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# DSA Individual Assignment

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**Date**

18/12/2020

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# R – Introduction

R is an integrated suite of software facilities for data manipulation, calculation, and graphical display. It is an effecting data handling and storage facility.

## R – Basics

```
# For comments
# Shortcuts in R
# ctrl+Enter ---> For execute of code
# ctrl+ L  -----> Clearing the console window
# ctrl + 1 ------> shift cursor to R editor
# ctrl + 2 -----> shift cursor to console window

# creating simple objects and doing mathematical operations


# Assigning value to a variable

a = 5   # value 5 is assigned to variable a

# Printing value assigned to a variable
a       # Printing the value of variable a

## [1] 5

a <- 6  # This is also one way of assigning value to a variable
a

## [1] 6

scr = 'ggg'     # Assigning character data to a variable. It can be done u
sing either '' or ""
scr

## [1] "ggg"

scrr = "dggg"
scrr

## [1] "dggg"

print(class(a))     # Printing data type of variable a

## [1] "numeric"

print(class(scr))

## [1] "character"

print(class(scrr))

## [1] "character"
```

```r
# class defines the data type of variable

class(a)           # Printing data type of variable a

## [1] "numeric"

class(scr)

## [1] "character"

class(scrr)

## [1] "character"

# Performing mathematical operations

a - 8    # 8 is subtracted from value of variable a

## [1] -2

a

## [1] 6

b=TRUE
b

## [1] TRUE

class(b)

## [1] "logical"

c = 4
c

## [1] 4

a+c      # Adding two variables

## [1] 10

# Using if condition
if(b){
  a+c
}

## [1] 10

# Mathematical Operations
sqrt(c)

## [1] 2

c^a

## [1] 4096

exp(c)
```

```
## [1] 54.59815
```

```
factorial(a)
```

```
## [1] 720
```

```
abs(a)
```

```
## [1] 6
```

```
cos(a)
```

```
## [1] 0.9601703
```

## R – Functions

An R function is created by using the keyword function. In R, a function is an object so the R interpreter is able to pass control to the function, along with arguments that may be necessary for the function to accomplish the actions. The different parts of a function are function name, arguments, function body and return value.

```
# Function

# Divider is the name of function having two inputs
divider = function(x,y) {
  result = x/y
  result
}
divider(2,4)   # calling function for operation and providing two inputs f
or output
```

```
## [1] 0.5
```

```
multiplication = function(a,b) {
  output = a*b
  output
}
multiplication(2,4)
```

```
## [1] 8
```

```
# concat and arrays

fuc <- c(1,2,3,4,5)   # Creating vector---using c (combine)
fuc     # Printing the array
```

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

```
fuc + 10    # This will add 10 to all values  individually
```

```
## [1] 11 12 13 14 15
```

```
fuc*10
```

```
## [1] 10 20 30 40 50
```

```
k = c(1,2,3)
k = c(a,b,c)
k+1
```

```
## [1] 7 2 5
```

```
# Listing & deleting objects(variable)
ls()     # Listing all the variables created
```

```
## [1] "a"              "b"              "c"              "divider"
## [5] "fuc"            "k"              "multiplication" "scr"
## [9] "scrr"
```

```
rm(scr)    # Deleting the variable
ls()
```

```
## [1] "a"              "b"              "c"              "divider"
## [5] "fuc"            "k"              "multiplication" "scrr"
```

```
rm (list = ls())  # Remove all the variables
ls()
```

```
## character(0)
```

## R- Data Types and Vector

### Data Types

```
# Data types (Normal, Ordinal, Interval, Ratio)
# But in system it is (Numeric, Character, Logical, Date, Vector)

x= 10
class(x)
```

```
## [1] "numeric"
```

```
# Numeric-- Integer and Decimal
x = 10.54
class(x)
```

```
## [1] "numeric"
```

```
x = 10L       # to make it as a integer we have to add L
class(x)
```

```
## [1] "integer"
```

```
# L - Integer
is.integer(x)    # checking whether the data type of x is an integer or no
t
```

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

```
is.numeric(x)    # # checking whether the data type of x is an numeric or
not
```

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

```
# Character--- Categorical Variable- Nominal
s = "R studio"
class(s)
```

```
## [1] "character"
```

```
# Characters----words/strings(Nominal), Classification(Gender- Male, Femal
e)
# Level of Classification- Factors----Involves Levels(Ordinals)

# Logical
a = TRUE
class(a)
```

```
## [1] "logical"
```

```
is.logical(a)
```

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

```
# Date---- 1 Jan 1970
# POSIXct - Date plus Time
date = as.Date("2012-06-28")   # Format is yyyy-mm-dd
date
```

```
## [1] "2012-06-28"
```

```
class(date)
```

```
## [1] "Date"
```

```
as.numeric(date)
```

```
## [1] 15519
```

```
date = as.POSIXct("2020-11-22  10:32:25")   # Date + Time
date
```

```
## [1] "2020-11-22 10:32:25 IST"
```

```
as.numeric(date)
```

```
## [1] 1606021345
```

## Vectors

```
# Vector
# R is called as Vectorized language


# vectors
# A vector is collec tion of elements, all of same type.
# A vector canot be of mixed type.
# c- combine
```

```r
x = c(1,2,3,4,5,6,7,8,9,10) # Vector creation
x
```

```
##  [1]  1  2  3  4  5  6  7  8  9 10
```

```r
# Arithmetic Operations on Vector
x+1
```

```
##  [1]  2  3  4  5  6  7  8  9 10 11
```

```r
x-1
```

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

```r
c =x
c-1
```

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

```r
c^2
```

```
##  [1]   1   4   9  16  25  36  49  64  81 100
```

```r
sqrt(c)
```

```
##  [1] 1.000000 1.414214 1.732051 2.000000 2.236068 2.449490 2.645751 2.8
28427
##  [9] 3.000000 3.162278
```

```r
sqrt(c^2)
```

```
##  [1]  1  2  3  4  5  6  7  8  9 10
```

```r
sqrt(c^4)
```

```
##  [1]   1   4   9  16  25  36  49  64  81 100
```

```r
# Vector creation

a = 1:10   # This is also one method of creating vector . It will create s
equence of nos from staring no. to ending no.
a
```

```
##  [1]  1  2  3  4  5  6  7  8  9 10
```

```r
b = -5:4
b
```

```
##  [1] -5 -4 -3 -2 -1  0  1  2  3  4
```

```r
a+b   # Adding two vectors. Corresponding elements of one vector will be a
dded to another.
```

```
##  [1] -4 -2  0  2  4  6  8 10 12 14
```

```r
a*b
```

```
##  [1] -5 -8 -9 -8 -5  0  7 16 27 40
```

```r
length(a)   # length of vector
```

```
## [1] 10
```

```r
length(b)
```

```
## [1] 10
```

```r
a
```

```
##  [1]  1  2  3  4  5  6  7  8  9 10
```

```r
a + c(1,2)
```

```
##  [1]  2  4  4  6  6  8  8 10 10 12
```

```r
a+c(1,2,3,4)    # If Longer vector is not "multiple" of shorter vector, th
ere will be warning
```

```
## Warning in a + c(1, 2, 3, 4): longer object length is not a multiple of
shorter
## object length
```

```
##  [1]  2  4  6  8  6  8 10 12 10 12
```

```r
# Vector comparisons

a>5  # Checking whether vector values are greater than 5 or not
```

```
##  [1] FALSE FALSE FALSE FALSE FALSE  TRUE  TRUE  TRUE  TRUE  TRUE
```

```r
a>0
```

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

```r
a>b   # Checking whether vector values of a are greater than b or not
```

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

```r
a<b
```

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

```r
any(a<b)  # Checking whether any value of vector a is less than value of v
ector b. If there it will return true else false.
```

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

```r
a
```

```
##  [1]  1  2  3  4  5  6  7  8  9 10
```

```r
b
```

```
##  [1] -5 -4 -3 -2 -1  0  1  2  3  4
```

```r
any(a>b)
```

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

```r
any(a<b)
```

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

```r
all(a<b)   # Checking whether all value of vector a is less than value of
vector b. If all the values satisfied then it will return true else false.
```

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

```r
all(a>b)
```

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

```r
c = c('cricket','football','basketball','hockey','athletics')
nchar(c)    # defines the no. of characters
```

```
## [1]  7  8 10  6  9
```

```r
nchar(b)
```

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

```r
# Accessing individual elements in a vector

c[1]  # Accessing 1st element
```

```
## [1] "cricket"
```

```r
c[0]
```

```
## character(0)
```

```r
c[3]
```

```
## [1] "basketball"
```

```r
c[1:2]   # Accessing 1st to 2nd element
```

```
## [1] "cricket"  "football"
```

```r
c[1:4]
```

```
## [1] "cricket"    "football"   "basketball" "hockey"
```

```r
c[c(1,4)]    # Accessing 1st and 4th element
```

```
## [1] "cricket" "hockey"
```

```r
# Assigning names to a vector
d = c(q='one', w='two',e='three')
d
```

```
##       q       w       e
##   "one"   "two" "three"
```

```r
d[1]
```

```
##     q
## "one"
```

```
d[1:4]
```

```
##       q       w       e    <NA> 
##   "one"   "two" "three"      NA
```

```
e = c(1:10, 20)  # Vector creation
e
```

```
##  [1]  1  2  3  4  5  6  7  8  9 10 20
```

```
s = 1:3
s
```

```
## [1] 1 2 3
```

```
# Assigning names after creation of vector
names(s)= c('one','two','three')
s
```

```
##   one   two three 
##     1     2     3
```

## Factors, Data Structure and Missing Values

### Factors

```
# Factors- Ordinal data

q1 = c(c,'javellin','volleyball','shooting')
length(q1)
```

```
## [1] 8
```

```
q1
```

```
## [1] "cricket"    "football"   "basketball" "hockey"     "athletics" 
## [6] "javellin"   "volleyball" "shooting"
```

```
q2 = c(q1,'hockey','cricket','badland')
q2
```

```
##  [1] "cricket"    "football"   "basketball" "hockey"     "athletics" 
##  [6] "javellin"   "volleyball" "shooting"   "hockey"     "cricket"   
## [11] "badland"
```

```
q2_F = as.factor(q2)    # Select only unique value, removes dulplicate
q2_F
```

```
##  [1] cricket    football   basketball hockey     athletics  javellin  
##  [7] volleyball shooting   hockey     cricket    badland   
## 9 Levels: athletics badland basketball cricket football hockey ... voll
eyball
```

```
class(q2)
```

```
## [1] "character"
```

```r
as.numeric(q2_F)  # assigning unique integer to each value(based on alphab
etical order)
```

```
##  [1] 4 5 3 6 1 7 9 8 6 4 2
```

## Data Structure

```r
# Data Structure
# DATA frame
# In Data Frame each individual column is a vector of same length. Each co
lumn can hold different types of data. In one column data type should be s
ame.

x = 10:1 # Vector
y = -4:5
z = c("Hockey","Football", "Cricket","vollleyball","xtx","gfygg","ggfgg","
kkkkk","llll","oooo")
# Creating Data frame from multiple vectors
w = data.frame(x,y,z)  # x,y,z will be three columns
w
```

```
##     x  y           z
## 1  10 -4      Hockey
## 2   9 -3    Football
## 3   8 -2     Cricket
## 4   7 -1 vollleyball
## 5   6  0         xtx
## 6   5  1       gfygg
## 7   4  2       ggfgg
## 8   3  3       kkkkk
## 9   2  4        llll
## 10  1  5        oooo
```

```r
str(w)   # structure of the data frame. It tells how many columns are ther
e and their data type
```

```
## 'data.frame':    10 obs. of  3 variables:
##  $ x: int  10 9 8 7 6 5 4 3 2 1
##  $ y: int  -4 -3 -2 -1 0 1 2 3 4 5
##  $ z: chr  "Hockey" "Football" "Cricket" "vollleyball" ...
```

```r
z = as.factor(z)
w = data.frame(First=x, Second=y, Third=z) # Naming the columns
w
```

```
##    First Second       Third
## 1     10     -4      Hockey
## 2      9     -3    Football
## 3      8     -2     Cricket
## 4      7     -1 vollleyball
## 5      6      0         xtx
## 6      5      1       gfygg
## 7      4      2       ggfgg
## 8      3      3       kkkkk
```

```
## 9      2      4        llll
## 10     1      5        oooo
```

```
# Checking the Dimension of Data Frame
```

```
nrow(w)  # No. of Rows
```

```
## [1] 10
```

```
ncol(w)  # No. of Columns
```

```
## [1] 3
```

```
dim(w)   # Rows * Column
```

```
## [1] 10  3
```

```
names(w)  # Names of columns
```

```
## [1] "First"  "Second" "Third"
```

```
rownames(w) # Row Names
```

```
##  [1] "1"  "2"  "3"  "4"  "5"  "6"  "7"  "8"  "9"  "10"
```

```
names(w)[3]  # Selecting individual column name
```

```
## [1] "Third"
```

```
# Head and Tail
```

```
head(w)   # Print First 6 rows
```

```
##   First Second       Third
## 1    10     -4      Hockey
## 2     9     -3    Football
## 3     8     -2     Cricket
## 4     7     -1 vollleyball
## 5     6      0         xtx
## 6     5      1       gfygg
```

```
head(w, n=7)   # Print First 7 rows
```

```
##   First Second       Third
## 1    10     -4      Hockey
## 2     9     -3    Football
## 3     8     -2     Cricket
## 4     7     -1 vollleyball
## 5     6      0         xtx
## 6     5      1       gfygg
## 7     4      2       ggfgg
```

```
tail(w)  # Print last 6 rows
```

```
##    First Second Third
## 5      6      0   xtx
## 6      5      1 gfygg
## 7      4      2 ggfgg
```

```
## 8      3      3 kkkkk
## 9      2      4  llll
## 10     1      5  oooo
```

```
class(w)
```

```
## [1] "data.frame"
```

```
# Accessing individual column
w$Third
```

```
##  [1] Hockey      Football    Cricket     vollleyball xtx         gfygg
##  [7] ggfgg       kkkkk       llll        oooo
## 10 Levels: Cricket Football gfygg ggfgg Hockey kkkkk llll oooo ... xtx
```

```
# Accessing Specific row and column
w[3,2] # 3rd row and 2nd Column
```

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

```
w[3,2:3] # 3rd Row and column 2 through 3
```

```
##   Second   Third
## 3     -2 Cricket
```

```
w[c(3,5), 2]# Row 3&5 , Column 2;
```

```
## [1] -2  0
```

## Missing Values

```
# Missing data in a vector

x = c(1,2,3,NA,5,6,NA,8)
x
```

```
## [1]  1  2  3 NA  5  6 NA  8
```

```
length(x)
```

```
## [1] 8
```

```
is.na(x)
```

```
## [1] FALSE FALSE FALSE  TRUE FALSE FALSE  TRUE FALSE
```

```
x = c(1,2,3,NA,5,6,NA,8,NULL,10)  # NA means data not available there it w
ill be counted in length but NULL means blank it will not be counted in le
ngth
x
```

```
## [1]  1  2  3 NA  5  6 NA  8 10
```

```
class(x)
```

```
## [1] "numeric"
```

```r
length(x)
```

```
## [1] 9
```

```r
is.null(x)
```

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

```r
y = c('hockey',NA,'cricket')
y
```

```
## [1] "hockey"  NA        "cricket"
```

```r
class(y)
```

```
## [1] "character"
```

```r
is.na(y)
```

```
## [1] FALSE  TRUE FALSE
```

```r
z = c(1,NULL,2)
z
```

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

```r
is.null(z)
```

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

## Matrices Arrays Lists and Loading data into R

## Matrices

```r
# Matrix

A = matrix(1:10, nrow = 5) # Create a 5x2 matrix
A
```

```
##      [,1] [,2]
## [1,]    1    6
## [2,]    2    7
## [3,]    3    8
## [4,]    4    9
## [5,]    5   10
```

```r
B = matrix(21:30, nrow = 5)
B
```

```
##      [,1] [,2]
## [1,]   21   26
## [2,]   22   27
## [3,]   23   28
## [4,]   24   29
## [5,]   25   30
```

```r
C = matrix(21:40, nrow = 2) # Create a 2x10 matrix
C
```

```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]
## [1,]   21   23   25   27   29   31   33   35   37    39
## [2,]   22   24   26   28   30   32   34   36   38    40
```

```r
A+B   # Matrix Addition
```

```
##      [,1] [,2]
## [1,]   22   32
## [2,]   24   34
## [3,]   26   36
## [4,]   28   38
## [5,]   30   40
```

```r
A*B   # A = 5*2 B = 5*2
```

```
##      [,1] [,2]
## [1,]   21  156
## [2,]   44  189
## [3,]   69  224
## [4,]   96  261
## [5,]  125  300
```

```r
A==B  # checking whether elements are equal
```

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

```r
# Matrix Multiplication
A %*% t(B)   # A is 5x2. B is 5x2. B-transpose is 2x5
```

```
##      [,1] [,2] [,3] [,4] [,5]
## [1,]  177  184  191  198  205
## [2,]  224  233  242  251  260
## [3,]  271  282  293  304  315
## [4,]  318  331  344  357  370
## [5,]  365  380  395  410  425
```

```r
# Naming the Columns and Rows
colnames(A)    # Printing columns names of matrix A
```

```
## NULL
```

```r
rownames(A)
```

```
## NULL
```

```r
colnames(A)= c("Left","Right")    # Assigning column names
rownames(A)= c("1st","2nd","3rd","4th","5th")
colnames(B)
```

```
## NULL
```

```
rownames(B)
```

```
## NULL
```

```
colnames(B)= c("First","Second")
rownames(B)= c("One","Two","Three","Four","Five")
colnames(C)
```

```
## NULL
```

```
rownames(C)
```

```
## NULL
```

```
colnames(C) = LETTERS [1:10]
rownames(C) = c("Top", "Bottom")

dim(A)
```

```
## [1] 5 2
```

```
dim(C)
```

```
## [1]  2 10
```

```
t(A)
```

```
##       1st 2nd 3rd 4th 5th
## Left    1   2   3   4   5
## Right   6   7   8   9  10
```

```
A %*% C
```

```
##       A   B   C   D   E   F   G   H   I   J
## 1st 153 167 181 195 209 223 237 251 265 279
## 2nd 196 214 232 250 268 286 304 322 340 358
## 3rd 239 261 283 305 327 349 371 393 415 437
## 4th 282 308 334 360 386 412 438 464 490 516
## 5th 325 355 385 415 445 475 505 535 565 595
```

## Arrays

```
# Arrays
# It is a multi-dimensional vector
a1 = array(1:12, dim = c(2,3,2))  # First element is Row Index, Second Ele
ment is Column Index and third element is outer dimension
a1
```

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

```
## , , 2
##
##      [,1] [,2] [,3]
## [1,]    7    9   11
## [2,]    8   10   12
```

```
a1 = array(1:12, dim = c(2,3,1))
a1
```

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

```
a1 = array(1:12, dim = c(2,6,2))
a1
```

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

```
a1 = array(1:12, dim = c(2,6,1))
a1
```

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

```
a1[,,1]  # Accessing 1st outer Dimension
```

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

```
a1[1,2,]  # Accessing 1st row 2nd column in both the dimensions
```

```
## [1] 3
```

```
a1 = array(1:12, dim = c(2,3,3))   # Since after 2nd dim all nos are taken
therefore it will repeat as in 1st dimension
a1
```

```
## , , 1
##
##      [,1] [,2] [,3]
```

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

```
a1 = array(1:12, dim = c(2,3,2))
a1
```

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

```
a1[1,,]   # Accessing 1st row in both the dimension
```

```
##      [,1] [,2]
## [1,]    1    7
## [2,]    3    9
## [3,]    5   11
```

### Lists

```
# List
# It Stores any number of items of any type.
a2 = list(1,2,3)  # Creating 3 element list
a2
```

```
## [[1]]
## [1] 1
##
## [[2]]
## [1] 2
##
## [[3]]
## [1] 3
```

```r
a3 = list(c(1,2,3))  # Creating single element list(a vector)
a3
```

```
## [[1]]
## [1] 1 2 3
```

```r
a4 = list(c(1,2,3), 4:7)  # Creating 2 element list-- 1st element a 3 elem
ent vector, 2nd element a 4 element vector
a4
```

```
## [[1]]
## [1] 1 2 3
##
## [[2]]
## [1] 4 5 6 7
```

```r
a5 = list(w,1:10)   # Creating list--1st element a data frame, 2nd a vecto
r of 10 elements
a6 = list(w,a2,a3)

#Naming List (similar to column name in data.frame)
names(a5)= c("data.frame", "vector")
names(a5)
```

```
## [1] "data.frame" "vector"
```

```r
a5
```

```
## $data.frame
##    First Second       Third
## 1     10     -4      Hockey
## 2      9     -3    Football
## 3      8     -2     Cricket
## 4      7     -1 vollleyball
## 5      6      0         xtx
## 6      5      1       gfygg
## 7      4      2       ggfgg
## 8      3      3       kkkkk
## 9      2      4        llll
## 10     1      5        oooo
##
## $vector
##  [1]  1  2  3  4  5  6  7  8  9 10
```

```r
#Naming using "Name-Value" pair
a6 = list(DataFrame = w, Vector = a2, vector1 = a3)
names(a6)
```

```
## [1] "DataFrame" "Vector"    "vector1"
```

```r
a6
```

```
## $DataFrame
##    First Second       Third
## 1     10     -4      Hockey
## 2      9     -3    Football
```

```
## 3      8     -2     Cricket
## 4      7     -1 vollleyball
## 5      6      0         xtx
## 6      5      1       gfygg
## 7      4      2       ggfgg
## 8      3      3       kkkkk
## 9      2      4        llll
## 10     1      5        oooo
##
## $Vector
## $Vector[[1]]
## [1] 1
##
## $Vector[[2]]
## [1] 2
##
## $Vector[[3]]
## [1] 3
##
##
## $vector1
## $vector1[[1]]
## [1] 1 2 3
```

```
# Creating an empty list
(emptylist = vector(mode="list", length =4))
```

```
## [[1]]
## NULL
##
## [[2]]
## NULL
##
## [[3]]
## NULL
##
## [[4]]
## NULL
```

```
# LENGTH OF LIST
length(a6)
```

```
## [1] 3
```

```
# Accessing elements
a6[[1]]   # Accessing 1st element
```

```
##    First Second       Third
## 1     10     -4      Hockey
## 2      9     -3    Football
## 3      8     -2     Cricket
## 4      7     -1 vollleyball
## 5      6      0         xtx
## 6      5      1       gfygg
## 7      4      2       ggfgg
```

```
## 8      3      3       kkkkk
## 9      2      4        llll
## 10     1      5        oooo
```

```
a6[["DataFrame"]] # Accessing elements using names
```

```
##    First Second       Third
## 1     10     -4      Hockey
## 2      9     -3    Football
## 3      8     -2     Cricket
## 4      7     -1 vollleyball
## 5      6      0         xtx
## 6      5      1       gfygg
## 7      4      2       ggfgg
## 8      3      3       kkkkk
## 9      2      4        llll
## 10     1      5        oooo
```

```
a6[[1]]$Third    # Accessing column with name from 1st elements
```

```
##  [1] Hockey      Football    Cricket     vollleyball xtx         gfygg
##  [7] ggfgg       kkkkk       llll        oooo
## 10 Levels: Cricket Football gfygg ggfgg Hockey kkkkk llll oooo ... xtx
```

```
a6[[1]][,"Second"]
```

```
##  [1] -4 -3 -2 -1  0  1  2  3  4  5
```

```
a6[[1]][,"Second", drop = FALSE]
```

```
##    Second
## 1      -4
## 2      -3
## 3      -2
## 4      -1
## 5       0
## 6       1
## 7       2
## 8       3
## 9       4
## 10      5
```

## Loading data into R

```
# Loading data into R

b1 = "http://www.jaredlander.com/data/Tomato%20First.csv"  # Loading csv f
ile from the path
b2 = read.table(file=b1,header = TRUE, sep = ",")    # Read the csv file l
oaded in b1.  # header means 1st row it will consider it as header else it
will assign own header name
head(b2)
```

```
##   Round             Tomato Price      Source Sweet Acid Color Texture O
verall
## 1     1         Simpson SM  3.99 Whole Foods   2.8  2.8   3.7     3.4
3.4
## 2     1  Tuttorosso (blue)  2.99     Pioneer   3.3  2.8   3.4     3.0
2.9
## 3     1 Tuttorosso (green)  0.99     Pioneer   2.8  2.6   3.3     2.8
2.9
## 4     1     La Fede SM DOP  3.99   Shop Rite   2.6  2.8   3.0     2.3
2.8
## 5     2       Cento SM DOP  5.49  D Agostino   3.3  3.1   2.9     2.8
3.1
## 6     2      Cento Organic  4.99  D Agostino   3.2  2.9   2.9     3.1
2.9
##   Avg.of.Totals Total.of.Avg
## 1          16.1         16.1
## 2          15.3         15.3
## 3          14.3         14.3
## 4          13.4         13.4
## 5          14.4         15.2
## 6          15.5         15.1
```

```
# Reading Text Files
Garden = read.table("C:/Users/Sneha/Downloads/R-Test.txt",header=TRUE,sep=
"")
head(Garden)
```

```
##   Name ID
## 1  aaa 10
## 2  bbb 20
## 3  ccc 30
## 4  ddd 40
## 5  eee 50
## 6  fff 60
```

```
#R Binary Files
# save the tomato data.frame to Disk
save(b2, file="E:\\R\\4-Data Structure\\R-Test.rdata")
# remove tomato from memory
rm(b2)
# Check if it still exists
#head(b2)
# read it from the rdata file
load("E:\\R\\4-Data Structure\\R-Test.rdata")
head(b2)
```

```
##   Round             Tomato Price      Source Sweet Acid Color Texture O
verall
## 1     1         Simpson SM  3.99 Whole Foods   2.8  2.8   3.7     3.4
3.4
## 2     1  Tuttorosso (blue)  2.99     Pioneer   3.3  2.8   3.4     3.0
2.9
## 3     1 Tuttorosso (green)  0.99     Pioneer   2.8  2.6   3.3     2.8
2.9
## 4     1     La Fede SM DOP  3.99   Shop Rite   2.6  2.8   3.0     2.3
```

```
2.8
## 5     2       Cento SM DOP  5.49  D Agostino   3.3  3.1   2.9     2.8
3.1
## 6     2      Cento Organic  4.99  D Agostino   3.2  2.9   2.9     3.1
2.9
##   Avg.of.Totals Total.of.Avg
## 1          16.1         16.1
## 2          15.3         15.3
## 3          14.3         14.3
## 4          13.4         13.4
## 5          14.4         15.2
## 6          15.5         15.1
```

```
# Read data from anywhere in the Disk/Computer
#myData = read.csv(file.choose()) # No working directory setup is needed
```

# R – Statistics

## Mean, Variance and Standard Deviation

```
# Basic statistics

# Generate a random sample of 100 numbers between 1 and 100
x = sample(x=1:100, size = 100,replace = TRUE)  # Duplicate values present
x
```

```
##   [1] 90 76 55 85 23 78 64 98 77 43 47 65 89 28 19 45 98 88 36 86 14 32
91 17 44
##  [26]  5  3 21 21 74 32 33 68 97 73 37 19 77 29 83 21 89 43 70 53 46 64
12 85 42
##  [51] 92 36 22 81 98 95 38 45 56 82 19 60 92 25 32  4 31  1 37 94 61 29
27 95 91
##  [76] 28 76 58 91 93 70 34 68 84 46 30 12 13  8 95 85 79 63 45 53 11 54
65 22 90
```

```
x = sample(x=1:100, size = 100,replace = FALSE) # Unique values
x
```

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

```
mean(x)  # Calculating Mean
```

```
## [1] 50.5
```

```r
y = x
y = sample(x=1:100, size = 20, replace = FALSE)
y
```

```
##  [1] 38 79 74 24 72 30 61  9 70  5 62 93 80 83 40 17 96 73 87 32
```

```r
mean(y)
```

```
## [1] 56.25
```

```r
y = sample(x, size = 20, replace = FALSE)
y
```

```
##  [1] 16 86 87 42 21 94 95 19 47 45 13 57 43 20 65  5 36 91 78 24
```

```r
mean(y)
```

```
## [1] 49.2
```

```r
z=x
z[sample(x=1:100, size = 20, replace = FALSE)] = NA  # 20 values will be N
A in a sample of 100.
z
```

```
##   [1]  67  15  50  NA  37  46  40 100  87  45  79  63  NA  31  23  86
17  70
##  [19]  89  NA  NA  NA   4  59  NA   6   7  18   9  68  57  44  61  NA
92  54
##  [37]  33  90  66  62  51  91  55  43  26  34  96  80  75  22  20  NA
77   8
##  [55]  NA  30  NA  74  94  38  NA  97  11  64   1  83  52  NA  NA  NA
95  NA
##  [73]  49  NA  41  42  76  NA  71  73  32  NA  88  10  25  14  84  78
28  NA
##  [91]  36  13  12  29  82  35   5  53  NA  21
```

```r
mean(z)
```

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

```r
mean(z, na.rm=TRUE) # To calculate mean of sample containing NA value. We
have to remove NA from sample.
```

```
## [1] 49.8625
```

```r
# Weighted means
grades = c(10,20,30,40)
weights = c(1/2,1/4,1/8,1/8)
weighted.mean(x= grades, w= weights)  # Weighted Mean
```

```
## [1] 18.75
```

```r
#Variance
var(y)
```

```
## [1] 927.5368
```

```r
# Variance using formula
sum((y- mean(y))^2)/ (length(y)-1)
```

```
## [1] 927.5368
```

```r
# Standard Deviation
sqrt(var(y))
```

```
## [1] 30.45549
```

```r
sd(y)
```

```
## [1] 30.45549
```

```r
sd(z)
```

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

```r
sd(z, na.rm= TRUE)
```

```
## [1] 28.76564
```

```r
# Other Commonly Used Functions
min(x)   # Minimum value of sample
```

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

```r
max(x)   # Maximum value of sample
```

```
## [1] 100
```

```r
median(x)   # Median of Sample
```

```
## [1] 50.5
```

```r
min(z)
```

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

```r
min(z, na.rm=TRUE)
```

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

```r
# Summary Statistics
summary(x)  # Irt will give Min, Max, Mean, median 1st and 3rd Quantile.
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    1.00   25.75   50.50   50.50   75.25  100.00
```

```r
summary(y)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    5.00   20.75   44.00   49.20   80.00   95.00
```

```r
# Quantiles
quantile(y, probs = c(0.25, 0.75)) # Calculate 25th and 75th Quantile
```

```
##   25%   75%
## 20.75 80.00
```

```r
quantile(y, probs = c(0.1,0.25,0.5, 0.75,0.99))
```

```
##   10%   25%   50%   75%   99%
## 15.70 20.75 44.00 80.00 94.81
```

```r
quantile(z, probs = c(0.25, 0.75), na.rm = TRUE)
```

```
##   25%   75%
## 25.75 75.25
```

```r
# Package Installation
# install.packages("ggplot2")
library(ggplot2)
```

## Hypothesis Testing – T – Test

A t-test is used as a hypothesis testing tool, which allows testing of an assumption applicable to a population. A t-test is a type of inferential statistic used to determine if there is a significant difference between the means of two groups, which may be related in certain features. It is mostly used when the data sets, like the data set recorded as the outcome from flipping a coin 100 times, would follow a normal distribution and may have unknown variances.

## One Sample T – Test

```r
# T-tests

data(tips, package = "reshape2")   # Loading Datasets from Package
head(tips)    # Printing 1st6 rows of Dataset
```

```
##   total_bill  tip    sex smoker day   time size
## 1      16.99 1.01 Female     No Sun Dinner    2
## 2      10.34 1.66   Male     No Sun Dinner    3
## 3      21.01 3.50   Male     No Sun Dinner    3
## 4      23.68 3.31   Male     No Sun Dinner    2
## 5      24.59 3.61 Female     No Sun Dinner    4
## 6      25.29 4.71   Male     No Sun Dinner    4
```

```r
str(tips)    # Print the structure of Dataset
```

```
## 'data.frame':    244 obs. of  7 variables:
##  $ total_bill: num  17 10.3 21 23.7 24.6 ...
##  $ tip       : num  1.01 1.66 3.5 3.31 3.61 4.71 2 3.12 1.96 3.23 ...
##  $ sex       : Factor w/ 2 levels "Female","Male": 1 2 2 2 1 2 2 2 2 2
...
##  $ smoker    : Factor w/ 2 levels "No","Yes": 1 1 1 1 1 1 1 1 1 1 ...
##  $ day       : Factor w/ 4 levels "Fri","Sat","Sun",..: 3 3 3 3 3 3 3 3
3 3 ...
##  $ time      : Factor w/ 2 levels "Dinner","Lunch": 1 1 1 1 1 1 1 1 1 1
...
##  $ size      : int  2 3 3 2 4 4 2 4 2 2 ...
```

```r
write.csv(tips, "E:/R/5-Statistics/tips.csv", row.names = FALSE)   # Savin
g csv file into location. Without any arbitrary row names.
```

```r
# Selecting unique values from a column
unique(tips$sex)
```

```
## [1] Female Male
## Levels: Female Male
```

```r
unique(tips$day)
```

```
## [1] Sun  Sat  Thur Fri
## Levels: Fri Sat Sun Thur
```

```r
#One Sample t-test - ONE GROUP [Two Tail. Ho:Mean = 2.5]
t.test(tips$tip, alternative = "two.sided", mu=2.5)
```

```
##
##  One Sample t-test
##
## data:  tips$tip
## t = 5.6253, df = 243, p-value = 5.08e-08
## alternative hypothesis: true mean is not equal to 2.5
## 95 percent confidence interval:
##  2.823799 3.172758
## sample estimates:
## mean of x
##  2.998279
```

**Here in this example consider alpha = 0.05, but p-value = 5.08e-08 which means that p – value is less than alpha therefore we reject the null hypothesis.**

```r
#One Sample t-test - Upper Tail. Ho:Mean LE 2.5
t.test(tips$tip, alternative = "greater", mu=2.5)
```

```
##
##  One Sample t-test
##
## data:  tips$tip
## t = 5.6253, df = 243, p-value = 2.54e-08
## alternative hypothesis: true mean is greater than 2.5
## 95 percent confidence interval:
##  2.852023      Inf
## sample estimates:
## mean of x
##  2.998279
```

**Here in this example consider alpha = 0.05, but p-value = 2.54e-08 which means that p – value is less than alpha therefore we reject the null hypothesis.**

## Two Sample T- Test

```
# Two Sample T-test - TWO GROUP
t.test(tip ~ sex, data = tips, var.equal = TRUE)
```

```
##
##  Two Sample t-test
##
## data:  tip by sex
## t = -1.3879, df = 242, p-value = 0.1665
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.6197558  0.1074167
## sample estimates:
## mean in group Female   mean in group Male
##             2.833448             3.089618
```

**Here in this example consider alpha = 0.05, but p-value = 0.1665 which means that p – value is greater than alpha therefore we do not reject the null hypothesis.**

```
#Paired- Two-Sample T-Test
# install.packages("UsingR")
require(UsingR)
```

```
## Loading required package: UsingR
```

```
## Loading required package: MASS
```

```
## Loading required package: HistData
```

```
## Loading required package: Hmisc
```

```
## Loading required package: lattice
```

```
## Loading required package: survival
```

```
## Loading required package: Formula
```

```
##
## Attaching package: 'Hmisc'
```

```
## The following objects are masked from 'package:base':
##
##     format.pval, units
```

```
##
## Attaching package: 'UsingR'
```

```
## The following object is masked _by_ '.GlobalEnv':
##
##     grades
```

```
## The following object is masked from 'package:survival':
##
##     cancer
```

```
head(father.son)
```

```
##    fheight  sheight
## 1 65.04851 59.77827
## 2 63.25094 63.21404
## 3 64.95532 63.34242
## 4 65.75250 62.79238
## 5 61.13723 64.28113
## 6 63.02254 64.24221
```

```
write.csv(father.son, "E:\\R\\5-Statistics\\father_son.csv", row.names = FALSE)
```

## Anova

```
#ANOVA  - Comparing Multiple Samples
str(tips)
```

```
## 'data.frame':    244 obs. of  7 variables:
##  $ total_bill: num  17 10.3 21 23.7 24.6 ...
##  $ tip       : num  1.01 1.66 3.5 3.31 3.61 4.71 2 3.12 1.96 3.23 ...
##  $ sex       : Factor w/ 2 levels "Female","Male": 1 2 2 2 1 2 2 2 2 2
...
##  $ smoker    : Factor w/ 2 levels "No","Yes": 1 1 1 1 1 1 1 1 1 1 ...
##  $ day       : Factor w/ 4 levels "Fri","Sat","Sun",..: 3 3 3 3 3 3 3 3
3 3 ...
##  $ time      : Factor w/ 2 levels "Dinner","Lunch": 1 1 1 1 1 1 1 1 1 1
...
##  $ size      : int  2 3 3 2 4 4 2 4 2 2 ...
```

```
tipAnova = aov(tip ~ day, tips)   # Comparing different samples, i.e there are 4 days in tips therefore there will be 4 samples regarding that.
summary(tipAnova)
```

```
##              Df Sum Sq Mean Sq F value Pr(>F)
## day           3    9.5   3.175   1.672  0.174
## Residuals   240  455.7   1.899
```

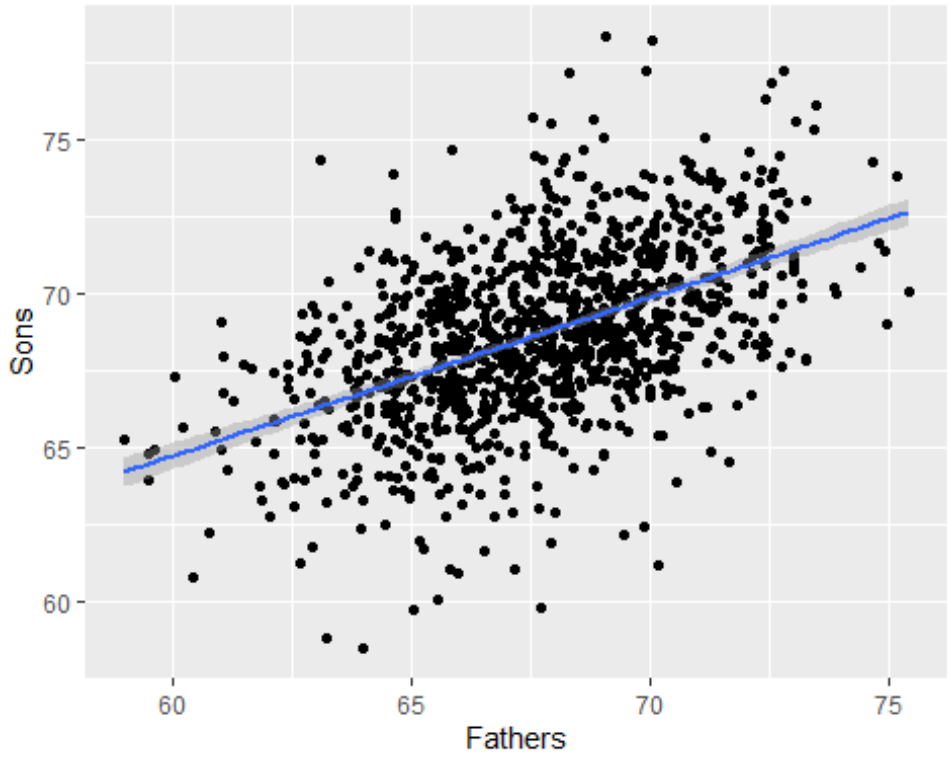
## Simple Linear Regression

```
# Simple Linear Regression (SLR)
# Using fathers' heights to predit sons' heights using SLR.
# Fathers height as predictor(Indep - X) and
# Son's height as the response /Target(Dep - Y)
require(UsingR)
require(ggplot2)
head(father.son)
```

```
##    fheight  sheight
## 1 65.04851 59.77827
## 2 63.25094 63.21404
## 3 64.95532 63.34242
## 4 65.75250 62.79238
## 5 61.13723 64.28113
## 6 63.02254 64.24221
```

```
ggplot(father.son, aes(x=fheight, y=sheight))+geom_point()+
  geom_smooth(method="lm")+labs(x="Fathers", y="Sons")
```

```
## `geom_smooth()` using formula 'y ~ x'
```




```
heightsLM = lm(sheight ~ fheight, data = father.son)
heightsLM
```

```
##
## Call:
## lm(formula = sheight ~ fheight, data = father.son)
##
## Coefficients:
## (Intercept)      fheight
##     33.8866       0.5141
```

```
summary(heightsLM)
```

```
##
## Call:
## lm(formula = sheight ~ fheight, data = father.son)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
```

```
## -8.8772 -1.5144 -0.0079  1.6285  8.9685
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 33.88660    1.83235   18.49   <2e-16 ***
## fheight      0.51409    0.02705   19.01   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.437 on 1076 degrees of freedom
## Multiple R-squared:  0.2513, Adjusted R-squared:  0.2506
## F-statistic: 361.2 on 1 and 1076 DF,  p-value: < 2.2e-16
```

## Learnings from the Assignment

- R is a vectorized language.
- R is case sensitive.
- R is a collection of libraries designed for data science.
- R executes code line by line.