  22.5547235471  -0.791070200503   9 0.10361639349669   1 domestic
```

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```
## Cameron    9.1412014607  7.123930850066  7 0.00746894870988  3  foreign
## Wyatt     23.4697835083  8.215136942454  3 0.00071852705959  3 domestic
## Dylan     21.8592481366  5.448319064453  5 0.26777704120766  4 domestic
## Nathan    15.9622565254  8.859179294668  6 0.00623394114276  3 domestic
## Nicholas  14.9431229964 -3.782155923545  7 0.13475610687862  2  foreign
## Julian    11.7159413859  9.876922997646  1 0.06732882792130  4  foreign
## Eli       16.7813810780 -4.015083936974  9 0.13879786400279  2 domestic
## Levi      16.9444361441  5.684761065058  8 0.00806690550720  6  foreign
## Isaiah    18.9350416393  1.464875508100  3 0.14545895552003  4 domestic
## Landon    15.5555725919 -8.569849198684  8 0.02616881299764  1 domestic
## David     18.6655555835 -5.116261625662  4 0.00067885321912  3 domestic
## Christian 11.1496134509 -4.553827419877  5 0.11147624615941  0 domestic
## Andrew    16.7662030927  2.718090941198  6 0.12016604892029  0 domestic
## Brayden    4.0201644693 -4.481565901078  9 0.48373850390826  4  foreign
## John      16.8453169616 -6.629325649701  7 0.32361155745933  4  foreign
## Lincoln   12.4903377917  7.780601638369  5 0.01700789686577  2 domestic
```

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

```
print(z[ ,6])
```

```
##   [1] domestic domestic foreign  foreign  foreign  domestic domestic foreign
##   [9] domestic domestic foreign  domestic domestic domestic domestic foreign
##  [17] domestic domestic foreign  foreign  foreign  domestic domestic domestic
##  [25] domestic domestic foreign  domestic domestic domestic domestic domestic
##  [33] domestic domestic domestic domestic domestic domestic domestic domestic
##  [41] foreign  domestic domestic domestic domestic foreign  domestic domestic
##  [49] domestic domestic domestic domestic domestic domestic domestic domestic
##  [57] foreign  domestic domestic domestic domestic domestic domestic foreign
##  [65] foreign  foreign  domestic domestic domestic domestic domestic domestic
##  [73] domestic foreign  domestic domestic domestic domestic domestic foreign
##  [81] domestic domestic domestic domestic foreign  domestic domestic domestic
##  [89] foreign  foreign  domestic foreign  domestic domestic domestic domestic
##  [97] domestic foreign  foreign  domestic
## Levels: domestic foreign
```

```
table(z[ ,6])
```

```
##
## domestic  foreign
##       76       24
```

Print out a summary of the whole dataframe.

```
summary(z)
```

```
##        V1                 V2                V3           V4
##  Min.   :-1.3401404  Min.   :-9.8359956  Min.   : 1  Min.   :0.00067885322
##  1st Qu.:11.3386487  1st Qu.:-3.9842537  1st Qu.: 5  1st Qu.:0.02380228360
##  Median :16.7737921  Median : 1.2199011  Median : 6  Median :0.06860465298
##  Mean   :16.4205319  Mean   : 1.0482038  Mean   : 6  Mean   :0.09939876771
##  3rd Qu.:21.0249374  3rd Qu.: 5.9536176  3rd Qu.: 7  3rd Qu.:0.13904825505
##  Max.   :32.6805543  Max.   : 9.9137509  Max.   :11  Max.   :0.48373850391
##        V5                 V6
##  Min.   :0.00    domestic:76
##  1st Qu.:1.00    foreign :24
##  Median :2.00
```

```
##  Mean   :2.28
##  3rd Qu.:3.00
##  Max.   :6.00
```

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

```
R=matrix(data=sample(c(rep(0,50),rep(1,25),rep(2,25))),nrow=50,ncol=50,byrow=FALSE,dimnames=NULL)
R
```

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

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

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

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

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

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

```
R=replace(R,sample(c(1:2500),size=750),NA)
R
```

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

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

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

##	[,38]	[,39]	[,40]	[,41]	[,42]	[,43]	[,44]	[,45]	[,46]	[,47]	[,48]	[,49]
## [1,]	0	NA	NA	0	0	0	0	NA	0	NA	0	0
## [2,]	0	0	0	0	NA	0	0	0	0	0	NA	0
## [3,]	1	2	1	2	1	2	1	2	1	2	1	2
## [4,]	1	2	1	2	1	2	1	2	1	2	1	2
## [5,]	0	NA	0	2	0	2	0	2	0	NA	0	NA
## [6,]	NA	0	NA	0	0	0	NA	0	0	0	0	0
## [7,]	0	NA	NA	0	0	0	NA	0	NA	0	0	0
## [8,]	1	0	1	0	NA	0	1	NA	NA	0	NA	0

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

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

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

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

```
##  [1]  0  0 53 57 24  0  0 12  0 66 30 52 14 17  0 19 24 59  0 18 34 56 36 30 17
## [26] 32 32 31 42 19  0 60 15  0  0 34 55 17 34 33 16 19 66 36  0  0 10  0 76 32
```

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

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

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

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

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

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

```
## [18,]     2
## [19,]     0
## [20,]     2
## [21,]     1
## [22,]    NA
## [23,]     2
## [24,]     0
## [25,]     0
## [26,]     0
## [27,]     1
## [28,]     0
## [29,]    NA
## [30,]     1
## [31,]     1
## [32,]     1
## [33,]     0
## [34,]     1
## [35,]     0
## [36,]     1
## [37,]     1
## [38,]     0
## [39,]     0
## [40,]     0
## [41,]     0
## [42,]     0
## [43,]     0
## [44,]     0
## [45,]    NA
## [46,]     0
## [47,]     0
## [48,]    NA
## [49,]     0
## [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(A,1,sd,na.rm=TRUE)
```

```
##  [1] 0.00000000000 0.00000000000 0.00000000000 0.50503537376 0.50389662287
##  [6] 0.50522792407 0.50671170971 0.50630939785 0.50709255284 0.50395263068
## [11] 0.98654043611 1.01342341942 1.01201881248 0.00000000000 1.00128123051
## [16] 1.01503843785 0.00000000000 1.01600101600 0.99227787671 1.01503843785
## [21] 0.00000000000 1.01600101600 1.00000000000 0.98373875368 1.00790526136
## [26] 0.50671170971 0.50630939785 0.50630939785 0.50243310439 0.50709255284
## [31] 0.50751921892 0.50630939785 0.50751921892 0.50854762772 0.50401612877
## [36] 0.48507125007 0.47519096331 0.00000000000 0.00000000000 0.00000000000
## [41] 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000
## [46] 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000
```

```
apply(A,2,sd,na.rm=TRUE)
```

```
##  [1] 0.92728015446 0.72811999709 0.90626779780 0.80891195385 0.86705137903
##  [6] 0.74528085202 0.84890218555 0.73611950197 0.89087080637 0.80070533423
```

```
## [11] 0.89763418297 0.73780406526 0.88611864831 0.69695032136 0.91210348816
## [16] 0.75935031654 0.89348717267 0.76477052086 0.93297660428 0.81188617377
## [21] 0.88013003579 0.75126156523 0.89294371875 0.79282496717 0.91697374054
## [26] 0.78187980687 0.92728015446 0.67202150503 0.87988269013 0.74293796182
## [31] 0.85835983666 0.84281592351 0.87581131218 0.77459666924 0.89928422716
## [36] 0.77757017987 0.89929425592 0.72803161335 0.86711818075 0.76786452693
## [41] 0.91146543038 0.74971258861 0.94321958331 0.83666002653 0.88252260812
## [46] 0.76786452693 0.89000123974 0.78000215471 0.92279572865 0.79939001135
```

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

```
apply(A!=0,2,sum,na.rm=TRUE)
```

```
##  [1] 17 17 20 18 17 16 17 12 15 12 14 17 20 17 18 13 15 17 19 18 18 19 16 17 17
## [26] 17 15 10 15 19 15 15 15 15 19 14 19 16 16 20 19 16 19 14 22 20 21 19 18 22
```

- 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`.

```
L=split(A,col(A))
L
```

```
## $`1`
##  [1]  2  2  2  2  2 NA  2  1 NA NA  2  2 NA NA  2 NA  1 NA  2  0  1  2  0 NA  2
## [26]  1 NA  1  0 NA NA  0 NA NA NA  0  0  0  0  0  0 NA  0  0 NA  0  0 NA  0  0
##
## $`2`
##  [1]  2  2 NA  1 NA NA  1 NA  1 NA NA  0  0  1  0  2 NA  2  0 NA  1 NA  2  0 NA
## [26]  0  1  0  1  1 NA  1  0  1  0  1  1  0  0  0  0  0  0 NA  0 NA  0 NA  0  0
##
## $`3`
##  [1]  2  2  2  2  2  2 NA  1  2  1  2  2  2  1  2  0  1  0  2  0 NA  2  0 NA NA
## [26]  1 NA NA  0  0  0 NA  1  0  1  0  0 NA  0 NA NA  0  0  0  0  0 NA NA  0 NA
##
## $`4`
##  [1]  2 NA  2  1  1 NA  1  2 NA  2  0  0  0 NA  0  2  1  2  0  2  1  0  2 NA  0
## [26]  0 NA  0  1  1  1 NA  0  1  0 NA  1 NA  0  0 NA  0  0 NA  0  0  0 NA  0  0
##
## $`5`
##  [1]  2 NA NA  2  2 NA  2  1 NA  1  2 NA NA  1  2  0 NA  0  2 NA  1  2  0  2  2
## [26] NA  0  1  0  0  0  0  1  0  1  0  0 NA  0 NA  0  0  0  0  0  0  0  0 NA  0
##
## $`6`
##  [1]  2 NA  2  1  1 NA  1  2  1 NA NA  0  0  1  0  2  1 NA  0  2  1 NA NA NA  0
## [26] NA NA  0  1 NA  1  1 NA NA NA NA  1  0  0  0  0  0  0  0  0  0  0 NA NA NA
##
## $`7`
##  [1]  2  2 NA NA  2  2  2  1  2  1  2 NA NA  1 NA  0  1  0 NA  0  1  2  0  2 NA
## [26]  1 NA  1  0 NA  0  0 NA  0  1 NA  0  0  0 NA  0  0  0  0  0 NA  0 NA  0  0
##
## $`8`
##  [1] NA NA NA  1  1  1 NA  2  1  2  0  0  0 NA  0 NA NA NA  0  2 NA  0  2  0 NA
## [26]  0 NA  0  1  1 NA  1 NA NA  0  1 NA  0 NA NA  0  0  0  0 NA NA  0  0 NA NA
##
## $`9`
##  [1] NA  2  2  2  2  2  2  1 NA  1  2  2 NA NA NA NA  1 NA NA NA  1 NA  0  2 NA
```

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

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```
## $`23`
##  [1]  2  2  2  2  2  2  2 NA  2  1  2 NA  2  1 NA  0  1  0 NA NA NA NA  0 NA NA
## [26] NA NA  1  0  0  0  0  1 NA  1  0  0  0 NA NA  0  0 NA NA  0  0  0  0 NA  0
##
## $`24`
##  [1]  2 NA  2 NA  1  1  1  2  1  2  0  0  0 NA  0  2 NA NA  0  2  1  0  2  0  0
## [26]  0  1  0  1  1  1 NA NA NA  0  1 NA  0  0 NA  0  0 NA  0 NA  0 NA  0 NA  0
##
## $`25`
##  [1]  2  2 NA  2 NA  2  2  1  2  1  2  2  2  1  2  0  1 NA  2  0 NA  2  0 NA NA
## [26] NA  0 NA  0  0  0  0  1  0 NA  0  0  0  0  0  0  0 NA  0  0 NA  0  0 NA NA  0
##
## $`26`
##  [1]  2  2 NA  1  1  1 NA  2 NA NA  0  0  0 NA  0  2  1  2  0  2 NA  0  2  0  0
## [26]  0  1  0  1  1  1  1  0  1 NA NA NA  0 NA  0  0 NA  0  0  0  0  0  0  0  0
##
## $`27`
##  [1]  2  2  2  2  2  2  2 NA  2  1  2  2 NA  1  2 NA NA NA NA  0 NA NA  0 NA NA
## [26]  1  0  1  0  0  0  0 NA  0 NA  0  0 NA NA NA  0  0  0 NA  0  0  0  0 NA  0
##
## $`28`
##  [1]  2 NA NA NA NA NA NA  2  1 NA  0  0  0  1  0 NA  1 NA  0 NA NA  0  2  0  0
## [26]  0 NA NA NA  1  1  1  0  1 NA NA NA  0 NA  0  0 NA  0  0  0  0  0  0  0  0
##
## $`29`
##  [1] NA NA NA  2 NA  2 NA  1  2  1 NA  2  2  1 NA  0 NA  0  2  0 NA  2 NA  2  2
## [26] NA  0  1  0  0  0  0  1  0  1  0  0 NA NA NA  0 NA NA  0  0 NA  0  0 NA  0
##
## $`30`
##  [1] NA  2  2  1  1  1  1  2  1  2  0  0  0  1  0 NA  1  2  0  2 NA  0 NA  0 NA
## [26] NA  1 NA  1  1  1 NA  0 NA  0  1  1  0  0  0  0  0  0  0  0  0  0 NA  0 NA
##
## $`31`
##  [1]  2 NA NA  2  2  2 NA NA NA  1  2  2  2  1  2 NA  1 NA NA  0  1 NA  0 NA NA
## [26]  1 NA  1  0 NA NA  0 NA NA  1  0  0  0  0  0  0  0 NA  0 NA  0  0 NA  0 NA
##
## $`32`
##  [1]  2  2  2 NA  1 NA  1  2 NA NA  0 NA  0 NA  0  2 NA  2  0  2  1 NA  2  0  0
## [26] NA  1  0  1  1 NA NA NA NA  0 NA  1  0 NA  0 NA  0  0  0  0  0  0  0  0  0
##
## $`33`
##  [1] NA NA  2 NA  2  2 NA NA  2  1  2  2  2 NA  2 NA  1 NA  2 NA  1 NA  0 NA NA
## [26]  1  0  1  0  0 NA  0  1  0 NA  0  0  0  0  0 NA  0  0 NA  0  0 NA  0  0  0
##
## $`34`
##  [1]  2  2 NA  1  1 NA  1  2 NA  2 NA  0  0  1  0  2 NA NA  0  2  1  0 NA  0 NA
## [26]  0  1  0 NA  1  1  1 NA NA NA NA NA  0  0  0  0  0  0  0  0  0  0  0  0 NA
##
## $`35`
##  [1] NA  2  2  2  2 NA NA NA NA  1  2  2  2  1  2  0  1 NA  2 NA  1  2 NA  2  2
## [26]  1  0 NA  0 NA  0  0  1 NA  1 NA  0 NA  0 NA NA  0  0  0 NA  0  0 NA  0  0
##
## $`36`
##  [1] NA  2  2  1 NA  1 NA NA  1  2 NA  0  0  1  0 NA  1 NA  0  2  1  0  2 NA  0
```

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

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

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

```
lapply(L,summary)
```

```
## $`1`
##       Min.    1st Qu.     Median       Mean    3rd Qu.       Max.       NA's
## 0.00000000 0.00000000 1.00000000 0.87878788 2.00000000 2.00000000         17
##
## $`2`
##       Min.    1st Qu.     Median       Mean    3rd Qu.       Max.       NA's
## 0.00000000 0.00000000 0.00000000 0.61111111 1.00000000 2.00000000         14
##
## $`3`
##       Min.    1st Qu.     Median       Mean    3rd Qu.       Max.       NA's
## 0.00000000 0.00000000 1.00000000 0.89189189 2.00000000 2.00000000         13
##
## $`4`
##       Min.    1st Qu.     Median       Mean    3rd Qu.       Max.       NA's
## 0.00000000 0.00000000 0.00000000 0.68421053 1.00000000 2.00000000         12
##
## $`5`
##       Min.    1st Qu.     Median       Mean    3rd Qu.       Max.       NA's
## 0.00000000 0.00000000 0.00000000 0.71052632 1.75000000 2.00000000         12
##
## $`6`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.     NA's
## 0.00000 0.00000 0.50000 0.65625 1.00000 2.00000       18
##
## $`7`
##       Min.    1st Qu.     Median       Mean    3rd Qu.       Max.       NA's
## 0.00000000 0.00000000 0.00000000 0.72222222 1.25000000 2.00000000         14
##
## $`8`
##       Min.    1st Qu.     Median       Mean    3rd Qu.       Max.       NA's
## 0.00000000 0.00000000 0.00000000 0.55172414 1.00000000 2.00000000         21
##
## $`9`
##       Min.    1st Qu.     Median       Mean    3rd Qu.       Max.       NA's
## 0.00000000 0.00000000 1.00000000 0.85714286 2.00000000 2.00000000         22
##
## $`10`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.     NA's
##  0.0000  0.0000  0.0000  0.5625  1.0000  2.0000       18
##
## $`11`
##       Min.    1st Qu.     Median       Mean    3rd Qu.       Max.       NA's
## 0.00000000 0.00000000 0.00000000 0.76666667 2.00000000 2.00000000         20
##
```

```
## $`12`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##  0.0000  0.0000  1.0000  0.6875  1.0000  2.0000      18
##
## $`13`
##       Min.    1st Qu.     Median       Mean    3rd Qu.       Max.      NA's
## 0.00000000 0.00000000 1.00000000 0.84210526 2.00000000 2.00000000        12
##
## $`14`
##       Min.    1st Qu.     Median       Mean    3rd Qu.       Max.      NA's
## 0.00000000 0.00000000 0.50000000 0.61764706 1.00000000 2.00000000        16
##
## $`15`
##       Min.    1st Qu.     Median       Mean    3rd Qu.       Max.      NA's
## 0.00000000 0.00000000 1.00000000 0.85714286 2.00000000 2.00000000        15
##
## $`16`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##  0.0000  0.0000  0.0000  0.5625  1.0000  2.0000      18
##
## $`17`
##       Min.    1st Qu.     Median       Mean    3rd Qu.       Max.      NA's
## 0.00000000 0.00000000 0.00000000 0.71428571 2.00000000 2.00000000        15
##
## $`18`
##       Min.    1st Qu.     Median       Mean    3rd Qu.       Max.      NA's
## 0.00000000 0.00000000 0.00000000 0.65714286 1.00000000 2.00000000        15
##
## $`19`
##       Min.    1st Qu.     Median       Mean    3rd Qu.       Max.      NA's
## 0.00000000 0.00000000 0.00000000 0.84615385 2.00000000 2.00000000        11
##
## $`20`
##      Min.   1st Qu.    Median      Mean   3rd Qu.      Max.      NA's
## 0.0000000 0.0000000 0.0000000 0.7027027 1.0000000 2.0000000        13
##
## $`21`
##       Min.    1st Qu.     Median       Mean    3rd Qu.       Max.      NA's
## 0.00000000 0.00000000 0.00000000 0.74358974 2.00000000 2.00000000        11
##
## $`22`
##       Min.    1st Qu.     Median       Mean    3rd Qu.       Max.      NA's
## 0.00000000 0.00000000 1.00000000 0.75757576 1.00000000 2.00000000        17
##
## $`23`
##       Min.    1st Qu.     Median       Mean    3rd Qu.       Max.      NA's
## 0.00000000 0.00000000 0.00000000 0.78787879 2.00000000 2.00000000        17
##
## $`24`
##       Min.    1st Qu.     Median       Mean    3rd Qu.       Max.      NA's
## 0.00000000 0.00000000 0.00000000 0.66666667 1.00000000 2.00000000        14
##
## $`25`
##       Min.    1st Qu.     Median       Mean    3rd Qu.       Max.      NA's
```

```
## 0.00000000 0.00000000 0.00000000 0.78378378 2.00000000 2.00000000         13
##
## $`26`
##        Min.    1st Qu.     Median       Mean    3rd Qu.       Max.      NA's
## 0.00000000 0.00000000 0.00000000 0.61538462 1.00000000 2.00000000         11
##
## $`27`
##        Min.    1st Qu.     Median       Mean    3rd Qu.       Max.      NA's
## 0.00000000 0.00000000 0.00000000 0.78787879 2.00000000 2.00000000         17
##
## $`28`
##        Min.    1st Qu.     Median       Mean    3rd Qu.       Max.      NA's
## 0.00000000 0.00000000 0.00000000 0.41935484 1.00000000 2.00000000         19
##
## $`29`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##    0.00    0.00    0.00    0.75    2.00    2.00      18
##
## $`30`
##        Min.    1st Qu.     Median       Mean    3rd Qu.       Max.      NA's
## 0.00000000 0.00000000 0.00000000 0.64102564 1.00000000 2.00000000         11
##
## $`31`
##        Min.    1st Qu.     Median       Mean    3rd Qu.       Max.      NA's
## 0.00000000 0.00000000 0.50000000 0.76666667 1.75000000 2.00000000         20
##
## $`32`
##        Min.    1st Qu.     Median       Mean    3rd Qu.       Max.      NA's
## 0.00000000 0.00000000 0.00000000 0.67647059 1.00000000 2.00000000         16
##
## $`33`
##        Min.    1st Qu.     Median       Mean    3rd Qu.       Max.      NA's
## 0.00000000 0.00000000 0.00000000 0.72727273 2.00000000 2.00000000         17
##
## $`34`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##     0.0     0.0     0.0     0.6     1.0     2.0      15
##
## $`35`
##        Min.    1st Qu.     Median       Mean    3rd Qu.       Max.      NA's
## 0.00000000 0.00000000 1.00000000 0.93939394 2.00000000 2.00000000         17
##
## $`36`
##        Min.    1st Qu.     Median       Mean    3rd Qu.       Max.      NA's
## 0.00000000 0.00000000 1.00000000 0.73076923 1.00000000 2.00000000         24
##
## $`37`
##        Min.    1st Qu.     Median       Mean    3rd Qu.       Max.      NA's
## 0.00000000 0.00000000 1.00000000 0.86111111 2.00000000 2.00000000         14
##
## $`38`
##        Min.    1st Qu.     Median       Mean    3rd Qu.       Max.      NA's
## 0.00000000 0.00000000 0.00000000 0.56756757 1.00000000 2.00000000         13
##
```

```
## $`39`
##        Min.    1st Qu.     Median       Mean    3rd Qu.       Max.       NA's
## 0.00000000 0.00000000 0.00000000 0.75757576 2.00000000 2.00000000         17
##
## $`40`
##        Min.    1st Qu.     Median       Mean    3rd Qu.       Max.       NA's
## 0.00000000 0.00000000 1.00000000 0.71052632 1.00000000 2.00000000         12
##
## $`41`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##     0.0     0.0     0.0     0.8     2.0     2.0      10
##
## $`42`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##     0.0     0.0     1.0     0.7     1.0     2.0      20
##
## $`43`
##        Min.    1st Qu.     Median       Mean    3rd Qu.       Max.       NA's
## 0.00000000 0.00000000 0.00000000 0.80952381 2.00000000 2.00000000          8
##
## $`44`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##     0.0     0.0     0.0     0.7     1.0     2.0      20
##
## $`45`
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##   0.000   0.000   1.000   0.875   2.000   2.000      10
##
## $`46`
##        Min.    1st Qu.     Median       Mean    3rd Qu.       Max.       NA's
## 0.00000000 0.00000000 1.00000000 0.71052632 1.00000000 2.00000000         12
##
## $`47`
##        Min.    1st Qu.     Median       Mean    3rd Qu.       Max.       NA's
## 0.00000000 0.00000000 0.50000000 0.80952381 2.00000000 2.00000000          8
##
## $`48`
##        Min.    1st Qu.     Median       Mean    3rd Qu.       Max.       NA's
## 0.00000000 0.00000000 1.00000000 0.74285714 1.00000000 2.00000000         15
##
## $`49`
##        Min.    1st Qu.     Median       Mean    3rd Qu.       Max.       NA's
## 0.00000000 0.00000000 0.00000000 0.79487179 2.00000000 2.00000000         11
##
## $`50`
##        Min.    1st Qu.     Median       Mean    3rd Qu.       Max.       NA's
## 0.00000000 0.00000000 1.00000000 0.75609756 1.00000000 2.00000000          9
```

- 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(1984)
v=rnorm(1000, mean=-10, sd=10)
v
```

```
##     [1]  -5.907967837848 -13.230249711542  -3.641476728099 -28.461287840183
##     [5]  -0.463526345932   1.884898434527  -4.575455508365 -18.327254297791
##     [9] -15.262078844968   4.159827577661  -7.179889961089  -7.120662839077
##    [13]  -1.629517497472   0.239344591583  -9.822549038531   7.239940163302
##    [17]  -8.792581946274 -27.755604888401  -8.738544713872 -27.137578805260
##    [21]   2.419565681512  -5.702593853895 -16.486159297728  -0.966060191427
##    [25] -10.132181397739  -7.524822819274  -9.082818499712  -1.777153515054
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## [833]  -13.253337044886 -10.657245124878 -17.430851815142 -18.857815794514
## [837]   -1.570414913321 -22.983821329745  -1.828951836073  -7.409274592819
## [841]  -22.243251475791  -8.385006744564 -18.546972774969 -13.640683500843
## [845]  -12.208594516976 -13.786681397402 -14.797433816646  -3.692713570951
## [849]   -5.757700853492  -7.624217656462 -17.866840232006 -32.338761142262
## [853]   -1.699971459628   4.274093673272 -12.943019145814  -5.346004927162
## [857]    0.576473737031 -11.926587523145  -8.020020948113  -3.804940400593
## [861]    7.418474128932  -6.881962690596   1.462574291375 -26.377141719257
```

```
## [865]  -9.439039554436 -31.432286114822   9.296192256955  -7.278129105980
## [869] -17.108840045471  -4.173688842575  16.832244966630 -14.170754881253
## [873] -13.076863414513 -14.471540416624 -16.397904276812  -0.594558700914
## [877]   0.655111536204  -4.124118076765 -23.993803075941 -11.934902243331
## [881] -24.043704609620   4.929232838767  -4.974201447739  -4.396818561231
## [885]   2.583795483214  -5.854809802245  -8.515997485576  -0.632613656023
## [889]  -1.810246577249  -0.840016362101 -21.542492459438   1.406589479366
## [893] -15.062480221766  -5.288125629505   4.518471778389  -1.627866678623
## [897]   7.824685988660  -3.379611518472   4.328321561186  -6.991724341270
## [901]  15.604521456049 -15.998362421540   6.759240162884 -11.091065339937
## [905] -14.503382238486  -8.062595302692  -4.680961288146 -19.648129307928
## [909]  -5.133941747158 -27.271084932827  -8.189517366368 -13.783325527097
## [913]   0.775835008295 -24.924236717901   4.823427817493  -8.277910139633
## [917] -18.432308414271 -15.496054534321 -10.492922671606 -26.661529285528
## [921]  -6.371823984003 -11.551026691417   0.166512808679  -1.478373083754
## [925] -19.195115577427  -2.508490616413 -21.266954368021  -7.326771716285
## [929] -15.546732144415 -13.253557701186  -9.019487664448  -2.261330442106
## [933]  -0.256667769085  -1.810942994580 -18.229719923919  15.067205185317
## [937] -14.137841420159   4.916043498359  -8.536090458718 -20.557742188117
## [941] -12.616347254563 -21.263577347676 -26.561000566661 -16.434811095816
## [945] -12.116937160783 -17.708349873144  -9.529553483022  -3.519242270986
## [949]  -2.785983145909  -9.652226706081   4.256032373663 -10.079037741626
## [953] -20.881090388130  -9.520827512512  -2.909114042759  -3.545075397819
## [957]  -8.112496881723 -25.065071197945 -11.227639418990  -3.084041925953
## [961]  -4.089651133319 -21.802231017585 -26.619907286451  -4.541318223911
## [965]   6.946753383932 -12.107801572086 -11.513590454149 -28.367633799160
## [969]  -5.819835243973 -22.120006238393  -8.064739337816  -6.853646958583
## [973] -30.536354845714  -4.741093905914  -4.138380817021 -27.545721102617
## [977]  12.581803528468   0.408654403883 -11.179603552132 -19.761283307194
## [981]  -4.459718417565   8.332551147257  -8.560509630305  -0.972337434717
## [985]   5.609664333370  -2.752444433041  -4.046963301637 -31.109777308833
## [989] -23.120062908659 -24.351341934072  -1.765302502889  -0.217312241380
## [993]  -4.577909083109   3.489837076073  -7.861940827184 -11.654735703889
## [997] -32.307206322589 -10.891012634756  -8.758025142259 -20.952176209139
```

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

```
set.seed(1984)
rnorm(1000, mean=-10, sd=10)
```

```
##    [1]  -5.907967837848 -13.230249711542  -3.641476728099 -28.461287840183
##    [5]  -0.463526345932   1.884898434527  -4.575455508365 -18.327254297791
##    [9] -15.262078844968   4.159827577661  -7.179889961089  -7.120662839077
##   [13]  -1.629517497472   0.239344591583  -9.822549038531   7.239940163302
##   [17]  -8.792581946274 -27.755604888401  -8.738544713872 -27.137578805260
##   [21]   2.419565681512  -5.702593853895 -16.486159297728  -0.966060191427
##   [25] -10.132181397739  -7.524822819274  -9.082818499712  -1.777153515054
##   [29] -15.863086046754   0.079884895602 -21.075868894090 -24.704241772855
##   [33]  -3.941626535813  -0.437010718166  -7.023340366897 -18.540283563095
##   [37]  15.043537483732 -12.885110625623 -13.414171677182  -7.566944854592
##   [41]  -9.505236602083  -1.990133477413 -11.096117546406 -23.391921634916
##   [45]   2.413408685243   1.844163655127 -14.567750979295   1.488720466005
##   [49] -16.665213892812   1.086566888100   2.433551595888 -16.300208079582
##   [53] -19.742576234419 -21.768072753930 -13.802778431831 -25.658038024179
##   [57] -16.482595589272 -18.241688010551 -16.894619981025 -10.165760888876
```

```
##     [61] -17.373002462482  -3.464473713071   6.659049799653 -13.321305243734
##     [65]   6.165060618426 -12.827467143342 -15.400284670377 -16.295196830202
##     [69]  -8.858491637950  -1.004302660494 -15.083693956850 -20.749370120806
##     [73]  -7.001793876345 -15.521919477345 -14.212968950599 -12.698072164255
##     [77]  -5.049670733834 -13.885928724155 -17.649676612805 -14.862037282777
##     [81]  -8.049045745867  -4.382631482206 -14.567309558063 -24.493760197247
##     [85]  -8.410937198140   1.713361217610 -14.720721343185 -18.831191856760
##     [89]  12.241012961202 -11.088447670934 -10.780651567418 -15.831032592703
##     [93] -28.406454759483   1.695408930296   2.435150380876  -2.631564364475
##     [97] -14.358805528767 -17.592505011760   4.049569284674 -23.172188266200
##    [101]  -7.879751588063 -21.319399604980  -5.253177064529 -17.270474137982
##    [105]  13.227819475928 -16.292793210798 -21.821565209665 -10.108592633176
##    [109] -15.445859335521 -11.220809642277 -22.579709047418  -4.192769747001
##    [113] -13.520318820538  -6.113335687084 -11.557133250441 -18.800990882444
##    [117] -25.304083452334 -13.589279914083   2.429299728249   0.570734650090
##    [121] -11.000496522589 -23.389355173269  -0.483385834283 -18.244146028459
##    [125] -10.164068610706  -0.440215338231  -1.615417652724 -16.582196348099
##    [129] -12.942885941587 -12.285283135299 -17.394519397224 -21.285678626194
##    [133] -10.143975759934  -0.393138709567  -8.959825919445   9.287073372188
##    [137] -11.980988389462 -27.661027280500 -19.093465856646  -1.123038674641
##    [141]  -3.112646264292 -26.673999255343 -19.344306610818  -8.777229397747
##    [145] -15.051440042064  -4.423859629458 -11.564024080641  -5.163291482224
##    [149] -36.418631696018   6.854775777339 -15.990068769031  -0.910574549707
##    [153]  -1.688020714881  -1.476077303500 -20.906549236909 -14.191691955532
##    [157] -16.896340546112  -1.401676233388  -7.201499375011 -19.259043541469
##    [161] -10.997795405381 -10.713773019271  -7.464686074121 -12.212801514453
##    [165] -12.388043119996 -13.064274160836 -12.874575170328 -31.105916505358
##    [169] -14.203826790807  -9.539991533779 -10.894715446609 -10.820980389922
##    [173]  -7.304629514025 -35.769294802098   0.752112928745   3.726943647744
##    [177] -21.881178852076   9.188975131770 -16.657397669512 -10.813516107026
##    [181]  -8.103999052844 -20.800994917407  -4.210874478890  -2.117733035486
##    [185] -18.909043715714  -8.615838471917 -21.923244363360 -10.936292659635
##    [189]  -4.603019466692  -3.172761926535 -11.732138682117 -17.490394782113
##    [193] -23.732475277553   1.426375676840   1.008098510431  -7.064687878542
##    [197]   4.748953178030 -13.019355856452  -1.285150417710  -1.963289931885
##    [201] -12.481528001114  -8.656481870154 -16.870429133637 -16.927508118387
##    [205] -12.848990628530  -7.195425835717 -17.449784307604 -21.399208107464
##    [209] -21.100783063785 -19.499084208761  -8.042964192706 -11.296324270516
##    [213]  10.463493457482 -22.947859415248 -19.316140097778  -1.226497233014
##    [217] -10.506181574521 -20.733794220824  -8.699243250622 -12.071578583631
##    [221] -10.032840378538 -18.552060616865 -16.269728934031 -20.409276351113
##    [225]   0.303448901382 -14.281653835455  17.323465736565 -20.921447288450
##    [229]  -3.515407274625 -20.409512570056 -15.280293165995 -12.720127823532
##    [233] -15.827845910575 -18.264471427469  -0.657805250830 -18.662170035406
##    [237]  -8.798509639946 -36.117488827543 -21.476608683333 -16.469819284430
##    [241] -14.175947498281   4.355943448218  -1.416029803095 -11.075370039267
##    [245]  -2.665790934636  -0.535948556907 -17.881662275682   7.820248935160
##    [249] -22.436815366911 -24.258688546876  16.130540363414 -14.136750884748
##    [253]  -2.715420499469   0.496226416136  -0.808340055030 -16.315756160382
##    [257] -12.673371205995  -9.937855279209 -14.273729499485  -5.073282031037
##    [261] -11.522713054223   0.876445073960 -10.519955278107  -6.731176388956
##    [265] -10.769451555755  -4.637561693192   0.028611698593  -2.694812662126
##    [269] -15.739656750104 -20.506762485241  -7.351332141586 -36.452300687178
##    [273] -13.837302669591 -27.947268623835   0.108822407068  -5.739633467294
```

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```
## [277]  -3.871617773590   1.885998355699 -16.522282041095 -21.775160138229
## [281]  -0.060037225553 -18.912748287671   2.765917537768 -20.981307373965
## [285] -16.680454737034 -13.273650030875 -23.393934493673 -25.793503654633
## [289]  -0.190753384703  -5.154931274367 -19.460353814415 -11.785024137145
## [293] -20.979996826494 -20.838989883113  -3.165014417318 -14.839167888403
## [297] -11.317729496136  -5.332116376795 -12.188243769223 -13.967688057996
## [301]  -9.295509521372 -15.052289167383  -9.360786531757  -4.192678742600
## [305]  -8.348648468926 -31.301770697135 -29.329902619032   5.544880344353
## [309]  -9.871539886944  -3.905640963104  -7.287178884539 -21.995362586758
## [313]  -0.080470852660 -16.666840477431  -4.669569201240   0.370911173633
## [317] -10.653258367436   4.671293101751 -12.353629140039  13.553788203311
## [321]   3.806083401774 -13.585889447945   3.222199058553   2.508451264930
## [325] -19.950984243812 -21.378209578435 -13.850683195657  -3.631332870780
## [329] -17.035650587295 -18.230616826056  -7.533150641651 -11.823589111847
## [333] -13.243559595414 -11.320464629371 -14.143129106299 -10.195474234454
## [337]  -6.511340343784  -8.912760383219  -0.414650025364 -10.501162155552
## [341] -23.652234829064  -5.959653434834 -17.352375249251 -24.111516551579
## [345]  -2.424698423065   1.975708313105 -21.362344389827 -25.516506747560
## [349] -11.377548628837 -15.390354626410 -31.137015785045  -1.160938203500
## [353] -19.377985710845 -18.287923989528 -13.705556890629 -11.375601091558
## [357]   4.875659387303   2.864997746061 -32.012858809437  -2.638440038843
## [361]  -8.478000242231  -5.405785712991 -16.892520789861  -6.936036269504
## [365]  -7.447241593357  -9.721933037352 -11.885865658399 -16.537068104134
## [369] -17.627134733980  -3.062658730968  -6.002217115931 -12.023507306357
## [373] -12.327543803221   6.119626314299  -4.983114962191 -14.399007658295
## [377]  -4.013288360791  -1.883170272478 -15.102679547797 -11.050272170434
## [381] -14.363243147620  -4.464214043029  -2.629156535275  14.502319261124
## [385] -31.321871328736  -3.539593168041 -20.894417832653  -9.450165991637
## [389]  -1.225885888899  -7.415846090362  -1.649700469415   4.350227400892
## [393]  -5.010632080886 -23.800476936127  -6.817542711522 -31.502239765334
## [397] -11.047175613040  -6.622695881386  11.237629339891 -18.703758956861
## [401]  -2.205454783091 -21.321996562884 -25.855691241136  -7.921666743598
## [405]  -9.143811026381  -8.218372648966  -8.584126343044  14.681311922425
## [409] -14.993470906826   6.616838199881 -27.343482016719 -21.682895202473
## [413] -10.565585010288  -5.685463546366  -2.770541513744  -8.350238346628
## [417] -11.826576647438 -18.722973104199  -7.933471222281 -14.927235102510
## [421] -18.270578602393  -5.215961524815 -15.571616732356 -15.596811966398
## [425]  -6.194221617798 -10.070238604443   2.315382744595  -8.067810855508
## [429] -14.267075260544  -6.526527147017 -11.047580651524  -3.137368110646
## [433] -18.245750888746 -30.552057037150 -23.814183527912  -8.582758008547
## [437]   4.356459050377  -4.446465740489   5.819946746543  -6.129245841334
## [441]   5.407106555049 -10.660886944598 -17.114772583616  -4.021091979941
## [445] -13.869595237718  -4.830242261184  -7.895332493730 -10.872138296623
## [449] -10.026750600324  -3.994633739237  -7.696606542032 -15.440426028858
## [453]  -3.079332558114   6.259108187631 -19.114264576306   3.627537230302
## [457]  -7.127879370304   3.524074837024 -12.540985685399   4.208205881425
## [461] -28.781815973298 -12.671541013176  -5.332865574341 -17.230031395726
## [465] -24.680622731835 -14.578427505458   8.718366880519 -10.153025011819
## [469] -29.964890731059 -19.235425621797 -11.828824474634 -15.474793038822
## [473]  -9.158717453615 -29.208401503265 -21.952455298257 -13.826007452325
## [477] -17.019785250090 -10.129245105693   1.733863802217 -14.617985522934
## [481]   0.235367029154   6.450253937556 -13.014461819738   1.448217192583
## [485]  -3.192832405117 -13.134230654378 -15.597797706019 -12.829081378583
## [489]  -6.266122903782 -11.875599885965 -14.232942706784  -1.292969758640
```

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```
##    [493] -24.294342296176  -7.076236318416 -10.358180764982   0.139955520932
##    [497] -14.379240242927   0.322065338253   5.711308388404  12.256920288776
##    [501] -14.555500962659 -19.493648190935 -11.719753718798  -2.162891902173
##    [505]   3.976371252068 -26.579439344259 -15.331719279167 -11.990722368401
##    [509] -10.949414902123  -9.725280111563 -18.462022709099 -14.468065135914
##    [513] -11.920356634368 -21.084374805564   1.060806517513  -5.479358644945
##    [517] -12.353273309171 -22.338954349380 -25.119591964887 -34.624231785273
##    [521]  -6.569891829041   2.050389156138  -6.800072080707  -5.293094198328
##    [525]   4.383736120283 -11.270635721473 -10.545392846413 -17.473493128655
##    [529]   1.015595896583 -14.091697948425 -16.760754276234  -6.734904221588
##    [533] -15.490309351448 -17.228813280232  -0.079881218364  -8.923050153828
##    [537] -13.091375380636 -14.199899562882 -36.249558330412 -10.395774633912
##    [541] -13.470102605547 -24.291421578637 -17.094404273500  -8.263239754959
##    [545]  11.234068036702   2.610133414323 -19.046521659644   1.832498929591
##    [549] -10.921069394892   0.034455297857  -1.398068451037  -1.813306366622
##    [553] -24.221095233032 -17.644869052896  -4.644207116310 -10.034738354643
##    [557]   7.086038673258  -4.081394812980  -6.519796607461 -18.082339206840
##    [561] -14.545156559797  -6.070639784849 -34.983499401790  -8.776979782170
##    [565]  -7.965457546340 -32.361264555459 -15.150271005176 -19.148165100135
##    [569]  -5.779021112018  -5.931963334840  -6.365195393789   8.273378322711
##    [573]  -4.546625860587 -14.816368355185 -25.905741019258 -22.965478299249
##    [577]  18.075192110328  -5.920883762827 -15.894704145439 -11.200164333395
##    [581]  -1.405939184275 -13.697798386752 -13.119126033441 -11.379516451225
##    [585] -37.074451556222 -15.496907641250 -19.618370148513 -16.792911439902
##    [589]  -4.866461852037 -24.853940997907 -29.725135036892  -7.654416730168
##    [593] -16.295932239993  20.151469209636 -13.322685042422   6.940742013021
##    [597] -25.663733794587  -6.757755029319 -18.516812361399 -23.623185620267
##    [601]  -6.383344922303  -7.390285924840 -16.285803434962 -28.088962329960
##    [605] -10.495421649439  -5.502488207977 -15.033282742532  -8.910278058209
##    [609]   0.512003394753 -16.818292548619  -3.691836865301 -12.030644366977
##    [613] -18.418463286127  -3.801052817304  13.089558143522  -4.668255127423
##    [617] -18.844273991635  -6.470488648822  -8.467944989510  -3.664951564133
##    [621] -18.220547763016   0.357650322319 -26.434044453216  10.407809854215
##    [625] -10.788900099189 -23.033313441574 -15.033017754166  -2.880816350591
##    [629] -15.171146029940 -12.282494835785 -28.808009935254 -12.395999748514
##    [633]  -9.224246164120 -20.917442488056 -24.847987655300 -23.309909298221
##    [637] -20.636053579667   1.016725286760 -11.294704311803 -12.297229114023
##    [641]  -1.522031002062 -27.635161919387  -9.518945542057 -12.934459282048
##    [645]   0.505594760025 -12.193711036033  -8.280145619826 -21.808004721312
##    [649] -24.605469088986 -20.909805074367 -20.138092598866   3.246804042723
##    [653] -14.438000510211   1.217300386578 -30.664473120921   1.355879211553
##    [657] -28.664927449892 -22.500020744172 -20.361828823428 -10.095650478695
##    [661] -12.988514056496  -0.353703243674  -8.070403580153   3.251492573138
##    [665] -19.534374398250   7.014937713478 -11.524073469346 -24.799447757933
##    [669]  -8.527391442382 -26.791814522303 -13.303570721329  -7.059140197667
##    [673] -11.811353827334 -10.952040013190  10.270309057244  -3.283895463910
##    [677]  -6.670895772173  -8.271726884733  -1.625013805320  -3.083814034457
##    [681]  -7.689302588421  -7.667548822962  -6.939165371016  -5.646697276032
##    [685] -22.264596145893 -18.435448077518 -18.648650770261 -20.241192118467
##    [689] -21.027317571116  -2.736500183287 -12.850014512323 -24.077704497454
##    [693] -23.600655806012  -1.378681680281   1.925360185559   6.037197863199
##    [697] -12.131744796222 -20.632275908633  -9.320793585273 -13.211972497069
##    [701]  -1.381834095610 -23.306193759365 -10.037345196936 -23.852224526905
##    [705] -12.810797570694  -7.704551155983 -17.643989538282  -7.912312788601
```

```
## [709]   10.130711932976  -5.182476894938   3.990215952453   1.257358979452
## [713]   -7.744757196009  -7.453386074161  -6.912886264416  -1.747859909154
## [717]  -15.387032084497 -18.856485158014 -14.284205646933 -17.630527150499
## [721]   -5.973156455445 -19.293096170008 -21.561668320724 -16.469840463653
## [725]   -2.645310225514 -11.630181068026 -13.269773029785 -22.066786820106
## [729]  -23.535718246327 -22.921831868020 -22.460731450019  -9.194097583731
## [733]  -24.961788728513  -9.160624244011   8.767533033464 -15.289125031823
## [737]  -17.833353647457 -10.189036160689 -23.011310935238 -13.742595430912
## [741]  -14.596774871344 -12.498919911353 -11.795642145879 -21.971668253703
## [745]  -10.755296998140 -22.692931568827 -24.491900663328   1.358602220525
## [749]  -11.886169259088  -9.840675198682 -13.002490755053  10.196817306848
## [753]  -16.770163023441  10.520596183913 -32.888934358354  -3.836071446515
## [757]   -2.825594924180   5.222152700027 -30.476401194871 -17.761650209474
## [761]    1.163287296688 -13.245602348485  -6.816767463464  -4.053374520024
## [765]  -20.841630693010  -8.454074401458 -22.592800248113 -17.868129362409
## [769]   -4.870512278589 -11.646716408076  -1.882013894074  -5.216040446776
## [773]  -24.724692654231  -8.081347295116   0.075142601202  -2.595774573009
## [777]   -3.956522552684   2.836004511918 -15.427987440477 -16.728096137994
## [781]  -16.235706216531 -13.400996555262 -17.027197218526  -5.626307081955
## [785]  -21.279992876218   6.175452799584  -2.034637399608  -0.987570319110
## [789]  -30.721000707981   2.411869495672  -3.255317539253 -12.735896100006
## [793]  -13.574793779872 -20.136239520409 -16.115411018193   2.383242199250
## [797]   -8.668264007508 -19.835627640429 -31.042141504609 -23.373248228689
## [801]  -18.674176331499 -11.818848083992 -12.138470145355   0.965961017079
## [805]   -6.103533758463 -21.382939602587 -17.105425766300 -17.865370376538
## [809]  -11.214421288463  -5.486979570914  -2.890127739091 -27.683528121239
## [813]  -20.300215423144 -17.682174924247 -23.603745463959  -3.118999025381
## [817]    6.992072305571  -9.220136340306 -12.662861162528   4.504170047680
## [821]   -6.591060975043  -6.766576256497 -23.246911356221   1.195313668134
## [825]  -13.267236620648   3.805167481101   1.866820447964 -17.146761752978
## [829]  -14.716643083454 -20.587686508747  -5.862627404996  -3.357646076817
## [833]  -13.253337044886 -10.657245124878 -17.430851815142 -18.857815794514
## [837]   -1.570414913321 -22.983821329745  -1.828951836073  -7.409274592819
## [841]  -22.243251475791  -8.385006744564 -18.546972774969 -13.640683500843
## [845]  -12.208594516976 -13.786681397402 -14.797433816646  -3.692713570951
## [849]   -5.757700853492  -7.624217656462 -17.866840232006 -32.338761142262
## [853]   -1.699971459628   4.274093673272 -12.943019145814  -5.346004927162
## [857]    0.576473737031 -11.926587523145  -8.020020948113  -3.804940400593
## [861]    7.418474128932  -6.881962690596   1.462574291375 -26.377141719257
## [865]   -9.439039554436 -31.432286114822   9.296192256955  -7.278129105980
## [869]  -17.108840045471  -4.173688842575  16.832244966630 -14.170754881253
## [873]  -13.076863414513 -14.471540416624 -16.397904276812  -0.594558700914
## [877]    0.655111536204  -4.124118076765 -23.993803075941 -11.934902243331
## [881]  -24.043704609620   4.929232838767  -4.974201447739  -4.396818561231
## [885]    2.583795483214  -5.854809802245  -8.515997485576  -0.632613656023
## [889]   -1.810246577249  -0.840016362101 -21.542492459438   1.406589479366
## [893]  -15.062480221766  -5.288125629505   4.518471778389  -1.627866678623
## [897]    7.824685988660  -3.379611518472   4.328321561186  -6.991724341270
## [901]   15.604521456049 -15.998362421540   6.759240162884 -11.091065339937
## [905]  -14.503382238486  -8.062595302692  -4.680961288146 -19.648129307928
## [909]   -5.133941747158 -27.271084932827  -8.189517366368 -13.783325527097
## [913]    0.775835008295 -24.924236717901   4.823427817493  -8.277910139633
## [917]  -18.432308414271 -15.496054534321 -10.492922671606 -26.661529285528
## [921]   -6.371823984003 -11.551026691417   0.166512808679  -1.478373083754
```

```
## [925] -19.195115577427  -2.508490616413 -21.266954368021  -7.326771716285
## [929] -15.546732144415 -13.253557701186  -9.019487664448  -2.261330442106
## [933]  -0.256667769085  -1.810942994580 -18.229719923919  15.067205185317
## [937] -14.137841420159   4.916043498359  -8.536090458718 -20.557742188117
## [941] -12.616347254563 -21.263577347676 -26.561000566661 -16.434811095816
## [945] -12.116937160783 -17.708349873144  -9.529553483022  -3.519242270986
## [949]  -2.785983145909  -9.652226706081   4.256032373663 -10.079037741626
## [953] -20.881090388130  -9.520827512512  -2.909114042759  -3.545075397819
## [957]  -8.112496881723 -25.065071197945 -11.227639418990  -3.084041925953
## [961]  -4.089651133319 -21.802231017585 -26.619907286451  -4.541318223911
## [965]   6.946753383932 -12.107801572086 -11.513590454149 -28.367633799160
## [969]  -5.819835243973 -22.120006238393  -8.064739337816  -6.853646958583
## [973] -30.536354845714  -4.741093905914  -4.138380817021 -27.545721102617
## [977]  12.581803528468   0.408654403883 -11.179603552132 -19.761283307194
## [981]  -4.459718417565   8.332551147257  -8.560509630305  -0.972337434717
## [985]   5.609664333370  -2.752444433041  -4.046963301637 -31.109777308833
## [989] -23.120062908659 -24.351341934072  -1.765302502889  -0.217312241380
## [993]  -4.577909083109   3.489837076073  -7.861940827184 -11.654735703889
## [997] -32.307206322589 -10.891012634756  -8.758025142259 -20.952176209139
```

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

```
mean(v)
```

```
## [1] -10.403337321
```

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

```
## [1] 0.31315004412
```

*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?

```
quantile(v,prob=0.05)
```

```
##             5%
## -26.581462741
```

```
qnorm(.05,mean=-10,sd=10)
```

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

*The estimate and what is expected are very similar.

- 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?

```
inverse_quantile=ecdf(v)
inverse_quantile(0)
```

```
## [1] 0.85
```

```
quantile(v,prob=.85)
```

```
##            85%
## -0.046739886931
```

*Theoretically it should be 85%. The estimate and what is expected are very similar to one another.