Lab 1

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

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

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

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

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

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

```
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 * ...`

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

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

Is this answer *exactly* correct?

Experienced a numerical underflow. Eventually the computer multiplied a small number by a even smaller number

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

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

```
## [1] -74691
```

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

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

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

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

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

Comment on the appropriateness of the non-numeric values.

Non numeric values occur when a function does not define an output for a given input. (i.e log(-1) = NA)

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

```
y <- x[is.finite(x) & !is.nan(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)
```

```
## integer(0)
```

- 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
```

```
which.min(y)
```

```
## [1] 50
```

```
which.max(y)
```

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

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

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

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

```
length(unique(y))
```

```
## [1] 50
```

- 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[is.finite(x) & !is.nan(x)])
```

```
##  [1] 4 4 4 4 4 4 4 4 4 4 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 2
## [39] 2 2 2 2 2 2 2 2 1 1 1 0
```

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

```
y <- x[is.finite(x) & !is.nan(x)]
```

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

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

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

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

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

```
## [1] 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(0.9,0.1)))
```

```
## [1] 0.09
```

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

```
mean(rbinom(1000, 1, c(0.9, 0.1)))
```

```
## [1] 0.504
```

- 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"), 100, replace=TRUE))
```

- 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"
```

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

```
x_3_ord <- as.factor(x_3)
lv <- c("none", "infraction", "misdimeanor", "felony")

x_3_ord <- factor(x_3, levels=lv, ordered=TRUE)
x_3_ord
```

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

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

```
a <- as.numeric(x_3_ord == "infraction")
b <- as.numeric(x_3_ord == "misdimeanor")
c <- as.numeric(x_3_ord == "felony")
z = c(a, b ,c)
z <- matrix(z, nrow=100, ncol=3)

head(z)
```

```
##      [,1] [,2] [,3]
## [1,]    0    1    0
## [2,]    1    0    0
## [3,]    0    0    0
## [4,]    0    0    1
## [5,]    0    0    0
## [6,]    1    0    0
```

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

Take a row and add each element of column and append it to a matrix global variable.

Verify that.

```
sums1 = matrix(NA, nrow = 1, ncol=nrow(z))

for (i in 1:nrow(z)) {

  sum1 <- 0

  #For each column index do sum
  for (j in 1:ncol(z)) {
```

```
    sum1 <- sum1 + z[i, j]

  }

  sums1[1,i] <- sum1

}

#sums1


#or

sums1 <- rowSums(z)
sums1
```

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

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

Take a column and add each element of row and append it to a matrix global variable.

Verify that.

```
sums1 = matrix(NA, nrow = 1, ncol=3)

for (j in 1:3) {

  sum1 <- 0

  #For each row index do sum
  for (i in 1:nrow(z)) {

    sum1 <- sum1 + z[i, j]

  }

  sums1[1,j] <- sum1
}

#sums1



#or

colSums(z)
```

```
## [1] 21 27 24
```

- 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"
)

a <-  rnorm(100, mean=17, sqrt(38))
b <-  runif(100, -10, 10)
c <-  rpois(100, 6)
d <-  rexp(100, 9)
e <-  rbinom(100, 20, prob=.12)
f <-  sample(c(0,1), 100, replace=TRUE, prob = c(1-.24, .24))


z <- matrix(c(a,b,c,d,e,f), nrow=100, ncol=6, byrow=FALSE)

rownames(z) <- fake_first_names

head(z)
```

```
##                   [,1]           [,2] [,3]           [,4] [,5] [,6]
## Sophia    5.5254997383 -2.12655299809    5 0.226709263415    1    0
## Emma     13.2149314377  8.02768824156    5 0.044510270728    3    0
## Olivia   27.6173504444  0.67036652938    6 0.029761390140    2    1
## Ava       9.2607754556 -9.45537828840    3 0.102753815354    3    1
## Mia      12.5159214907 -3.95529460628    3 0.008654872059    1    0
## Isabella  5.3157299149  4.48686417658    7 0.177954834566    1    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.

```
z1 <- data.frame(z)

for (i in 1 : nrow(z1)) {
```

```
  for(j in 1: ncol(z1)) {
    if (j == 6) {
      if (z1[i,j] == 1) z1[i,j] <- "FOREIGN"
      else z1[i,j] <- "DOMESTIC"
    }
  }
}

View(z1)
```

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

```
table(z[, ncol(z1)])
```

```
##
##  0  1
## 82 18
```

```
table(z1[, ncol(z1)])/nrow(z1)
```

```
##
## DOMESTIC  FOREIGN
##     0.82     0.18
```

Print out a summary of the whole dataframe.

```
summary(z1)
```

```
##        X1                  X2                  X3
##  Min.   : 3.6518263   Min.   :-9.9976087   Min.   : 1.00
##  1st Qu.:12.4279359   1st Qu.:-5.4489063   1st Qu.: 5.00
##  Median :16.8917099   Median :-2.1428592   Median : 6.00
##  Mean   :16.9832838   Mean   :-1.1559632   Mean   : 6.19
##  3rd Qu.:21.2454707   3rd Qu.: 3.8595016   3rd Qu.: 7.25
##  Max.   :34.3916371   Max.   : 9.6928934   Max.   :14.00
##        X4                    X5            X6
##  Min.   :0.0022537157   Min.   :0.00   Length:100
##  1st Qu.:0.0360274088   1st Qu.:1.00   Class :character
##  Median :0.0723064742   Median :2.00   Mode  :character
##  Mean   :0.1058796042   Mean   :2.33
##  3rd Qu.:0.1570614776   3rd Qu.:3.00
##  Max.   :0.5629222776   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.

```
n <- 50

z <- c(rep(0, n * n / 2), rep (1, n * n / 4), rep(2, n * n / 4))
```

```
z <- sample(z)
R <- matrix(z,nrow = n, ncol = n)

head(R)
```

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

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

```
for (i in 1:n) {
  for (j in 1:n) {
      if (runif(1) <= .30) {
        R[i,j] <- NA
      }
    }
}

head(R)
```

```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12] [,13] [,14]
## [1,]   NA   NA    0    1   NA    2    0    0   NA    NA    NA     0     1    NA
## [2,]    1    0    1    0   NA   NA    1    0    0     0     2    NA     0     2
## [3,]    0    0    2    0    0    2    1   NA    1     2    NA     1     1    NA
## [4,]   NA    1   NA   NA    1    0    0    0    2     0     0    NA     0    NA
```

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

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

```
z <- order(rowSums(R, na.rm = TRUE), decreasing = TRUE)
z
```

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

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

```
rows = apply(R, 1, sd, na.rm=TRUE)
rows2 = apply(R, 2, sd, na.rm=TRUE)

head(rows)
```

```
## [1] 0.67521402421 0.84334901040 0.82915619759 0.75377836144 0.83029750053
## [6] 0.84890218555
```

```
head(rows2)
```

```
## [1] 0.80229555709 0.65222452070 0.96430547933 0.90551882884 0.67680463660
## [6] 0.83333333333
```

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

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

```
##  [1] 14 13 16 14 13 21 17 17 18 22 17 13 17 14 25 20 14 23 27 19 14 18 21 18 16
## [26] 16 12 10 17 19 17 13 17 23 14 15 22 17 16 22 22 24 15 17 20 15 18 14 16 13
```

- 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`.

```
a <- split(R, col(R))
head(a)
```

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

```
func <- function(a) {
#  as.list( #concatenation is a list
    c(min = min(a, na.rm = TRUE),
    max = max(a, na.rm = TRUE),
    pct_missing = mean(is.na(a)),
    first_NA = which.min(is.na(a))
#    )
  )
}

a <-lapply(split(R, col(R)), func)
head(a)
```

```
## $`1`
##         min         max pct_missing    first_NA
##         0.0         2.0         0.4         2.0
##
## $`2`
##         min         max pct_missing    first_NA
##        0.00        2.00        0.28        2.00
##
## $`3`
##         min         max pct_missing    first_NA
##         0.0         2.0         0.4         1.0
##
## $`4`
##         min         max pct_missing    first_NA
##        0.00        2.00        0.32        1.00
##
## $`5`
##         min         max pct_missing    first_NA
##        0.00        2.00        0.38        3.00
##
## $`6`
##         min         max pct_missing    first_NA
##        0.00        2.00        0.28        1.00
```

- 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(1)
v <- rnorm(1000, -10, sqrt(100))

head(v)
```

```
## [1] -16.2645381074  -8.1635667578 -18.3562861241   5.9528080214  -6.7049222818
## [6] -18.2046838412
```

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

```
set.seed(1)
v <- rnorm(1000, -10, sqrt(100))

head(v)
```

```
## [1] -16.2645381074  -8.1635667578 -18.3562861241   5.9528080214  -6.7049222818
## [6] -18.2046838412
```

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

```
mean(v)
```

```
## [1] -10.116481419
```

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

```
## [1] 0.32726912404
```

- 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, 0.05)
```

```
##           5%
## -27.269599864
```

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

```
## [1] -27.139332146
```

- 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?

```
c <- ecdf(v)(0)
c
```

```
## [1] 0.842
```

```
#Generated
d <- pnorm(0, mean(v), sd(v))
d
```

```
## [1] 0.83584344242
```

```
#Theoretical
d <- pnorm(0, -10, sqrt(100))
d
```

```
## [1] 0.84134474607
```

```
#All three values generated are similarly. Therefore yes it is expected because v was generated using a
```