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 $1 + 1/2 + 1/4 + 1/8 + \ldots$

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

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

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

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

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

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

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

- 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] 0.914
```

- 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] 0.885
```

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

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

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

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

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

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

```
##    [1] infraction  infraction  felony      felony      infraction  none
##    [7] none        misdimeanor felony      felony      infraction  none
##   [13] infraction  infraction  misdimeanor infraction  infraction  misdimeanor
##   [19] misdimeanor infraction  misdimeanor infraction  misdimeanor misdimeanor
##   [25] none        felony      felony      none        none        misdimeanor
##   [31] infraction  felony      felony      infraction  felony      none
##   [37] misdimeanor misdimeanor none        none        misdimeanor none
##   [43] misdimeanor misdimeanor felony      misdimeanor felony      none
##   [49] infraction  infraction  infraction  misdimeanor infraction  felony
##   [55] infraction  misdimeanor felony      felony      felony      infraction
##   [61] infraction  none        misdimeanor infraction  none        misdimeanor
##   [67] infraction  misdimeanor none        none        misdimeanor infraction
##   [73] none        infraction  felony      infraction  none        misdimeanor
##   [79] misdimeanor misdimeanor felony      misdimeanor felony      infraction
##   [85] misdimeanor misdimeanor infraction  felony      felony      felony
##   [91] misdimeanor felony      misdimeanor infraction  felony      felony
##   [97] none        felony      misdimeanor 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,]   TRUE  TRUE FALSE FALSE  TRUE FALSE FALSE FALSE FALSE FALSE  TRUE FALSE
## [2,]  FALSE FALSE FALSE FALSE FALSE FALSE FALSE  TRUE FALSE FALSE FALSE FALSE
## [3,]  FALSE FALSE  TRUE  TRUE FALSE FALSE FALSE FALSE  TRUE  TRUE FALSE FALSE
##        [,13] [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24]
## [1,]   TRUE  TRUE FALSE  TRUE  TRUE FALSE FALSE  TRUE FALSE  TRUE FALSE FALSE
## [2,]  FALSE FALSE  TRUE FALSE FALSE  TRUE  TRUE FALSE  TRUE FALSE  TRUE  TRUE
## [3,]  FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##        [,25] [,26] [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34] [,35] [,36]
## [1,]  FALSE FALSE FALSE FALSE FALSE FALSE  TRUE FALSE FALSE  TRUE FALSE FALSE
## [2,]  FALSE FALSE FALSE FALSE FALSE  TRUE FALSE FALSE FALSE FALSE FALSE FALSE
## [3,]  FALSE  TRUE  TRUE FALSE FALSE FALSE FALSE  TRUE  TRUE FALSE  TRUE FALSE
##        [,37] [,38] [,39] [,40] [,41] [,42] [,43] [,44] [,45] [,46] [,47] [,48]
## [1,]  FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
## [2,]   TRUE  TRUE FALSE FALSE  TRUE FALSE  TRUE  TRUE FALSE  TRUE FALSE FALSE
## [3,]  FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE  TRUE FALSE  TRUE FALSE
##        [,49] [,50] [,51] [,52] [,53] [,54] [,55] [,56] [,57] [,58] [,59] [,60]
## [1,]   TRUE  TRUE  TRUE FALSE  TRUE FALSE  TRUE FALSE FALSE FALSE FALSE  TRUE
## [2,]  FALSE FALSE FALSE  TRUE FALSE FALSE FALSE  TRUE FALSE FALSE FALSE FALSE
## [3,]  FALSE FALSE FALSE FALSE FALSE  TRUE FALSE FALSE  TRUE  TRUE  TRUE FALSE
##        [,61] [,62] [,63] [,64] [,65] [,66] [,67] [,68] [,69] [,70] [,71] [,72]
## [1,]   TRUE FALSE FALSE  TRUE FALSE FALSE  TRUE FALSE FALSE FALSE FALSE  TRUE
## [2,]  FALSE FALSE  TRUE FALSE FALSE  TRUE FALSE  TRUE FALSE FALSE  TRUE FALSE
## [3,]  FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##        [,73] [,74] [,75] [,76] [,77] [,78] [,79] [,80] [,81] [,82] [,83] [,84]
## [1,]  FALSE  TRUE FALSE  TRUE FALSE FALSE  TRUE FALSE FALSE FALSE FALSE  TRUE
## [2,]  FALSE FALSE FALSE FALSE FALSE  TRUE  TRUE  TRUE FALSE  TRUE FALSE FALSE
## [3,]  FALSE FALSE  TRUE FALSE FALSE FALSE FALSE FALSE  TRUE FALSE  TRUE FALSE
##        [,85] [,86] [,87] [,88] [,89] [,90] [,91] [,92] [,93] [,94] [,95] [,96]
## [1,]  FALSE FALSE  TRUE FALSE FALSE FALSE FALSE FALSE FALSE  TRUE FALSE FALSE
## [2,]   TRUE  TRUE FALSE FALSE FALSE FALSE  TRUE FALSE  TRUE FALSE FALSE FALSE
## [3,]  FALSE FALSE FALSE  TRUE  TRUE  TRUE FALSE  TRUE FALSE FALSE  TRUE  TRUE
##        [,97] [,98] [,99] [,100]
## [1,]  FALSE FALSE FALSE   TRUE
## [2,]  FALSE FALSE  TRUE  FALSE
## [3,]  FALSE  TRUE FALSE  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] 28 29 25
```

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

5

- 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     23.2836849250 -5.73184106499    4 0.06115157082097    2    0
## Emma       18.4888426859 -8.96446971223    5 0.05912462818540    1    0
## Olivia      9.8259564683 -0.76690061018    4 0.10515832631485    3    0
## Ava        16.9284098687 -6.39862801880    7 0.04605200048536    2    0
## Mia        13.2840364236  7.35696705058    7 0.28638955431935    4    1
## Isabella   12.2951436312 -2.37060625106    5 0.05553200380463    2    0
## Riley      20.2682809367  8.14133613836    5 0.00332338836521    2    0
## Aria       14.2496854656 -4.08092662692    3 0.04489202901813    2    0
## Zoe        19.1320490557 -9.72904576920    2 0.04996458290973    3    0
## Charlotte  26.6249822893  4.46663099341    9 0.00642387734519    2    0
## Lily       25.1873457447 -9.63663997594    5 0.04149605530418    3    0
## Layla      19.0417230561 -8.71979445685    8 0.11422953805937    2    0
## Amelia      6.6767823312  9.47460126597    6 0.00035396921966    1    1
## Emily      28.5012716789  3.12814994249    5 0.13688407775790    3    0
## Madelyn    20.2684787480  3.32202179357    6 0.00898266551284    4    0
## Aubrey     22.9885864887 -3.28088263050    8 0.02141321855626    2    1
## Adalyn     14.3117153353 -4.62093761191    2 0.09655773721996    3    0
## Madison    19.7248354327 -3.09472011868    2 0.06115246921157    3    1
## Chloe      28.8614424419 -2.43400041014    6 0.24916632693179    1    0
## Harper     14.8743995423  9.44360948168    7 0.11135493942794    1    1
## Abigail    24.3865696955  8.71935680509    6 0.39662301847121    3    1
## Aaliyah    11.9383551432  7.65437357128    7 0.23928515891789    6    0
## Avery      21.6891605474 -8.42282390688    6 0.23826174457295    1    0
## Evelyn     13.1927450507  7.96995546203    4 0.05967875554537    5    0
## Kaylee      8.7055592951  2.13052366395    3 0.02285433343301    4    0
```

```
## Ella       17.6914084486  8.51689843927   5 0.01063886988494  2  0
## Ellie      11.8221373789  9.35763090383   9 0.02923880946926  1  0
## Scarlett   14.3087649124 -1.80588693824   2 0.11444359013551  3  0
## Arianna    19.7938178934  4.64391287882   2 0.08675161107080  2  0
## Hailey     21.4943703846 -6.27199995797   5 0.45025549723192  1  1
## Nora       21.1315290826  1.63252462167   6 0.01163275172520  0  0
## Addison    13.4914958786 -5.14930867124   6 0.09030822022455  2  0
## Brooklyn   10.0051186534 -5.35547992680   5 0.39232894896071  2  0
## Hannah     19.8233078526  9.24955765251   1 0.05974113097828  3  0
## Mila       19.3556665286 -6.57403145451   7 0.13876043683900  2  1
## Leah       19.9487553755 -8.99995605927   5 0.05323030064917  2  0
## Elizabeth 21.4133433197 -3.29631065018   5 0.07747443968154  4  0
## Sarah      32.6659566145 -1.13493533805   3 0.05991696721564  1  0
## Eliana     14.9953784581 -0.19522134215   9 0.12563914344526  3  1
## Mackenzie 25.3025787937 -2.23320175428   6 0.01039451233140  1  0
## Peyton      8.6561088005  8.00217564683   6 0.05097273256009  4  0
## Maria      14.5245662896 -4.02641186491   4 0.13884676775118  1  0
## Grace      12.0908618741 -2.61522502638   6 0.03564232246329  1  0
## Adeline    22.5429297544  2.91191337164   8 0.02551346624063  1  0
## Elena      23.2435392418  5.99745161831   5 0.30757977915562  4  1
## Anna       21.1586306922 -2.77456684969   9 0.27140440064350  2  0
## Victoria   14.3380864028  7.82582872547   6 0.06882852150334  1  1
## Camilla    22.6453660077  7.46128685772   5 0.44405525154687  1  0
## Lillian    11.1586551455 -6.94699863903   3 0.04014880675822  3  1
## Natalie     7.8870993497 -4.68024144415   5 0.10068056387657  4  0
## Jackson    14.7503793687  0.77990238555   5 0.01453816657886  4  0
## Aiden       9.6135485759 -3.38710531592   3 0.29352399808920  1  0
## Lucas      -2.0331694469  8.89465195592   4 0.09530324550500  3  0
## Liam        5.5816383042  8.80401910283   3 0.01829504117273  2  0
## Noah       18.4481825694  0.67654845770   7 0.04581285407767  3  0
## Ethan       6.4626353023  1.71666843817   7 0.01768647045692  3  1
## Mason      10.9526377029  4.24322713166   7 0.20800392225279  0  0
## Caden      18.5117201004  1.35754894931  12 0.05056324492114  5  0
## Oliver     21.0822189874  9.54055431299   4 0.13379251573596  3  1
## Elijah     17.3550785297  7.77902411763   4 0.00562723907125  0  0
## Grayson     9.8941603819 -1.63080094848   2 0.21302746131910  0  0
## Jacob      16.0638447693  0.89590618853   6 0.02884608714117  2  1
## Michael    31.4683448117  4.21353017446   9 0.14513488326470  3  0
## Benjamin   20.6426699999 -1.31083538290   3 0.33353429120237  3  0
## Carter     19.9673910695 -4.28675552830   7 0.00544449681830  3  0
## James      10.4052059394  4.61689659394   5 0.04050787833209  5  0
## Jayden     11.9556229031 -7.97792634461   6 0.00512536030470  3  0
## Logan      15.5539309447 -1.09067776240   7 0.01960305595357  2  0
## Alexander 27.8329618207  8.29500985332   1 0.04911757979394  4  0
## Caleb      15.5415537421 -7.54696348216   3 0.00583725241530  5  0
## Ryan       18.8571010834  7.66303841490  10 0.11477699047523  3  0
## Luke       18.7049322529 -0.43319149408   7 0.03057619903444  2  1
## Daniel     24.9523410112 -3.75579109415   5 0.22618462289267  3  0
## Jack       17.4400375922  5.17465409823   5 0.20036347519915  1  0
## William    19.2888038924 -1.38718867209   8 0.27560134582477  3  0
## Owen       14.6477808207  1.76201258320   7 0.42720913615641  3  0
## Gabriel    21.8924031972  4.62041456718   9 0.28407157231792  3  0
## Matthew    18.5590866149 -2.41242873482   3 0.07751430767225  2  1
## Connor     12.6669041546  6.58265450969   1 0.04922791285854  2  1
```

7

```
## Jayce     11.1333912727 -3.06752357166   5 0.01451986174410   2  0
## Isaac      14.9191270004 -9.54902912024   7 0.15072130194088   0  1
## Sebastian 16.0372834651 -3.81496375892   7 0.09515109295594   0  1
## Henry      14.8676037089  8.54945912957   6 0.06492295012706   2  0
## Muhammad   3.7192385054 -0.22761017550   3 0.25719428855766   2  0
## Cameron    18.2032200529  4.82945176773   7 0.15502826976955   3  0
## Wyatt      17.4057979649  3.64977343008   4 0.02904962179148   1  1
## Dylan      15.2976708292  7.09935735445   8 0.07019706820655   5  0
## Nathan      9.7376866975  9.21194962692   6 0.00866235218321   3  1
## Nicholas   22.2870047024 -2.00047489256   4 0.01505970750316   0  0
## Julian     16.6330076777  1.45944006741   6 0.01723378152524   3  0
## Eli        12.3849184465 -5.12354058679   3 0.04382553210275   1  0
## Levi       16.4486708880 -5.12636031024   9 0.04071056656539   1  0
## Isaiah     28.6461455484  1.45417151507   5 0.02896953736328   3  0
## Landon     15.9345767830 -1.02530566044   8 0.12687326377412   0  0
## David      17.7346736629 -4.01636247523   5 0.01739935323389   1  0
## Christian 20.2114242037  0.64881164115   2 0.01077977609303   2  1
## Andrew     18.6124353562 -1.39414331876   9 0.01437715458392   4  1
## Brayden    20.3632232436 -4.85006677918   4 0.28553114933528   1  0
## John       28.7784081657 -8.30038272310   5 0.01423060573224   1  0
## Lincoln    23.3247230173 -1.62268554326   4 0.09915538251570   6  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     23.2836849250 -5.73184106499   4 0.06115157082097   2  0
## Emma       18.4888426859 -8.96446971223   5 0.05912462818540   1  0
## Olivia      9.8259564683 -0.76690061018   4 0.10515832631485   3  0
## Ava        16.9284098687 -6.39862801880   7 0.04605200048536   2  0
## Mia        13.2840364236  7.35696705058   7 0.28638955431935   4  1
## Isabella   12.2951436312 -2.37060625106   5 0.05553200380463   2  0
## Riley      20.2682809367  8.14133613836   5 0.00332338836521   2  0
## Aria       14.2496854656 -4.08092662692   3 0.04489202901813   2  0
## Zoe        19.1320490557 -9.72904576920   2 0.04996458290973   3  0
## Charlotte 26.6249822893  4.46663099341   9 0.00642387734519   2  0
## Lily       25.1873457447 -9.63663997594   5 0.04149605530418   3  0
## Layla      19.0417230561 -8.71979445685   8 0.11422953805937   2  0
## Amelia      6.6767823312  9.47460126597   6 0.00035396921966   1  1
## Emily      28.5012716789  3.12814994249   5 0.13688407775790   3  0
## Madelyn    20.2684787480  3.32202179357   6 0.00898266551284   4  0
## Aubrey     22.9885864887 -3.28088263050   8 0.02141321855626   2  1
## Adalyn     14.3117153353 -4.62093761191   2 0.09655773721996   3  0
## Madison    19.7248354327 -3.09472011868   2 0.06115246921157   3  1
## Chloe      28.8614424419 -2.43400041014   6 0.24916632693179   1  0
## Harper     14.8743995423  9.44360948168   7 0.11135493942794   1  1
## Abigail    24.3865696955  8.71935680509   6 0.39662301847121   3  1
## Aaliyah    11.9383551432  7.65437357128   7 0.23928515891789   6  0
## Avery      21.6891605474 -8.42282390688   6 0.23826174457295   1  0
## Evelyn     13.1927450507  7.96995546203   4 0.05967875554537   5  0
## Kaylee      8.7055592951  2.13052366395   3 0.02285433343301   4  0
## Ella       17.6914084486  8.51689843927   5 0.01063886988494   2  0
```

```
## Ellie     11.8221373789  9.35763090383   9 0.02923880946926  1  0
## Scarlett  14.3087649124 -1.80588693824   2 0.11444359013551  3  0
## Arianna   19.7938178934  4.64391287882   2 0.08675161107080  2  0
## Hailey    21.4943703846 -6.27199995797   5 0.45025549723192  1  1
## Nora      21.1315290826  1.63252462167   6 0.01163275172520  0  0
## Addison   13.4914958786 -5.14930867124   6 0.09030822022455  2  0
## Brooklyn  10.0051186534 -5.35547992680   5 0.39232894896071  2  0
## Hannah    19.8233078526  9.24955765251   1 0.05974113097828  3  0
## Mila      19.3556665286 -6.57403145451   7 0.13876043683900  2  1
## Leah      19.9487553755 -8.99995605927   5 0.05323030064917  2  0
## Elizabeth 21.4133433197 -3.29631065018   5 0.07747443968154  4  0
## Sarah     32.6659566145 -1.13493533805   3 0.05991696721564  1  0
## Eliana    14.9953784581 -0.19522134215   9 0.12563914344526  3  1
## Mackenzie 25.3025787937 -2.23320175428   6 0.01039451233140  1  0
## Peyton     8.6561088005  8.00217564683   6 0.05097273256009  4  0
## Maria     14.5245662896 -4.02641186491   4 0.13884676775118  1  0
## Grace     12.0908618741 -2.61522502638   6 0.03564232246329  1  0
## Adeline   22.5429297544  2.91191337164   8 0.02551346624063  1  0
## Elena     23.2435392418  5.99745161831   5 0.30757977915562  4  1
## Anna      21.1586306922 -2.77456684969   9 0.27140440064350  2  0
## Victoria  14.3380864028  7.82582872547   6 0.06882852150334  1  1
## Camilla   22.6453660077  7.46128685772   5 0.44405525154687  1  0
## Lillian   11.1586551455 -6.94699863903   3 0.04014880675822  3  1
## Natalie    7.8870993497 -4.68024144415   5 0.10068056387657  4  0
## Jackson   14.7503793687  0.77990238555   5 0.01453816657886  4  0
## Aiden      9.6135485759 -3.38710531592   3 0.29352399808920  1  0
## Lucas     -2.0331694469  8.89465195592   4 0.09530324550500  3  0
## Liam       5.5816383042  8.80401910283   3 0.01829504117273  2  0
## Noah      18.4481825694  0.67654845770   7 0.04581285407767  3  0
## Ethan      6.4626353023  1.71666843817   7 0.01768647045692  3  1
## Mason     10.9526377029  4.24322713166   7 0.20800392225279  0  0
## Caden     18.5117201004  1.35754894931  12 0.05056324492114  5  0
## Oliver    21.0822189874  9.54055431299   4 0.13379251573596  3  1
## Elijah    17.3550785297  7.77902411763   4 0.00562723907125  0  0
## Grayson    9.8941603819 -1.63080094848   2 0.21302746131910  0  0
## Jacob     16.0638447693  0.89590618853   6 0.02884608714117  2  1
## Michael   31.4683448117  4.21353017446   9 0.14513488326470  3  0
## Benjamin  20.6426699999 -1.31083538290   3 0.33353429120237  3  0
## Carter    19.9673910695 -4.28675552830   7 0.00544449681830  3  0
## James     10.4052059394  4.61689659394   5 0.04050787833209  5  0
## Jayden    11.9556229031 -7.97792634461   6 0.00512536030470  3  0
## Logan     15.5539309447 -1.09067776240   7 0.01960305595357  2  0
## Alexander 27.8329618207  8.29500985332   1 0.04911757979394  4  0
## Caleb     15.5415537421 -7.54696348216   3 0.00583725241530  5  0
## Ryan      18.8571010834  7.66303841490  10 0.11477699047523  3  0
## Luke      18.7049322529 -0.43319149408   7 0.03057619903444  2  1
## Daniel    24.9523410112 -3.75579109415   5 0.22618462289267  3  0
## Jack      17.4400375922  5.17465409823   5 0.20036347519915  1  0
## William   19.2888038924 -1.38718867209   8 0.27560134582477  3  0
## Owen      14.6477808207  1.76201258320   7 0.42720913615641  3  0
## Gabriel   21.8924031972  4.62041456718   9 0.28407157231792  3  0
## Matthew   18.5590866149 -2.41242873482   3 0.07751430767225  2  1
## Connor    12.6669041546  6.58265450969   1 0.04922791285854  2  1
## Jayce     11.1333912727 -3.06752357166   5 0.01451986174410  2  0
```

```
## Isaac      14.9191270004 -9.54902912024  7 0.15072130194088  0  1
## Sebastian  16.0372834651 -3.81496375892  7 0.09515109295594  0  1
## Henry      14.8676037089  8.54945912957  6 0.06492295012706  2  0
## Muhammad    3.7192385054 -0.22761017550  3 0.25719428855766  2  0
## Cameron    18.2032200529  4.82945176773  7 0.15502826976955  3  0
## Wyatt      17.4057979649  3.64977343008  4 0.02904962179148  1  1
## Dylan      15.2976708292  7.09935735445  8 0.07019706820655  5  0
## Nathan      9.7376866975  9.21194962692  6 0.00866235218321  3  1
## Nicholas   22.2870047024 -2.00047489256  4 0.01505970750316  0  0
## Julian     16.6330076777  1.45944006741  6 0.01723378152524  3  0
## Eli        12.3849184465 -5.12354058679  3 0.04382553210275  1  0
## Levi       16.4486708880 -5.12636031024  9 0.04071056656539  1  0
## Isaiah     28.6461455484  1.45417151507  5 0.02896953736328  3  0
## Landon     15.9345767830 -1.02530566044  8 0.12687326377412  0  0
## David      17.7346736629 -4.01636247523  5 0.01739935323389  1  0
## Christian  20.2114242037  0.64881164115  2 0.01077977609303  2  1
## Andrew     18.6124353562 -1.39414331876  9 0.01437715458392  4  1
## Brayden    20.3632232436 -4.85006677918  4 0.28553114933528  1  0
## John       28.7784081657 -8.30038272310  5 0.01423060573224  1  0
## Lincoln    23.3247230173 -1.62268554326  4 0.09915538251570  6  0
```

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

```
##                      V1            V2 V3               V4 V5       V6
## Sophia     23.2836849250 -5.73184106499  4 0.06115157082097  2 domestic
## Emma       18.4888426859 -8.96446971223  5 0.05912462818540  1 domestic
## Olivia      9.8259564683 -0.76690061018  4 0.10515832631485  3 domestic
## Ava        16.9284098687 -6.39862801880  7 0.04605200048536  2 domestic
## Mia        13.2840364236  7.35696705058  7 0.28638955431935  4  foreign
## Isabella   12.2951436312 -2.37060625106  5 0.05553200380463  2 domestic
## Riley      20.2682809367  8.14133613836  5 0.00332338836521  2 domestic
## Aria       14.2496854656 -4.08092662692  3 0.04489202901813  2 domestic
## Zoe        19.1320490557 -9.72904576920  2 0.04996458290973  3 domestic
## Charlotte  26.6249822893  4.46663099341  9 0.00642387734519  2 domestic
## Lily       25.1873457447 -9.63663997594  5 0.04149605530418  3 domestic
## Layla      19.0417230561 -8.71979445685  8 0.11422953805937  2 domestic
## Amelia      6.6767823312  9.47460126597  6 0.00035396921966  1  foreign
## Emily      28.5012716789  3.12814994249  5 0.13688407775790  3 domestic
## Madelyn    20.2684787480  3.32202179357  6 0.00898266551284  4 domestic
## Aubrey     22.9885864887 -3.28088263050  8 0.02141321855626  2  foreign
## Adalyn     14.3117153353 -4.62093761191  2 0.09655773721996  3 domestic
## Madison    19.7248354327 -3.09472011868  2 0.06115246921157  3  foreign
## Chloe      28.8614424419 -2.43400041014  6 0.24916632693179  1 domestic
## Harper     14.8743995423  9.44360948168  7 0.11135493942794  1  foreign
## Abigail    24.3865696955  8.71935680509  6 0.39662301847121  3  foreign
## Aaliyah    11.9383551432  7.65437357128  7 0.23928515891789  6 domestic
## Avery      21.6891605474 -8.42282390688  6 0.23826174457295  1 domestic
## Evelyn     13.1927450507  7.96995546203  4 0.05967875554537  5 domestic
## Kaylee      8.7055592951  2.13052366395  3 0.02285433343301  4 domestic
## Ella       17.6914084486  8.51689843927  5 0.01063886988494  2 domestic
## Ellie      11.8221373789  9.35763090383  9 0.02923880946926  1 domestic
## Scarlett   14.3087649124 -1.80588693824  2 0.11444359013551  3 domestic
## Arianna    19.7938178934  4.64391287882  2 0.08675161107080  2 domestic
## Hailey     21.4943703846 -6.27199995797  5 0.45025549723192  1  foreign
```

```
## Nora      21.1315290826  1.63252462167  6 0.01163275172520  0 domestic
## Addison   13.4914958786 -5.14930867124  6 0.09030822022455  2 domestic
## Brooklyn  10.0051186534 -5.35547992680  5 0.39232894896071  2 domestic
## Hannah    19.8233078526  9.24955765251  1 0.05974113097828  3 domestic
## Mila      19.3556665286 -6.57403145451  7 0.13876043683900  2  foreign
## Leah      19.9487553755 -8.99995605927  5 0.05323030064917  2 domestic
## Elizabeth 21.4133433197 -3.29631065018  5 0.07747443968154  4 domestic
## Sarah     32.6659566145 -1.13493533805  3 0.05991696721564  1 domestic
## Eliana    14.9953784581 -0.19522134215  9 0.12563914344526  3  foreign
## Mackenzie 25.3025787937 -2.23320175428  6 0.01039451233140  1 domestic
## Peyton     8.6561088005  8.00217564683  6 0.05097273256009  4 domestic
## Maria     14.5245662896 -4.02641186491  4 0.13884676775118  1 domestic
## Grace     12.0908618741 -2.61522502638  6 0.03564232246329  1 domestic
## Adeline   22.5429297544  2.91191337164  8 0.02551346624063  1 domestic
## Elena     23.2435392418  5.99745161831  5 0.30757977915562  4  foreign
## Anna      21.1586306922 -2.77456684969  9 0.27140440064350  2 domestic
## Victoria  14.3380864028  7.82582872547  6 0.06882852150334  1  foreign
## Camilla   22.6453660077  7.46128685772  5 0.44405525154687  1 domestic
## Lillian   11.1586551455 -6.94699863903  3 0.04014880675822  3  foreign
## Natalie    7.8870993497 -4.68024144415  5 0.10068056387657  4 domestic
## Jackson   14.7503793687  0.77990238555  5 0.01453816657886  4 domestic
## Aiden      9.6135485759 -3.38710531592  3 0.29352399808920  1 domestic
## Lucas     -2.0331694469  8.89465195592  4 0.09530324550500  3 domestic
## Liam       5.5816383042  8.80401910283  3 0.01829504117273  2 domestic
## Noah      18.4481825694  0.67654845770  7 0.04581285407767  3 domestic
## Ethan      6.4626353023  1.71666843817  7 0.01768647045692  3  foreign
## Mason     10.9526377029  4.24322713166  7 0.20800392225279  0 domestic
## Caden     18.5117201004  1.35754894931 12 0.05056324492114  5 domestic
## Oliver    21.0822189874  9.54055431299  4 0.13379251573596  3  foreign
## Elijah    17.3550785297  7.77902411763  4 0.00562723907125  0 domestic
## Grayson    9.8941603819 -1.63080094848  2 0.21302746131910  0 domestic
## Jacob     16.0638447693  0.89590618853  6 0.02884608714117  2  foreign
## Michael   31.4683448117  4.21353017446  9 0.14513488326470  3 domestic
## Benjamin  20.6426699999 -1.31083538290  3 0.33353429120237  3 domestic
## Carter    19.9673910695 -4.28675552830  7 0.00544449681830  3 domestic
## James     10.4052059394  4.61689659394  5 0.04050787833209  5 domestic
## Jayden    11.9556229031 -7.97792634461  6 0.00512536030470  3 domestic
## Logan     15.5539309447 -1.09067776240  7 0.01960305595357  2 domestic
## Alexander 27.8329618207  8.29500985332  1 0.04911757979394  4 domestic
## Caleb     15.5415537421 -7.54696348216  3 0.00583725241530  5 domestic
## Ryan      18.8571010834  7.66303841490 10 0.11477699047523  3 domestic
## Luke      18.7049322529 -0.43319149408  7 0.03057619903444  2  foreign
## Daniel    24.9523410112 -3.75579109415  5 0.22618462289267  3 domestic
## Jack      17.4400375922  5.17465409823  5 0.20036347519915  1 domestic
## William   19.2888038924 -1.38718867209  8 0.27560134582477  3 domestic
## Owen      14.6477808207  1.76201258320  7 0.42720913615641  3 domestic
## Gabriel   21.8924031972  4.62041456718  9 0.28407157231792  3 domestic
## Matthew   18.5590866149 -2.41242873482  3 0.07751430767225  2  foreign
## Connor    12.6669041546  6.58265450969  1 0.04922791285854  2  foreign
## Jayce     11.1333912727 -3.06752357166  5 0.01451986174410  2 domestic
## Isaac     14.9191270004 -9.54902912024  7 0.15072130194088  0  foreign
## Sebastian 16.0372834651 -3.81496375892  7 0.09515109295594  0  foreign
## Henry     14.8676037089  8.54945912957  6 0.06492295012706  2 domestic
## Muhammad   3.7192385054 -0.22761017550  3 0.25719428855766  2 domestic
```

```
## Cameron   18.2032200529  4.82945176773  7 0.15502826976955  3 domestic
## Wyatt      17.4057979649  3.64977343008  4 0.02904962179148  1  foreign
## Dylan      15.2976708292  7.09935735445  8 0.07019706820655  5 domestic
## Nathan      9.7376866975  9.21194962692  6 0.00866235218321  3  foreign
## Nicholas   22.2870047024 -2.00047489256  4 0.01505970750316  0 domestic
## Julian     16.6330076777  1.45944006741  6 0.01723378152524  3 domestic
## Eli        12.3849184465 -5.12354058679  3 0.04382553210275  1 domestic
## Levi       16.4486708880 -5.12636031024  9 0.04071056656539  1 domestic
## Isaiah     28.6461455484  1.45417151507  5 0.02896953736328  3 domestic
## Landon     15.9345767830 -1.02530566044  8 0.12687326377412  0 domestic
## David      17.7346736629 -4.01636247523  5 0.01739935323389  1 domestic
## Christian  20.2114242037  0.64881164115  2 0.01077977609303  2  foreign
## Andrew     18.6124353562 -1.39414331876  9 0.01437715458392  4  foreign
## Brayden    20.3632232436 -4.85006677918  4 0.28553114933528  1 domestic
## John       28.7784081657 -8.30038272310  5 0.01423060573224  1 domestic
## Lincoln    23.3247230173 -1.62268554326  4 0.09915538251570  6 domestic
```

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

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

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

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

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

Print out a summary of the whole dataframe.

```
summary(z)
```

```
##       V1                 V2                 V3
##  Min.   :-2.0331694  Min.   :-9.72904577  Min.   : 1.00
##  1st Qu.:13.2612136  1st Qu.:-4.01887482  1st Qu.: 4.00
##  Median :17.5657230  Median :-0.60004605  Median : 5.00
##  Mean   :17.2595969  Mean   : 0.36275276  Mean   : 5.42
##  3rd Qu.:21.0945465  3rd Qu.: 4.91575235  3rd Qu.: 7.00
##  Max.   :32.6659566  Max.   : 9.54055431  Max.   :12.00
##       V4                 V5                 V6
##  Min.   :0.00035396922  Min.   :0.00   domestic:76
##  1st Qu.:0.02484868304  1st Qu.:1.00   foreign :24
##  Median :0.05982904910  Median :2.00
```

```
##  Mean    :0.10685177036   Mean   :2.33
##  3rd Qu.:0.13878201957    3rd Qu.:3.00
##  Max.   :0.45025549723    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
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,]    1    1    1    1    1    1    1    1    1     1     1     1     1
##  [3,]    0    2    0    2    0    2    0    2    0     2     0     2     0
##  [4,]    0    0    0    0    0    0    0    0    0     0     0     0     0
##  [5,]    0    2    0    2    0    2    0    2    0     2     0     2     0
##  [6,]    0    0    0    0    0    0    0    0    0     0     0     0     0
##  [7,]    2    0    2    0    2    0    2    0    2     0     2     0     2
##  [8,]    0    0    0    0    0    0    0    0    0     0     0     0     0
##  [9,]    0    1    0    1    0    1    0    1    0     1     0     1     0
## [10,]    2    0    2    0    2    0    2    0    2     0     2     0     2
## [11,]    2    1    2    1    2    1    2    1    2     1     2     1     2
## [12,]    2    0    2    0    2    0    2    0    2     0     2     0     2
## [13,]    0    0    0    0    0    0    0    0    0     0     0     0     0
## [14,]    2    0    2    0    2    0    2    0    2     0     2     0     2
## [15,]    2    1    2    1    2    1    2    1    2     1     2     1     2
## [16,]    1    0    1    0    1    0    1    0    1     0     1     0     1
## [17,]    0    1    0    1    0    1    0    1    0     1     0     1     0
## [18,]    1    0    1    0    1    0    1    0    1     0     1     0     1
## [19,]    1    0    1    0    1    0    1    0    1     0     1     0     1
## [20,]    0    0    0    0    0    0    0    0    0     0     0     0     0
## [21,]    1    2    1    2    1    2    1    2    1     2     1     2     1
## [22,]    1    1    1    1    1    1    1    1    1     1     1     1     1
## [23,]    1    2    1    2    1    2    1    2    1     2     1     2     1
## [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,]    2    0    2    0    2    0    2    0    2     0     2     0     2
## [27,]    0    0    0    0    0    0    0    0    0     0     0     0     0
## [28,]    2    2    2    2    2    2    2    2    2     2     2     2     2
## [29,]    2    2    2    2    2    2    2    2    2     2     2     2     2
## [30,]    0    2    0    2    0    2    0    2    0     2     0     2     0
## [31,]    0    0    0    0    0    0    0    0    0     0     0     0     0
## [32,]    0    2    0    2    0    2    0    2    0     2     0     2     0
## [33,]    2    1    2    1    2    1    2    1    2     1     2     1     2
## [34,]    0    2    0    2    0    2    0    2    0     2     0     2     0
## [35,]    0    0    0    0    0    0    0    0    0     0     0     0     0
## [36,]    1    0    1    0    1    0    1    0    1     0     1     0     1
## [37,]    0    0    0    0    0    0    0    0    0     0     0     0     0
## [38,]    1    0    1    0    1    0    1    0    1     0     1     0     1
## [39,]    1    1    1    1    1    1    1    1    1     1     1     1     1
## [40,]    0    0    0    0    0    0    0    0    0     0     0     0     0
## [41,]    0    0    0    0    0    0    0    0    0     0     0     0     0
## [42,]    2    1    2    1    2    1    2    1    2     1     2     1     2
## [43,]    2    0    2    0    2    0    2    0    2     0     2     0     2
## [44,]    2    1    2    1    2    1    2    1    2     1     2     1     2
```

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

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

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

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

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

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

```
## [12,]     NA
## [13,]     NA
## [14,]     NA
## [15,]      1
## [16,]      0
## [17,]     NA
## [18,]      0
## [19,]      0
## [20,]      0
## [21,]      2
## [22,]     NA
## [23,]     NA
## [24,]      2
## [25,]      1
## [26,]      0
## [27,]      0
## [28,]      2
## [29,]      2
## [30,]     NA
## [31,]      0
## [32,]      2
## [33,]      1
## [34,]      2
## [35,]      0
## [36,]      0
## [37,]      0
## [38,]     NA
## [39,]     NA
## [40,]      0
## [41,]     NA
## [42,]      1
## [43,]      0
## [44,]     NA
## [45,]      2
## [46,]     NA
## [47,]      1
## [48,]     NA
## [49,]     NA
## [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 39 26  0 34  0 40  0 15 42 57 28  0 40 58 17 13 21 16  0 49 32 47 42 17
## [26] 36  0 68 64 36  0 42 40 32  0 18  0 19 33  0  0 46 30 55 30 15 19 20 17 30
```

```
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   NA    2    2    2     2     2     2    NA
## [2,]     2   NA    2   NA    2    2    2   NA   NA    NA     2     2    NA
## [3,]     2   NA    2    1    2    1    2    1   NA    NA    NA    NA     2
## [4,]     2    1    2    1    2    1   NA   NA    2     1    NA     1    NA
## [5,]     2    1    2    1    2   NA    2    1    2     1    NA     1     2
```

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

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

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

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

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

```
k=apply(A,1,sd,na.rm=TRUE)
k
```

```
##  [1] 0.00000000000 0.00000000000 0.48159399198 0.50503537376 0.50671170971
##  [6] 0.50399473726 0.50800050800 0.49619766345 1.00000000000 1.00779324575
## [11] 0.98654043611 1.01045584813 0.99910833687 0.50395263068 0.00000000000
## [16] 1.01328079421 1.01418510567 1.01045584813 0.00000000000 0.00000000000
## [21] 1.01503843785 1.00798947452 1.00798947452 1.00798947452 1.01175882204
## [26] 1.00801386599 0.50503537376 0.50209644525 0.50189036591 0.50636968354
## [31] 0.50600940624 0.50709255284 0.50709255284 0.50587941102 0.50543267096
## [36] 0.50399473726 0.50399473726 0.50917507722 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
```

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

```
## [1] 0.88330492811 0.83378366211 0.85215816722 0.80445456500 0.90517714369
## [6] 0.78288136126 0.86384984757 0.82182530102 0.89294371875 0.81066855082
## [11] 0.83858559876 0.79681907289 0.84890218555 0.74133651733 0.85215816722
## [16] 0.82196730598 0.87803459017 0.84611411223 0.89069261439 0.79247977485
## [21] 0.84091786587 0.82807867121 0.81649658093 0.77390598995 0.85993941549
## [26] 0.73598007219 0.84723257155 0.85489051326 0.84067612853 0.80024034851
## [31] 0.86772183127 0.77728158776 0.86309864515 0.82787876178 0.84242353917
## [36] 0.84660136485 0.87242971249 0.83266639979 0.88963130018 0.83029750053
## [41] 0.84540801671 0.80300703358 0.86694134841 0.81982893820 0.80243531766
## [46] 0.79042848102 0.83212797981 0.82787876178 0.84492824744 0.86711818075
```

- 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] 18 21 19 19 18 16 14 20 16 21 13 20 17 14 19 20 14 18 11 18 13 16 15 16 16
## [26] 17 15 17 19 22 18 16 17 17 16 18 19 15 16 17 17 24 14 20 17 18 16 17 18 16
```

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

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

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

30

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

```
## [26]  0  1  0  1 NA  1 NA NA  0  1  0 NA  0 NA  0 NA  0  0 NA  0  0  0 NA NA  0
##
## $`50`
##  [1]  2  2  1  1 NA  2 NA  1 NA  2  2  0 NA  1  1  0 NA NA NA NA  2  0  2  2 NA
## [26]  2  0 NA NA  1  0  0  1 NA  0 NA NA NA  0  0  0  0 NA  0  0  0  0  0  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(split(A, col(A)), function(x){as.list(c(min=min(x,na.rm=TRUE), max=max(x,na.rm=TRUE),pct_missing
```

```
## $`1`
## $`1`$min
## [1] 0
##
## $`1`$max
## [1] 2
##
## $`1`$pct_missing
## [1] 0.24
##
## $`1`$first_NA
## [1] 1
##
##
## $`2`
## $`2`$min
## [1] 0
##
## $`2`$max
## [1] 2
##
## $`2`$pct_missing
## [1] 0.26
##
## $`2`$first_NA
## [1] 1
##
##
## $`3`
## $`3`$min
## [1] 0
##
## $`3`$max
## [1] 2
##
## $`3`$pct_missing
## [1] 0.24
##
## $`3`$first_NA
## [1] 1
##
##
```

```
## $`4`
## $`4`$min
## [1] 0
##
## $`4`$max
## [1] 2
##
## $`4`$pct_missing
## [1] 0.26
##
## $`4`$first_NA
## [1] 1
##
##
## $`5`
## $`5`$min
## [1] 0
##
## $`5`$max
## [1] 2
##
## $`5`$pct_missing
## [1] 0.24
##
## $`5`$first_NA
## [1] 1
##
##
## $`6`
## $`6`$min
## [1] 0
##
## $`6`$max
## [1] 2
##
## $`6`$pct_missing
## [1] 0.38
##
## $`6`$first_NA
## [1] 2
##
##
## $`7`
## $`7`$min
## [1] 0
##
## $`7`$max
## [1] 2
##
## $`7`$pct_missing
## [1] 0.38
##
## $`7`$first_NA
## [1] 1
```

```
## 
## 
## $`8`
## $`8`$min
## [1] 0
## 
## $`8`$max
## [1] 2
## 
## $`8`$pct_missing
## [1] 0.28
## 
## $`8`$first_NA
## [1] 1
## 
## 
## $`9`
## $`9`$min
## [1] 0
## 
## $`9`$max
## [1] 2
## 
## $`9`$pct_missing
## [1] 0.34
## 
## $`9`$first_NA
## [1] 1
## 
## 
## $`10`
## $`10`$min
## [1] 0
## 
## $`10`$max
## [1] 2
## 
## $`10`$pct_missing
## [1] 0.24
## 
## $`10`$first_NA
## [1] 1
## 
## 
## $`11`
## $`11`$min
## [1] 0
## 
## $`11`$max
## [1] 2
## 
## $`11`$pct_missing
## [1] 0.38
## 
```

```
## $`11`$first_NA
## [1] 1
##
##
## $`12`
## $`12`$min
## [1] 0
##
## $`12`$max
## [1] 2
##
## $`12`$pct_missing
## [1] 0.28
##
## $`12`$first_NA
## [1] 1
##
##
## $`13`
## $`13`$min
## [1] 0
##
## $`13`$max
## [1] 2
##
## $`13`$pct_missing
## [1] 0.28
##
## $`13`$first_NA
## [1] 3
##
##
## $`14`
## $`14`$min
## [1] 0
##
## $`14`$max
## [1] 2
##
## $`14`$pct_missing
## [1] 0.3
##
## $`14`$first_NA
## [1] 1
##
##
## $`15`
## $`15`$min
## [1] 0
##
## $`15`$max
## [1] 2
##
## $`15`$pct_missing
```

```
## [1] 0.24
##
## $`15`$first_NA
## [1] 1
##
##
## $`16`
## $`16`$min
## [1] 0
##
## $`16`$max
## [1] 2
##
## $`16`$pct_missing
## [1] 0.3
##
## $`16`$first_NA
## [1] 1
##
##
## $`17`
## $`17`$min
## [1] 0
##
## $`17`$max
## [1] 2
##
## $`17`$pct_missing
## [1] 0.32
##
## $`17`$first_NA
## [1] 2
##
##
## $`18`
## $`18`$min
## [1] 0
##
## $`18`$max
## [1] 2
##
## $`18`$pct_missing
## [1] 0.34
##
## $`18`$first_NA
## [1] 4
##
##
## $`19`
## $`19`$min
## [1] 0
##
## $`19`$max
## [1] 2
```

```
## 
## $`19`$pct_missing
## [1] 0.5
## 
## $`19`$first_NA
## [1] 1
## 
## 
## $`20`
## $`20`$min
## [1] 0
## 
## $`20`$max
## [1] 2
## 
## $`20`$pct_missing
## [1] 0.36
## 
## $`20`$first_NA
## [1] 2
## 
## 
## $`21`
## $`21`$min
## [1] 0
## 
## $`21`$max
## [1] 2
## 
## $`21`$pct_missing
## [1] 0.28
## 
## $`21`$first_NA
## [1] 3
## 
## 
## $`22`
## $`22`$min
## [1] 0
## 
## $`22`$max
## [1] 2
## 
## $`22`$pct_missing
## [1] 0.28
## 
## $`22`$first_NA
## [1] 3
## 
## 
## $`23`
## $`23`$min
## [1] 0
## 
```

```
## $`23`$max
## [1] 2
##
## $`23`$pct_missing
## [1] 0.34
##
## $`23`$first_NA
## [1] 2
##
##
## $`24`
## $`24`$min
## [1] 0
##
## $`24`$max
## [1] 2
##
## $`24`$pct_missing
## [1] 0.32
##
## $`24`$first_NA
## [1] 2
##
##
## $`25`
## $`25`$min
## [1] 0
##
## $`25`$max
## [1] 2
##
## $`25`$pct_missing
## [1] 0.3
##
## $`25`$first_NA
## [1] 1
##
##
## $`26`
## $`26`$min
## [1] 0
##
## $`26`$max
## [1] 2
##
## $`26`$pct_missing
## [1] 0.34
##
## $`26`$first_NA
## [1] 1
##
##
## $`27`
## $`27`$min
```

```
## [1] 0
##
## $`27`$max
## [1] 2
##
## $`27`$pct_missing
## [1] 0.34
##
## $`27`$first_NA
## [1] 1
##
##
## $`28`
## $`28`$min
## [1] 0
##
## $`28`$max
## [1] 2
##
## $`28`$pct_missing
## [1] 0.32
##
## $`28`$first_NA
## [1] 1
##
##
## $`29`
## $`29`$min
## [1] 0
##
## $`29`$max
## [1] 2
##
## $`29`$pct_missing
## [1] 0.16
##
## $`29`$first_NA
## [1] 1
##
##
## $`30`
## $`30`$min
## [1] 0
##
## $`30`$max
## [1] 2
##
## $`30`$pct_missing
## [1] 0.2
##
## $`30`$first_NA
## [1] 1
##
##
```

```
## $`31`
## $`31`$min
## [1] 0
##
## $`31`$max
## [1] 2
##
## $`31`$pct_missing
## [1] 0.3
##
## $`31`$first_NA
## [1] 1
##
##
## $`32`
## $`32`$min
## [1] 0
##
## $`32`$max
## [1] 2
##
## $`32`$pct_missing
## [1] 0.34
##
## $`32`$first_NA
## [1] 1
##
##
## $`33`
## $`33`$min
## [1] 0
##
## $`33`$max
## [1] 2
##
## $`33`$pct_missing
## [1] 0.22
##
## $`33`$first_NA
## [1] 1
##
##
## $`34`
## $`34`$min
## [1] 0
##
## $`34`$max
## [1] 2
##
## $`34`$pct_missing
## [1] 0.32
##
## $`34`$first_NA
## [1] 1
```

```
##
##
## $`35`
## $`35`$min
## [1] 0
##
## $`35`$max
## [1] 2
##
## $`35`$pct_missing
## [1] 0.36
##
## $`35`$first_NA
## [1] 1
##
##
## $`36`
## $`36`$min
## [1] 0
##
## $`36`$max
## [1] 2
##
## $`36`$pct_missing
## [1] 0.36
##
## $`36`$first_NA
## [1] 1
##
##
## $`37`
## $`37`$min
## [1] 0
##
## $`37`$max
## [1] 2
##
## $`37`$pct_missing
## [1] 0.22
##
## $`37`$first_NA
## [1] 2
##
##
## $`38`
## $`38`$min
## [1] 0
##
## $`38`$max
## [1] 2
##
## $`38`$pct_missing
## [1] 0.5
##
```

```
## $`38`$first_NA
## [1] 2
##
##
## $`39`
## $`39`$min
## [1] 0
##
## $`39`$max
## [1] 2
##
## $`39`$pct_missing
## [1] 0.32
##
## $`39`$first_NA
## [1] 1
##
##
## $`40`
## $`40`$min
## [1] 0
##
## $`40`$max
## [1] 2
##
## $`40`$pct_missing
## [1] 0.34
##
## $`40`$first_NA
## [1] 4
##
##
## $`41`
## $`41`$min
## [1] 0
##
## $`41`$max
## [1] 2
##
## $`41`$pct_missing
## [1] 0.26
##
## $`41`$first_NA
## [1] 3
##
##
## $`42`
## $`42`$min
## [1] 0
##
## $`42`$max
## [1] 2
##
## $`42`$pct_missing
```

```
## [1] 0.12
##
## $`42`$first_NA
## [1] 1
##
##
## $`43`
## $`43`$min
## [1] 0
##
## $`43`$max
## [1] 2
##
## $`43`$pct_missing
## [1] 0.28
##
## $`43`$first_NA
## [1] 1
##
##
## $`44`
## $`44`$min
## [1] 0
##
## $`44`$max
## [1] 2
##
## $`44`$pct_missing
## [1] 0.24
##
## $`44`$first_NA
## [1] 1
##
##
## $`45`
## $`45`$min
## [1] 0
##
## $`45`$max
## [1] 2
##
## $`45`$pct_missing
## [1] 0.18
##
## $`45`$first_NA
## [1] 1
##
##
## $`46`
## $`46`$min
## [1] 0
##
## $`46`$max
## [1] 2
```

```
## 
## $`46`$pct_missing
## [1] 0.32
## 
## $`46`$first_NA
## [1] 1
## 
## 
## $`47`
## $`47`$min
## [1] 0
## 
## $`47`$max
## [1] 2
## 
## $`47`$pct_missing
## [1] 0.3
## 
## $`47`$first_NA
## [1] 2
## 
## 
## $`48`
## $`48`$min
## [1] 0
## 
## $`48`$max
## [1] 2
## 
## $`48`$pct_missing
## [1] 0.32
## 
## $`48`$first_NA
## [1] 2
## 
## 
## $`49`
## $`49`$min
## [1] 0
## 
## $`49`$max
## [1] 2
## 
## $`49`$pct_missing
## [1] 0.32
## 
## $`49`$first_NA
## [1] 2
## 
## 
## $`50`
## $`50`$min
## [1] 0
## 
```

```
## $`50`$max
## [1] 2
##
## $`50`$pct_missing
## [1] 0.34
##
## $`50`$first_NA
## [1] 1
```

- Set a seed and then create a vector v consisting of a sample of 1,000 iid normal realizations with mean -10 and variance 100.

```
set.seed(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
##    [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
## [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
## [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
```

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```
##    [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
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##    [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
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## [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
```

- 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
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##  [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
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##  [209] -21.100783063785 -19.499084208761  -8.042964192706 -11.296324270516
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```

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## [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
## [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
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## [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
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## [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
```

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## [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
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## [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
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## [497] -14.379240242927   0.322065338253   5.711308388404  12.256920288776
## [501] -14.555500962659 -19.493648190935 -11.719753718798  -2.162891902173
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## [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
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## [549] -10.921069394892   0.034455297857  -1.398068451037  -1.813306366622
## [553] -24.221095233032 -17.644869052896  -4.644207116310 -10.034738354643
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## [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
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## [577]  18.075192110328  -5.920883762827 -15.894704145439 -11.200164333395
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## [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
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## [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
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## [705] -12.810797570694  -7.704551155983 -17.643989538282  -7.912312788601
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## [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
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## [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
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## [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
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## [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
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## [853]  -1.699971459628   4.274093673272 -12.943019145814  -5.346004927162
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## [861]   7.418474128932  -6.881962690596   1.462574291375 -26.377141719257
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## [865]  -9.439039554436 -31.432286114822   9.296192256955  -7.278129105980
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## [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
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## [889]  -1.810246577249  -0.840016362101 -21.542492459438   1.406589479366
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## [909]  -5.133941747158 -27.271084932827  -8.189517366368 -13.783325527097
## [913]   0.775835008295 -24.924236717901   4.823427817493  -8.277910139633
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## [921]  -6.371823984003 -11.551026691417   0.166512808679  -1.478373083754
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## [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.