Ashutosh Sharma & 200102014

DSA Individual Assignment

Submitted To:

Prof. (Dr.) Sridhar Vaithianathan,

Associate Professor (Analytics).

IMT - Hyderabad.

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Table of Contents

200102014

Ashutosh Sharma

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```
# Creating Simple Objects and Doing Mathematical Calculation
v = 5
# 1. Command Line Interface
v
```

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

```
z = 10
z
```

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

```
# 2. object need not be explicitly defined.
v = 5
class(v)
```

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

```
v = "Hello"
class(v)
```

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

```
v = TRUE
class(v)
```

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

```
v = FALSE
class (v)
```

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

```
# Object Assignments and Simple Calculations
v = 10
w = 15
v+w
```

```
## [1] 25
```

```
v-w
```

```
## [1] -5
```

```
v*w
```

```
## [1] 150
```

```
v/w
```

```
## [1] 0.6666667
```

```
sqrt(v)
```

```
## [1] 3.162278
```

```
v^w
```

```
## [1] 1e+15
```

```
exp(v)
```

```
## [1] 22026.47
```

```
log(v, base=exp(1))
```

```
## [1] 2.302585
```

```
log10(v)
```

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

```
factorial(v)
```

```
## [1] 3628800
```

```
cos(v)
```

```
## [1] -0.8390715
```

```
abs(v)
```

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

```
There is no need for declaring the variables like in other languages
```

TypesofData

```
# line by Line Execution of command - Compiler
# Not explicitly declaring variables.

#A = 10
#Variable /Object -- > A (Case Sensitive)
#Value = 10
#Read from right to left.
# <- or = # Assignment.
# Simple Mathematical Operations.
# Remove the objects or variables created.

# DATA TYPES. (Nominal , Ordinal, Interval and Ratio)
# Self (NOIR) and System (Numeric, Character, Logical, Date, Vector). (Two
Brains).
```

```r
# DATA TYPES
x = 10
class(x)
```

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

```r
# Numeric - Integer and Decimal - (R)- Integer (Whole Number) and Numeric
(Float - Decimal)
i = 5L # L - Integer
class(i)
```

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

```r
is.integer(i)
```

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

```r
is.numeric(x)
```

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

```r
# Character - Categorical Variable - Words/String (Nominal), Classification
(Gender - Male , Female)
s = "R_Studio"
class(s)
```

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

```r
# Levels of Classification - Factor --- Involves levels.(Ordinal)
# Eg: Edu Quali - X, XII, Graduation, Post Graduation (4 Levels)

# Logical - TRUE (1) and FALSE (0)
TRUE * 5
```

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

```r
FALSE * 5
```

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

```r
K = TRUE
class(K)
```

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

```r
is.logical(K)
```

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

```r
# Date - Starting Date (1970) - Numeric Value.
# In R - 1 Jan 1970
# Date - mm/dd/yyyy
# POSIXct - Date plus Time.
```

```r
date1 = as.Date("2012-06-28")
# as.Date()# Auto complete # How to enter
# ? as.Date # help
date1
```

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

```r
class (date1)
```

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

```r
as.numeric(date1)
```

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

```r
#POSIXct - Date and Time
date2 = as.POSIXct("2012-06-28 17:42")
date2
```

```
## [1] "2012-06-28 17:42:00 IST"
```

```r
class(date2)
```

```
## [1] "POSIXct" "POSIXt"
```

```r
as.numeric(date2)
```

```
## [1] 1340885520
```

Main data types that we are going to use include Numeric and String

IntrotoR

```r
getwd()
```

```
## [1] "C:/Users/ash95/Desktop/Term 2/DSA/Assignment/R Code"
```

```r
a=2
a
```

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

Functions in R

```r
# Functions in R
divider = function(x,y) {
  result = x/y
  print(result)
}
divider(50,25)
```

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

```r
divider (100,25)
```

```
## [1] 4
```

```r
# Multiplication
multiply = function(a,b){
  result = a * b
  print (result)
}
multiply(23,25)
```

```
## [1] 575
```

```r
multiply (19,20)
```

```
## [1] 380
```

```r
# Variables Names are CASE SENSITIVE
A=10
a=24

# CONCATENATION AND ARRAYS
f <- c(1,2,3,4,5)
f = c(1,2,3,4,5)
f
```

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

```r
f+4
```

```
## [1] 5 6 7 8 9
```

```r
d = f / 4
d
```

```
## [1] 0.25 0.50 0.75 1.00 1.25
```

```r
f+d
```

```
## [1] 1.25 2.50 3.75 5.00 6.25
```

```r
f = c(1,2,3,4,5)

# Listing and Deleting Objects (Variables)
ls()
```

```
##  [1] "a"        "A"        "d"        "date1"    "date2"    "divider"
##  [7] "f"        "i"        "K"        "multiply" "s"        "v"
## [13] "w"        "x"        "z"
```

```r
rm (a)
rm (list = ls())
```

Functions are useful to create as we can again use the function by calling in different arguments into it.

Vectors

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

v = c(1,2,3,4,5)
s = v*2
s

## [1]  2  4  6  8 10

# A vector is collec tion of elements, all of same type.
# A vector canot be of mixed type.

# Vector Operation
d = v-2
d

## [1] -1  0  1  2  3

f = v /2
f

## [1] 0.5 1.0 1.5 2.0 2.5

sqrt(f)

## [1] 0.7071068 1.0000000 1.2247449 1.4142136 1.5811388
```

All about vectors

```
# A vector is collection of elements of same type.
# (ie) A vector cannot be of mixed type.
# R is a Vectorized Language. Thant means operations are applied to each
element of the vector automatically,
# .., without the need to loop through the vector.
# This is a powerful concept and vector plays a crucial and significant role
in R.

# Creating Vectors
# The most common way to create a Vector is using 'c' [combine]
x = c(1,2,3,4,5,6,7,8,9,10)
x

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

```r
# Vector Operations
x*3 # multiplies each element by 3; No loops necessary!
```

```
##  [1]  3  6  9 12 15 18 21 24 27 30
```

```r
x+2
```

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

```r
x-3
```

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

```r
x/4
```

```
##  [1] 0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50
```

```r
x^2
```

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

```r
sqrt(x)
```

```
##  [1] 1.000000 1.414214 1.732051 2.000000 2.236068 2.449490 2.645751
2.828427
##  [9] 3.000000 3.162278
```

```r
# colon (:)  operation - Sequencing
# Creates sequence of Numbers in either direction!
1:10 #(: - Through)
```

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

```r
10:1
```

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

```r
-2:3
```

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

```r
5:-7
```

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

```r
# More on Vector Operations ... Two vectors
# create two vectors of equal length
x = 1:10
y = -5:4
x + y # Add
```

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

```r
x-y
```

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

```
x*y
```

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

```
x/y
```

```
##  [1] -0.2 -0.5 -1.0 -2.0 -5.0  Inf  7.0  4.0  3.0  2.5
```

```
x^y
```

```
##  [1] 1.000000e+00 6.250000e-02 3.703704e-02 6.250000e-02 2.000000e-01
##  [6] 1.000000e+00 7.000000e+00 6.400000e+01 7.290000e+02 1.000000e+04
```

```
# check the length of each vector
length(x)
```

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

```
length(y)
```

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

```
# Unequal length vectors
x+c(1,2) # Shorter vector gets recycled!
```

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

```
x+c (1,2,3)# If Longer vector is not "multiple" of shorter vector, a warning
is given!
```

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

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

```
# Comparison also work on vector!
x <= 5
```

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

```
x<y
```

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

```
# Vector Comparison - "any" and "all"
x = 10:1
y = -4:5
any(x<y)
```

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

```
all(x<y)
```

```
## [1] FALSE

# The "nchar" function also acts on each element of vector.
q = c("Hockey","Football","Baseball","Curlin","Rugby","Lacrosse",
      "Basketball","Tennis","Cricket","Soccer")
q

##  [1] "Hockey"     "Football"   "Baseball"   "Curlin"     "Rugby"
##  [6] "Lacrosse"   "Basketball" "Tennis"     "Cricket"    "Soccer"

nchar(q)

##  [1]  6  8  8  6  5  8 10  6  7  6

nchar(y)

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

?nchar()

## starting httpd help server ... done

# Subscripting:Accessing "individual elements" in vector is done using square
brackets []
x[1]

## [1] 10

x[1:2]

## [1] 10  9

x[c(1:5,9)]

## [1] 10  9  8  7  6  2

# Give Names to Vector!
c(One = "a", Two = "y", Last = "r") # Name-Value pair

##  One  Two Last
##  "a"  "y"  "r"

# You can Name the vector after creating vector as well!
w = 1:3
names(w) = c("a","b","c")
w

## a b c
## 1 2 3

Vectors are the most basic R data objects and there are six types of atomic
vectors. They are logical, integer, double, complex, character and raw.

The most common data structure is the one-dimensional vector
```

Vector forms the basis of everything in R.

A vector is collection of elements of same type.

(ie) A vector cannot be of mixed type.

R is a Vectorized Language. That means operations are applied to each element of the vector automatically,

.., without the need to loop through the vector.

This is a powerful concept and vector plays a crucial and significant role in R.

Data Structures

```
# Sometimes data requires more complex storage than simple vectors.
# Data Structures - Apart from Vectors, we have Data Frames, Matrix, List and Array.

# Data Frames(DF) - Most useful features of R & also cited reason for R's ease of use.
# In dataframe, each column is actually a vector, each of which has same length.
# Each column can hold different type of data.
# Also within each column, each element must be of same type, like vectors.

# Creating a Dataframe from vectors

x = 10:1
y = -4:5
q = c("Hockey","Football","Baseball","Curlin","Rugby","Lacrosse",
      "Basketball","Tennis","Cricket","Soccer")
theDF = data.frame(x,y,q) # this would create a 10x3 data.frame with x, y and q as variable names
theDF
```

```
##     x  y          q
## 1  10 -4     Hockey
## 2   9 -3   Football
## 3   8 -2   Baseball
## 4   7 -1     Curlin
## 5   6  0      Rugby
## 6   5  1   Lacrosse
## 7   4  2 Basketball
## 8   3  3     Tennis
## 9   2  4    Cricket
## 10  1  5     Soccer
```

```r
# Assigning Names
theDF = data.frame (First=x, Second =y, Sport = q)
theDF
```

```
##    First Second      Sport
## 1     10     -4     Hockey
## 2      9     -3   Football
## 3      8     -2   Baseball
## 4      7     -1     Curlin
## 5      6      0      Rugby
## 6      5      1   Lacrosse
## 7      4      2 Basketball
## 8      3      3     Tennis
## 9      2      4    Cricket
## 10     1      5     Soccer
```

```r
# Checking the dimensions of the DF.
nrow(theDF)
```

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

```r
ncol(theDF)
```

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

```r
dim(theDF)
```

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

```r
names (theDF)
```

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

```r
names(theDF)[3]
```

```
## [1] "Sport"
```

```r
rownames(theDF)
```

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

```r
# Head and Tail
head(theDF)
```

```
##   First Second    Sport
## 1    10     -4   Hockey
## 2     9     -3 Football
## 3     8     -2 Baseball
## 4     7     -1   Curlin
## 5     6      0    Rugby
## 6     5      1 Lacrosse
```

```r
head(theDF, n=7)
```

```
##   First Second      Sport
## 1    10     -4     Hockey
## 2     9     -3   Football
## 3     8     -2   Baseball
## 4     7     -1     Curlin
## 5     6      0      Rugby
## 6     5      1   Lacrosse
## 7     4      2 Basketball
```

```
tail(theDF)
```

```
##    First Second      Sport
## 5      6      0      Rugby
## 6      5      1   Lacrosse
## 7      4      2 Basketball
## 8      3      3     Tennis
## 9      2      4    Cricket
## 10     1      5     Soccer
```

```
class(theDF)
```

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

```
# Accessing Individual Column using $
theDF$Sport # gives the third column named Sport
```

```
##  [1] "Hockey"     "Football"   "Baseball"   "Curlin"     "Rugby"
##  [6] "Lacrosse"   "Basketball" "Tennis"     "Cricket"    "Soccer"
```

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

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

```
theDF[3,2:3] # 3rd Row and column 2 thru 3
```

```
##   Second    Sport
## 3     -2 Baseball
```

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

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

```
# since only one column was selected, it was returned as vector and hence no
column names in output.

# Rows 3&5 and Columns 2 through 3
theDF[c(3,5), 2:3]
```

```
##   Second    Sport
## 3     -2 Baseball
## 5      0    Rugby
```

```
theDF[ ,3] # Access all Rows for column 3
```

```
##  [1] "Hockey"     "Football"   "Baseball"   "Curlin"     "Rugby"
##  [6] "Lacrosse"   "Basketball" "Tennis"     "Cricket"    "Soccer"
```

```
theDF[ , 2:3]
```

```
##    Second      Sport
## 1      -4     Hockey
## 2      -3   Football
## 3      -2   Baseball
## 4      -1     Curlin
## 5       0      Rugby
## 6       1   Lacrosse
## 7       2 Basketball
## 8       3     Tennis
## 9       4    Cricket
## 10      5     Soccer
```

```
theDF[2,]# Access all columns for Row 2
```

```
##   First Second    Sport
## 2     9     -3 Football
```

```
theDF[2:4,]
```

```
##   First Second    Sport
## 2     9     -3 Football
## 3     8     -2 Baseball
## 4     7     -1   Curlin
```

```
theDF[ , c("First", "Sport")]# access using Column Names
```

```
##    First      Sport
## 1     10     Hockey
## 2      9   Football
## 3      8   Baseball
## 4      7     Curlin
## 5      6      Rugby
## 6      5   Lacrosse
## 7      4 Basketball
## 8      3     Tennis
## 9      2    Cricket
## 10     1     Soccer
```

Factors

```
# Factor Vectors - Ordinal data [Ordered Categorical]
# Factors are important concept in R, esp. when building models

q2 = c(q,"Hockey","Lacrosse","Hockey","Water Polo","Hockey","Lacrosse")
q2
```

```
##  [1] "Hockey"     "Football"   "Baseball"   "Curlin"     "Rugby"
##  [6] "Lacrosse"   "Basketball" "Tennis"     "Cricket"    "Soccer"
## [11] "Hockey"     "Lacrosse"   "Hockey"     "Water Polo" "Hockey"
## [16] "Lacrosse"
```

```
class(q2)
```

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

```
as.numeric(q2)
```

```
## Warning: NAs introduced by coercion
```

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

```
class(q2)
```

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

```
# Converting "q2" to factor!
q2_F = as.factor(q2)
q2_F # notice the "Levels" info in the output!
```

```
##  [1] Hockey     Football   Baseball   Curlin     Rugby      Lacrosse
##  [7] Basketball Tennis     Cricket    Soccer     Hockey     Lacrosse
## [13] Hockey     Water Polo Hockey     Lacrosse
## 11 Levels: Baseball Basketball Cricket Curlin Football Hockey ... Water
Polo
```

```
# 11 Levels - 10 Distinct Names from "q" and one (Water polo) from "q2"
# The "levels" of a factor are the unique values of that factor variable.
# Technically R is giving "unique integer" to each distinct names, See below
as.numeric(q2_F)# IN the O/P --> Notice "6" = "Hockey"
```

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

```
# Ordered Levels and Un-ordered Levels
# Factors can drastically reduce the size of the variable...
# ... because they are storing only unique values!
factor(x=c("High School","College","Masters","Doctrate"),
       levels = c("High School","College","Masters","Doctrate"),
       ordered = TRUE)
```

```
## [1] High School College     Masters     Doctrate
## Levels: High School < College < Masters < Doctrate
```

Factors are the data objects which are used to categorize the data and store it as levels. They can store both strings and integers. They are useful in the columns which have a limited number of unique values. Like "Male, "Female" and True, False etc. They are useful in data analysis for statistical modeling.

MissingData

```
# Missing data plays a crucial role in computing and Statistics
# R has two types of missing data - NA and NULL
# while they are similar, but they behave differently and hence needs
attention!

# NA - Missing data - Missing Value
z = c(1,2,NA,8,3,NA,3)
z = c(1,2,NA,8,3,NA,3)
z

## [1]  1  2 NA  8  3 NA  3

# "is.na" tests each element of a vector for missingness
is.na(z)

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

#Another example
z_char = c("Hockey", NA ,"Cricket")
z_char

## [1] "Hockey"  NA        "Cricket"

is.na(z_char)

## [1] FALSE  TRUE FALSE

# NULL - Absence of anything. It is not exactly missingness, but nothingness
# Eg: Having Brain but thinking Nothing! - Makes Sense!!!
# Functions can sometimes return NULL and their arguments can be NULL.
# Important difference is, NULL is atomical and cannot exist within a
vector...
# ...If used inside a vector, it simply disappears! Let's see...
z= c(1,NULL,3)
z

## [1] 1 3

x = c(1,NA,3)
x

## [1]  1 NA  3

# Notice, here the "NULL" didnot get stored in "z", infact "z" has only
length of 2!
length(z)

## [1] 2

length(x)

## [1] 3
```

```r
# Assigning NULL and checking!
d = NULL
is.null(d)
```

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

DATA FRAME

Data Frames(DF) - Most useful features of R & also cited reason for R's ease of use.

In dataframe, each column is actually a vector, each of which has same length.

Each column can hold different type of data.

Also within each column, each element must be of same type, like vectors.

Refer the file : "4 DSA Data Structures_Data.Frame - 4 Dec" (R File)

MATRICES

A matrix (plural matrices) is a rectangular array or table of numbers, symbols, or expressions...

#..., arranged in rows and columns.(i.e.) 2-Dimensional Array # Similar to data.frame(RxC) and also similar to Vector # Matrix - Element by element operations are possible. # Refer the file : "4 DSA Data Structures_Matrices - 4 Dec" (R File)

DataStructuresinR

```r
# Sometimes data requires more complex storage than simple vectors.
# Data Structures - Apart from Vectors, we have Data Frames, Matrix, List and
Array.

# Data Frames(DF) - Most useful features of R & also cited reason for R's
ease of use.
# In dataframe, each column is actually a vector, each of which has same
length.
```

```r
# Each column can hold different type of data.
# Also within each column, each element must be of same type, like vectors.

# Creating a Dataframe from vectors

x = 10:1
y = -4:5
q = c("Hockey","Football","Baseball","Curlin","Rugby","Lacrosse",
      "Basketball","Tennis","Cricket","Soccer")
theDF = data.frame(x,y,q) # this would create a 10x3 data.frame with x, y and
q as variable names
theDF
```

```
##     x  y          q
## 1  10 -4     Hockey
## 2   9 -3   Football
## 3   8 -2   Baseball
## 4   7 -1     Curlin
## 5   6  0      Rugby
## 6   5  1   Lacrosse
## 7   4  2 Basketball
## 8   3  3     Tennis
## 9   2  4    Cricket
## 10  1  5     Soccer
```

```r
str(theDF)# Very important - Str - Structure
```

```
## '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
##  $ q: chr  "Hockey" "Football" "Baseball" "Curlin" ...
```

```r
q = as.factor(q)

# Assigning Names
theDF = data.frame (First=x, Second =y, Sport = q)
theDF
```

```
##    First Second      Sport
## 1     10     -4     Hockey
## 2      9     -3   Football
## 3      8     -2   Baseball
## 4      7     -1     Curlin
## 5      6      0      Rugby
## 6      5      1   Lacrosse
## 7      4      2 Basketball
## 8      3      3     Tennis
## 9      2      4    Cricket
## 10     1      5     Soccer
```

```r
# Checking the dimensions of the DF.
nrow(theDF)
```

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

```r
ncol(theDF)
```

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

```r
dim(theDF)
```

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

```r
names (theDF)
```

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

```r
names(theDF)[3]
```

```
## [1] "Sport"
```

```r
rownames(theDF)
```

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

```r
# Head and Tail
head(theDF)# First 6 rows with all columns
```

```
##   First Second    Sport
## 1    10     -4   Hockey
## 2     9     -3 Football
## 3     8     -2 Baseball
## 4     7     -1   Curlin
## 5     6      0    Rugby
## 6     5      1 Lacrosse
```

```r
head(theDF, n=10)
```

```
##    First Second      Sport
## 1     10     -4     Hockey
## 2      9     -3   Football
## 3      8     -2   Baseball
## 4      7     -1     Curlin
## 5      6      0      Rugby
## 6      5      1   Lacrosse
## 7      4      2 Basketball
## 8      3      3     Tennis
## 9      2      4    Cricket
## 10     1      5     Soccer
```

```r
tail(theDF)# last six rows with all columns
```

```
##    First Second      Sport
## 5      6      0      Rugby
```

```
## 6      5      1   Lacrosse
## 7      4      2 Basketball
## 8      3      3     Tennis
## 9      2      4    Cricket
## 10     1      5     Soccer
```

```
class(theDF)
```

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

```
# Accessing Individual Column using $
theDF$Sport # gives the third column named Sport
```

```
##  [1] Hockey     Football   Baseball   Curlin     Rugby      Lacrosse
##  [7] Basketball Tennis     Cricket    Soccer
## 10 Levels: Baseball Basketball Cricket Curlin Football Hockey ... Tennis
```

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

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

```
theDF[3,2:3] # 3rd Row and column 2 thru 3
```

```
##   Second    Sport
## 3     -2 Baseball
```

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

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

```
# since only one column was selected, it was returned as vector and hence no
column names in output.

# Rows 3&5 and Columns 2 through 3
theDF[c(3,5), 2:3]
```

```
##   Second    Sport
## 3     -2 Baseball
## 5      0    Rugby
```

```
theDF[ ,3] # Access all Rows for column 3
```

```
##  [1] Hockey     Football   Baseball   Curlin     Rugby      Lacrosse
##  [7] Basketball Tennis     Cricket    Soccer
## 10 Levels: Baseball Basketball Cricket Curlin Football Hockey ... Tennis
```

```
theDF[ , 2:3]
```

```
##    Second      Sport
## 1      -4     Hockey
## 2      -3   Football
## 3      -2   Baseball
```

```
## 4      -1     Curlin
## 5       0      Rugby
## 6       1   Lacrosse
## 7       2 Basketball
## 8       3     Tennis
## 9       4    Cricket
## 10      5     Soccer
```

```
theDF[2,]# Access all columns for Row 2
```

```
##   First Second    Sport
## 2     9     -3 Football
```

```
theDF[2:4,]
```

```
##   First Second    Sport
## 2     9     -3 Football
## 3     8     -2 Baseball
## 4     7     -1   Curlin
```

```
theDF[ , c("First", "Sport")]# access using Column Names
```

```
##    First      Sport
## 1     10     Hockey
## 2      9   Football
## 3      8   Baseball
## 4      7     Curlin
## 5      6      Rugby
## 6      5   Lacrosse
## 7      4 Basketball
## 8      3     Tennis
## 9      2    Cricket
## 10     1     Soccer
```

```
theDF[ ,"Sport"]# Access specific Column
```

```
##  [1] Hockey     Football   Baseball   Curlin     Rugby      Lacrosse
##  [7] Basketball Tennis     Cricket    Soccer
## 10 Levels: Baseball Basketball Cricket Curlin Football Hockey ... Tennis
```

```
class(theDF[ ,"Sport"])
```

```
## [1] "factor"
```

```
theDF["Sport"]# This returns the one column data.frame
```

```
##         Sport
## 1      Hockey
## 2    Football
## 3    Baseball
## 4      Curlin
## 5       Rugby
```

```
## 6    Lacrosse
## 7  Basketball
## 8      Tennis
## 9     Cricket
## 10     Soccer
```

```
class(theDF["Sport"]) # Data.Frame
```

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

```
theDF[["Sport"]]#To access Specific column using Double Square Brackets
```

```
##  [1] Hockey     Football   Baseball   Curlin     Rugby      Lacrosse
##  [7] Basketball Tennis     Cricket    Soccer
## 10 Levels: Baseball Basketball Cricket Curlin Football Hockey ... Tennis
```

```
class(theDF[["Sport"]]) # Factor
```

```
## [1] "factor"
```

```
theDF[ ,"Sport", drop = FALSE]# Use "Drop=FALSE" to get data.fame with single
sqaure bracket.
```

```
##         Sport
## 1      Hockey
## 2    Football
## 3    Baseball
## 4      Curlin
## 5       Rugby
## 6    Lacrosse
## 7  Basketball
## 8      Tennis
## 9     Cricket
## 10     Soccer
```

```
class(theDF[ ,"Sport", drop = FALSE]) # data.frame
```

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

```
theDF[ ,3, drop = FALSE]
```

```
##         Sport
## 1      Hockey
## 2    Football
## 3    Baseball
## 4      Curlin
## 5       Rugby
## 6    Lacrosse
## 7  Basketball
## 8      Tennis
## 9     Cricket
## 10     Soccer
```

```r
class(theDF[ ,3, drop = FALSE]) # data.frame
```

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

```r
# To see how factor is stored in data.frame
newFactor = factor(c("Pennsylvania","New York","New Jersey","New
York","Tennessee","Massachusetts","Pennsylvania","New York"))
newFactor
```

```
## [1] Pennsylvania  New York      New Jersey    New York      Tennessee
## [6] Massachusetts Pennsylvania  New York
## Levels: Massachusetts New Jersey New York Pennsylvania Tennessee
```

```r
# model.matrix(~newFactor -1)
# ? model.matrix()
```

DataStructure-Matrices

```r
# A matrix (plural matrices) is a rectangular array or table of numbers,
symbols, or expressions...
#..., arranged in rows and columns.(i.e.) 2-Dimensional Array

# Similar to data.frame(RxC) and also similar to Vector
# Matrix - Element by element operations are possible

A = matrix(1:10, nrow=5)# Create a 5x2 matrix
B = matrix(21:30, nrow=5)#Create another 5x2 matrix
C = matrix (21:40, nrow=2)#Create another 2x10 matrix

A
```

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

```r
B
```

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

```r
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
nrow(A)
```

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

```r
ncol(A)
```

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

```r
dim(A)
```

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

```r
# Add Them
A+B
```

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

```r
# Multiply Them (Vector Multiplication!)
A
```

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

```r
B
```

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

```r
A*B  # A = 5x2 and B = 5x2
```

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

```r
#See if the elements are equal
A == B
```

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

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

```
##      [,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
```

```
# Naming the Columns and Rows
colnames(A)
```

```
## NULL
```

```
rownames(A)
```

```
## NULL
```

```
colnames(A)= c("Left","Right")
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")

# Matrix Multiplication. A is 5x2 and C is 2x10
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 - An array is essentially a multidimensional vector.

It must all be of the same type and

...individual elements are accessed using Square Brackets.

First element is Row(R) Index, Second Element is Column(C) Index and

the remaining elements are for Outer Dimensions (OD).

Arrays

```
# Arrays - An array is essentially a multidimensional vector.
# It must all be of the same type and
# ...individual elements are accessed using Square Brackets.
# First element is Row(R) Index, Second Element is Column(C) Index and
# the remaining elements are for Outer Dimensions (OD).

theArray = array(1:12, dim=c(2,3,2))# Total Elements = R x C x OD
theArray
```

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

```
theArray [1, ,]# Accessing all elements from Row 1, all columns, all outer dimensions & build C x OD (R x C)
```

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

```
theArray[1, ,1]# Accessing all elements from Row 1, all columns, first outer dimension
```

```
## [1] 1 3 5
```

```
theArray[, ,1]# Accessing all rows, all columns, first outer dimension
```

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

```
# Array with Four Outer Dimensions (OD)
theArray_4D = array(1:32, dim=c(2,4,4))
theArray_4D
```

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

```
##
## , , 4
##
##      [,1] [,2] [,3] [,4]
## [1,]   25   27   29   31
## [2,]   26   28   30   32
```

```
theArray_4D [1, ,]
```

```
##      [,1] [,2] [,3] [,4]
## [1,]    1    9   17   25
## [2,]    3   11   19   27
## [3,]    5   13   21   29
## [4,]    7   15   23   31
```

```
theArray_4D[1, ,1]
```

```
## [1] 1 3 5 7
```

```
theArray[, ,1]
```

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

LIST

Lists - Stores any number of items of any type.

List can contain all numerics or characters or...

#...a mix of the two or data.frames or recursively other lists.

List

```
# Lists - Stores any number of items of any type.
# List can contain all numerics or characters or...
#...a mix of the two or data.frames or recursively other lists.

# Lists are created with the "list" function.
# Each argument in "list" becomes an element of the list.

list(1,2,3)# creates a three element list
```

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

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

```
list(c(1,2,3))# creates a single element(vector with three elements)
```

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

```
list3 = list(c(1,2,3), 3:7)# create two element list
# first is three elements vector, next is five element vector.
list3
```

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

```
# The same can be written as
(list3 = list(c(1,2,3), 3:7))
```

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

```
# Two Element list
# First element is data.frame and next is 10 element vector
list(theDF, 1:10)# theDF is already created in previous exercise!
```

```
## [[1]]
##    First Second      Sport
## 1     10     -4     Hockey
## 2      9     -3   Football
## 3      8     -2   Baseball
## 4      7     -1     Curlin
## 5      6      0      Rugby
## 6      5      1   Lacrosse
## 7      4      2 Basketball
## 8      3      3     Tennis
## 9      2      4    Cricket
## 10     1      5     Soccer
##
## [[2]]
##  [1]  1  2  3  4  5  6  7  8  9 10
```

```r
# Three element list
list5 = list(theDF, 1:10, list3)
list5
```

```
## [[1]]
##    First Second      Sport
## 1     10     -4     Hockey
## 2      9     -3   Football
## 3      8     -2   Baseball
## 4      7     -1     Curlin
## 5      6      0      Rugby
## 6      5      1   Lacrosse
## 7      4      2 Basketball
## 8      3      3     Tennis
## 9      2      4    Cricket
## 10     1      5     Soccer
##
## [[2]]
##  [1]  1  2  3  4  5  6  7  8  9 10
##
## [[3]]
## [[3]][[1]]
## [1] 1 2 3
##
## [[3]][[2]]
## [1] 3 4 5 6 7
```

```r
#Naming List (similar to column name in data.frame)
names(list5)= c("data.frame", "vector","list")
names(list5)
```

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

```r
list5
```

```
## $data.frame
##    First Second      Sport
## 1     10     -4     Hockey
## 2      9     -3   Football
## 3      8     -2   Baseball
## 4      7     -1     Curlin
## 5      6      0      Rugby
## 6      5      1   Lacrosse
## 7      4      2 Basketball
## 8      3      3     Tennis
## 9      2      4    Cricket
## 10     1      5     Soccer
##
## $vector
##  [1]  1  2  3  4  5  6  7  8  9 10
##
```

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

```
#Naming using "Name-Value" pair
list6 = list(TheDataFrame = theDF, TheVector = 1:10, TheList = list3)
names(list6)
```

```
## [1] "TheDataFrame" "TheVector"    "TheList"
```

```
list6
```

```
## $TheDataFrame
##    First Second      Sport
## 1     10     -4     Hockey
## 2      9     -3   Football
## 3      8     -2   Baseball
## 4      7     -1     Curlin
## 5      6      0      Rugby
## 6      5      1   Lacrosse
## 7      4      2 Basketball
## 8      3      3     Tennis
## 9      2      4    Cricket
## 10     1      5     Soccer
##
## $TheVector
##  [1]  1  2  3  4  5  6  7  8  9 10
##
## $TheList
## $TheList[[1]]
## [1] 1 2 3
##
## $TheList[[2]]
## [1] 3 4 5 6 7
```

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

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

```
## [[4]]
## NULL

# Accessing individual element of a list - Double Square Brackets
# specify either element number or name
list5[[1]]

##    First Second      Sport
## 1     10     -4     Hockey
## 2      9     -3   Football
## 3      8     -2   Baseball
## 4      7     -1     Curlin
## 5      6      0      Rugby
## 6      5      1   Lacrosse
## 7      4      2 Basketball
## 8      3      3     Tennis
## 9      2      4    Cricket
## 10     1      5     Soccer

list5[["data.frame"]]

##    First Second      Sport
## 1     10     -4     Hockey
## 2      9     -3   Football
## 3      8     -2   Baseball
## 4      7     -1     Curlin
## 5      6      0      Rugby
## 6      5      1   Lacrosse
## 7      4      2 Basketball
## 8      3      3     Tennis
## 9      2      4    Cricket
## 10     1      5     Soccer

list5[[1]]$Sport

##  [1] Hockey     Football   Baseball   Curlin     Rugby      Lacrosse
##  [7] Basketball Tennis     Cricket    Soccer
## 10 Levels: Baseball Basketball Cricket Curlin Football Hockey ... Tennis

list5[[1]][,"Second"]

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

list5[[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
```

```
# LENGTH OF LIST
length(list5)
```

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

```
names(list5)
```

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

```
list5
```

```
## $data.frame
##    First Second      Sport
## 1     10     -4     Hockey
## 2      9     -3   Football
## 3      8     -2   Baseball
## 4      7     -1     Curlin
## 5      6      0      Rugby
## 6      5      1   Lacrosse
## 7      4      2 Basketball
## 8      3      3     Tennis
## 9      2      4    Cricket
## 10     1      5     Soccer
##
## $vector
##  [1]  1  2  3  4  5  6  7  8  9 10
##
## $list
## $list[[1]]
## [1] 1 2 3
##
## $list[[2]]
## [1] 3 4 5 6 7
```

Reading data in R

```
# Its time that we load data in R.
# Most common way to get data is reading comma separated values(CSV)

# Reading CSVs
theUrl = "http://www.jaredlander.com/data/Tomato%20First.csv"
# visit https://www.jaredlander.com/data/ for other Datasets
tomato = read.table(file=theUrl, header=TRUE, sep =",")
head(tomato)
```

```
##   Round             Tomato Price      Source Sweet Acid Color Texture
Overall
```

```
## 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
```

```
#It might be tempting to use read.csv but that is more trouble than it is
worth,
#...and all it does is call read.table with some arguments preset.

# Sometimes CSVs(or tab delimited files) are poorly built,
# where the cell separator has been used inside a cell.
# In this case read.csv2(or read.delim2)should be used instead of read.table.

# Reading Excel Data - Not worth the Effort.
# Unfortunately, it is difficult to read Excel data into R - Requires
additional packages to be installed.
# Convert into CSV and read.

# Reading Text Files
myPeople = read.table("C:/Users/ash95/Desktop/Term 2/DSA/Assignment/New
folder/Azutoz.txt",
header=T, sep=" ",
na.strings="`",
stringsAsFactors=F)
myPeople
```

```
##        name    roll sex
## 1  ashutosh   20080   m
## 2      aman    1213   m
## 3     Rahul 4567567   M
## 4     Rahul 4567567   M
## 5     Rahul 4567567   M
## 6     Rahul 4567567   M
## 7     Rahul 4567567   M
## 8     Rahul 4567567   M
```

```
## 9     Rahul 4567567   M
## 10    Rahul 4567567   M

#Reading the files



# Add another person
addname = data.frame(name="Rahul",
roll="4567567",
sex="M")
myPeople = rbind(myPeople, addname)
myPeople

##        name    roll sex
## 1  ashutosh   20080   m
## 2      aman    1213   m
## 3     Rahul 4567567   M
## 4     Rahul 4567567   M
## 5     Rahul 4567567   M
## 6     Rahul 4567567   M
## 7     Rahul 4567567   M
## 8     Rahul 4567567   M
## 9     Rahul 4567567   M
## 10    Rahul 4567567   M
## 11    Rahul 4567567   M

# Update a record
myPeople[2,2] = "1213"
myPeople

##        name    roll sex
## 1  ashutosh   20080   m
## 2      aman    1213   m
## 3     Rahul 4567567   M
## 4     Rahul 4567567   M
## 5     Rahul 4567567   M
## 6     Rahul 4567567   M
## 7     Rahul 4567567   M
## 8     Rahul 4567567   M
## 9     Rahul 4567567   M
## 10    Rahul 4567567   M
## 11    Rahul 4567567   M

# Update the file by supplying the data.frame,
# the file to write, seperator, na, whether to
# quote strings, whether to include row numbers
write.table(x=myPeople, "C:/Users/ash95/Desktop/Term 2/DSA/Assignment/New
folder/Azutoz.txt",
sep=" ", na="`",
quote=F, row.names=F)
```

```r
# Get 1st 3 records
head(myPeople, 3)
```

```
##       name    roll sex
## 1 ashutosh   20080   m
## 2     aman    1213   m
## 3    Rahul 4567567   M
```

```r
# Get remaining records
tail(myPeople, 3)
```

```
##     name    roll sex
## 9  Rahul 4567567   M
## 10 Rahul 4567567   M
## 11 Rahul 4567567   M
```

Any kind of file (csv or txt) can be read into R and data manipulation and presentation can be done with the help of it.

builtindatasets

```r
# Built-in datasets in R
data()# List of built-in Datasets in R

# Loading
data(mtcars)
# Print the first 6 rows
head(mtcars, 6)
```

```
##                    mpg cyl disp  hp drat    wt  qsec vs am gear carb
## Mazda RX4         21.0   6  160 110 3.90 2.620 16.46  0  1    4    4
## Mazda RX4 Wag     21.0   6  160 110 3.90 2.875 17.02  0  1    4    4
## Datsun 710        22.8   4  108  93 3.85 2.320 18.61  1  1    4    1
## Hornet 4 Drive    21.4   6  258 110 3.08 3.215 19.44  1  0    3    1
## Hornet Sportabout 18.7   8  360 175 3.15 3.440 17.02  0  0    3    2
## Valiant           18.1   6  225 105 2.76 3.460 20.22  1  0    3    1
```

Summary Statistics

```r
# Basic Statistics - Mean, Variances,Correlations and T-tests

# Generate a random sample of 100 numbers between 1 and 100
x = sample(x=1:100, size = 100, replace = TRUE)
x # the output of "x" is a vector of data
```

```
##   [1] 29 91 74 55 45 51 87 45 40 45 49 54  5 55 28 35 14 70 38 83  3 65 86
83 23
```

```
##  [26] 24 15 55 66 79 81 99  3 39 89 74 13 39 28 23 92 84 77 86 76 41 17 69
7 31
##  [51] 70 80 89 84 52 56 70 94 65 54 65 57 83 26 83 22 58  6 72 30 46 92 75
48  1
##  [76] 98 97 11 92 13 59 41 68 47 37 17 51 44 77 92 69 99 47  4 85 75 90 43
42 60
```

```
# Simple Arithmetic Mean
mean(x)
```

```
## [1] 54.96
```

```
# Calculate Mean when Missing Data is found
y = x # copy x to y
y[sample(x=1:100, size = 20, replace = FALSE)] = NA
y
```

```
##   [1] 29 91 NA NA 45 51 NA 45 40 45 49 54  5 NA 28 35 14 70 NA 83  3 65 86
83 23
##  [26] 24 15 55 NA 79 81 99 NA 39 89 74 13 39 28 NA 92 NA 77 86 76 NA 17 69
7 31
##  [51] 70 80 NA 84 52 56 70 94 65 54 65 57 83 26 NA 22 58  6 NA 30 46 92 75
48  1
##  [76] 98 97 11 92 NA 59 41 68 47 NA NA 51 44 77 92 69 99 47 NA NA NA 90 43
NA 60
```

```
mean(y)# Will give NA!
```

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

```
# Remove missing value(s)and calculate mean
mean(y, na.rm=TRUE) # Now, it will give the mean value
```

```
## [1] 55.6625
```

```
# Weighted Mean
Grades = c(95,72,87,66)
Weights = c(1/2, 1/4, 1/8, 1/8)
mean(Grades)# Simple Arithmetic mean
```

```
## [1] 80
```

```
weighted.mean(x = Grades, w = Weights)# Weighted Mean
```

```
## [1] 84.625
```

```
#Variance
var(x)
```

```
## [1] 768.059
```

```
#Calculating Variance using formula!
sum((x-mean(x))^2)/ (length(x)-1)
```

```
## [1] 768.059

# Standard Deviation
sqrt(var(x))

## [1] 27.71388

sd(x)

## [1] 27.71388

sd(y)

## [1] NA

sd(y, na.rm=TRUE)

## [1] 27.46964

# Other Commonly Used Functions
min(x)

## [1] 1

max(x)

## [1] 99

median(x)

## [1] 55

min(y)

## [1] NA

min(y, na.rm=TRUE)

## [1] 1

# Summary Statistics
summary(x)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    1.00   36.50   55.00   54.96   79.25   99.00

summary(y)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##    1.00   38.00   55.50   55.66   79.25   99.00      20

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

```
##   25%   75%
## 36.50 79.25
```

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

```
##   10%   25%   50%   75%   99%
## 13.90 36.50 55.00 79.25 99.00
```

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

```
##   25%   75%
## 38.00 79.25
```

All the descriptive statistics parameters like mean, median and mode can be found out and not only this quantiles and percentiles could be found out using simple formulae

Correlation

```
# Correlation

# Prepare the Data
mydata <- mtcars[, c(1,3,4,5,6,7)]
head(mydata)
```

```
##                    mpg disp  hp drat    wt  qsec
## Mazda RX4         21.0  160 110 3.90 2.620 16.46
## Mazda RX4 Wag     21.0  160 110 3.90 2.875 17.02
## Datsun 710        22.8  108  93 3.85 2.320 18.61
## Hornet 4 Drive    21.4  258 110 3.08 3.215 19.44
## Hornet Sportabout 18.7  360 175 3.15 3.440 17.02
## Valiant           18.1  225 105 2.76 3.460 20.22
```

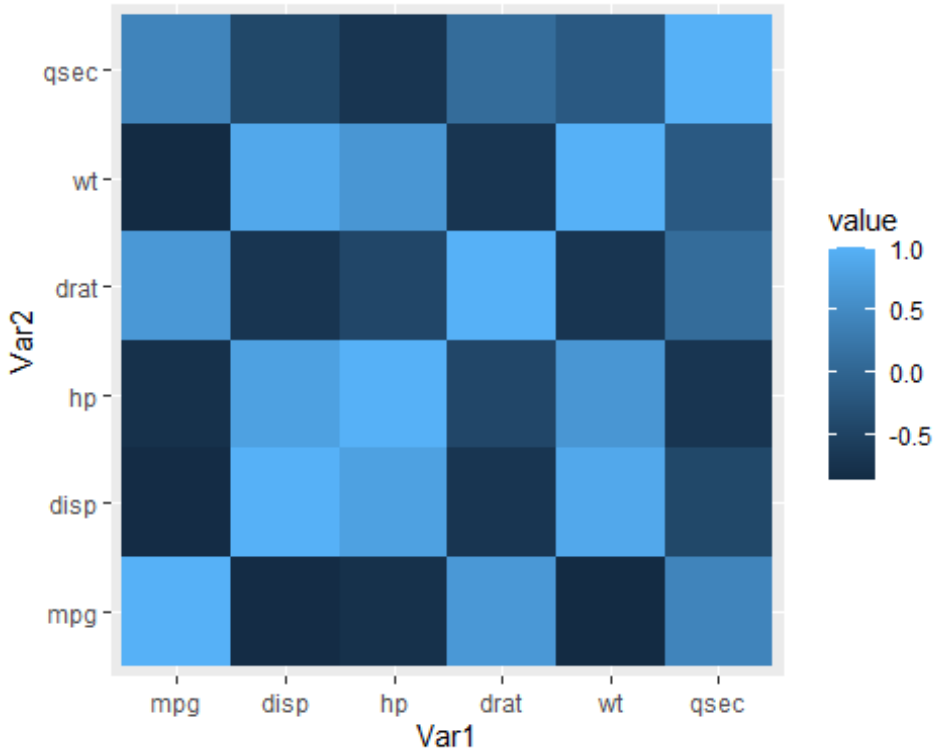
```
# Compute the correlation matrix - cor()
cormat <- round(cor(mydata),2)
head(cormat)
```

```
##        mpg  disp    hp  drat    wt  qsec
## mpg   1.00 -0.85 -0.78  0.68 -0.87  0.42
## disp -0.85  1.00  0.79 -0.71  0.89 -0.43
## hp   -0.78  0.79  1.00 -0.45  0.66 -0.71
## drat  0.68 -0.71 -0.45  1.00 -0.71  0.09
## wt   -0.87  0.89  0.66 -0.71  1.00 -0.17
## qsec  0.42 -0.43 -0.71  0.09 -0.17  1.00
```

```
# Create the correlation heatmap with ggplot2
# The package reshape is required to melt the correlation matrix.
library(reshape2)
melted_cormat <- melt(cormat)
head(melted_cormat)
```

```
##   Var1 Var2 value
## 1  mpg  mpg  1.00
## 2 disp  mpg -0.85
## 3   hp  mpg -0.78
## 4 drat  mpg  0.68
## 5   wt  mpg -0.87
## 6 qsec  mpg  0.42
```

```
#The function geom_tile()[ggplot2 package] is used to visualize the
correlation matrix :
library(ggplot2)
ggplot(data = melted_cormat, aes(x=Var1, y=Var2, fill=value)) +
  geom_tile()
```

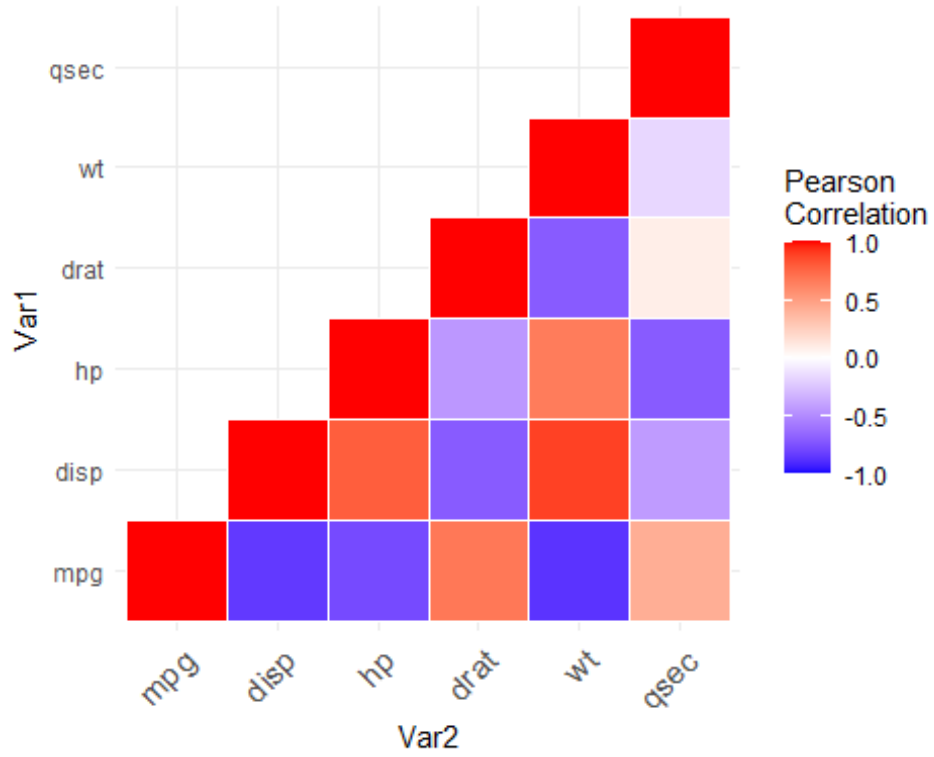



```
#Doesnot Look Great.. Let's Enhance the viz!

#Get the lower and upper triangles of the correlation matrix
## a correlation matrix has redundant information. We'll use the functions
below to set half of it to NA.

# Get lower triangle of the correlation matrix
get_lower_tri<-function(cormat){
  cormat[upper.tri(cormat)] <- NA
  return(cormat)
}
# Get upper triangle of the correlation matrix
get_upper_tri <- function(cormat){
```

```r
  cormat[lower.tri(cormat)]<- NA
  return(cormat)
}

upper_tri <- get_upper_tri(cormat)
upper_tri
```

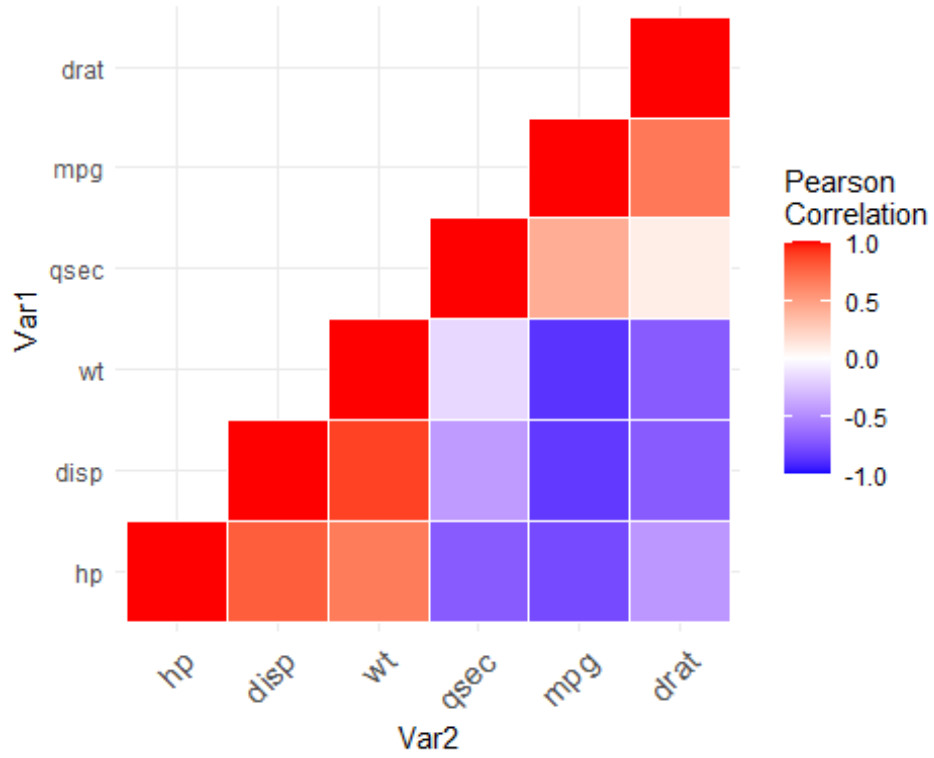
```
##      mpg  disp    hp  drat    wt  qsec
## mpg    1 -0.85 -0.78  0.68 -0.87  0.42
## disp  NA  1.00  0.79 -0.71  0.89 -0.43
## hp    NA    NA  1.00 -0.45  0.66 -0.71
## drat  NA    NA    NA  1.00 -0.71  0.09
## wt    NA    NA    NA    NA  1.00 -0.17
## qsec  NA    NA    NA    NA    NA  1.00
```

```r
#  Finished correlation matrix heatmap
## Melt the correlation data and drop the rows with NA values
# Melt the correlation matrix
library(reshape2)
melted_cormat <- melt(upper_tri, na.rm = TRUE)
# Heatmap
library(ggplot2)
ggplot(data = melted_cormat, aes(Var2, Var1, fill = value))+
  geom_tile(color = "white")+
  scale_fill_gradient2(low = "blue", high = "red", mid = "white",
                       midpoint = 0, limit = c(-1,1), space = "Lab",
                       name="Pearson\nCorrelation") +
  theme_minimal()+
  theme(axis.text.x = element_text(angle = 45, vjust = 1,
                                   size = 12, hjust = 1))+
  coord_fixed()
```



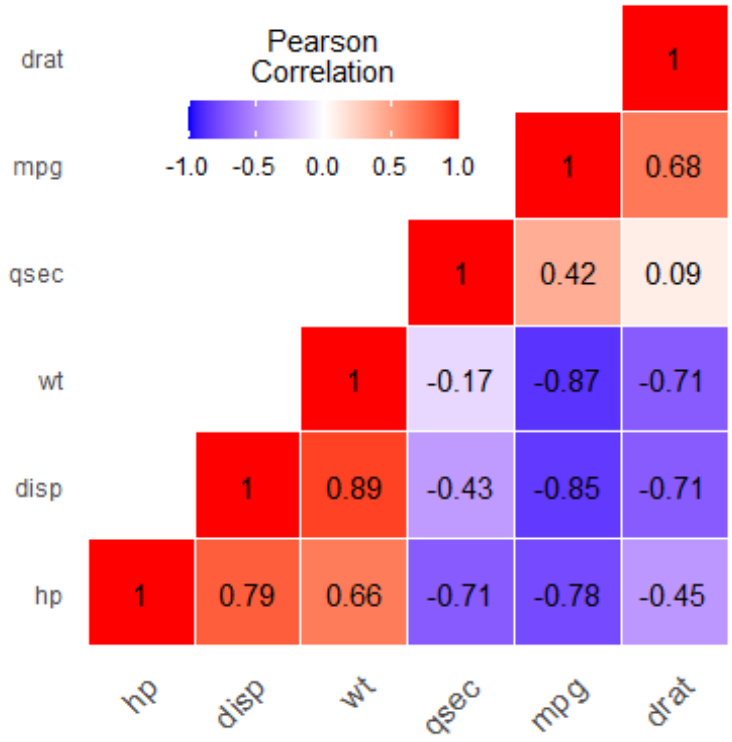

```
# negative correlations are in blue color and positive correlations in red.
# The function scale_fill_gradient2 is used with the argument limit = c(-1,1)
as correlation coefficients range from -1 to 1.
# coord_fixed() : this function ensures that one unit on the x-axis is the
same length as one unit on the y-axis.

# Reorder the correlation matrix

# This section describes how to reorder the correlation matrix according to
the correlation coefficient.
# This is useful to identify the hidden pattern in the matrix.
# hclust for hierarchical clustering order is used in the example below.

reorder_cormat <- function(cormat){
  # Use correlation between variables as distance
  dd <- as.dist((1-cormat)/2)
  hc <- hclust(dd)
  cormat <-cormat[hc$order, hc$order]
}

# Reorder the correlation matrix
cormat <- reorder_cormat(cormat)
upper_tri <- get_upper_tri(cormat)
# Melt the correlation matrix
melted_cormat <- melt(upper_tri, na.rm = TRUE)
# Create a ggheatmap
```

```r
ggheatmap <- ggplot(melted_cormat, aes(Var2, Var1, fill = value))+
  geom_tile(color = "white")+
  scale_fill_gradient2(low = "blue", high = "red", mid = "white",
                       midpoint = 0, limit = c(-1,1), space = "Lab",
                       name="Pearson\nCorrelation") +
  theme_minimal()+ # minimal theme
  theme(axis.text.x = element_text(angle = 45, vjust = 1,
                                   size = 12, hjust = 1))+
  coord_fixed()
# Print the heatmap
print(ggheatmap)
```




```r
#Add correlation coefficients on the heatmap

## Use geom_text() to add the correlation coefficients on the graph
## Use a blank theme (remove axis labels, panel grids and background, and
axis ticks)
## Use guides() to change the position of the legend title

ggheatmap +
  geom_text(aes(Var2, Var1, label = value), color = "black", size = 4) +
  theme(
    axis.title.x = element_blank(),
    axis.title.y = element_blank(),
    panel.grid.major = element_blank(),
    panel.border = element_blank(),
    panel.background = element_blank(),
```

```
    axis.ticks = element_blank(),
    legend.justification = c(1, 0),
    legend.position = c(0.6, 0.7),
    legend.direction = "horizontal")+
  guides(fill = guide_colorbar(barwidth = 7, barheight = 1,
                               title.position = "top", title.hjust = 0.5))
```



The heatmap() function is natively provided in R. It produces high quality matrix and offers statistical tools to normalize input data, run clustering algorithm and visualize the result with dendrograms.

ggplot2 also allows to build heatmaps thanks to geom_tile()

Three options exist to build an interactive heatmap from R:

plotly: as described above, plotly allows to turn any heatmap made with ggplot2 interactive.

d3heatmap: a package that uses the same syntax as the base R heatmap() function to make interactive version.

heatmaply: the most flexible option, allowing many different kind of customization. See the code of the chart beside here.

Hypothesis Testing

```
# T-tests
# Dataset: Tips dependents on...
data(tips, package = "reshape2")
head(tips)
```

```
##   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
```

```
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 ...
```

```
write.csv(tips, "C:/Users/ash95/Desktop/Term 2/DSA/Assignment/R
Code/tips.csv", row.names = FALSE)

# Gender
unique(tips$sex)
```

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

```
#Day of the week
unique(tips$day)
```

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

```
#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
```

```
#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
```

```
# 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
```

```
#Paired Two-Sample T-Test
# Dataset: Heights of Father and Son (Package:UsingR)
install.packages("UsingR", repo= "https://cran.us.r-project.org")
```

```
## Installing package into 'C:/Users/ash95/Documents/R/win-library/4.0'
## (as 'lib' is unspecified)
```

```
## package 'UsingR' successfully unpacked and MD5 sums checked
##
```

```
## The downloaded binary packages are in
##  C:\Users\ash95\AppData\Local\Temp\RtmpGSvHxq\downloaded_packages
```

```
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 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, "C:/Users/ash95/Desktop/Term 2/DSA/Assignment/R
Code/father_son.csv", row.names = FALSE)

#ANOVA  - Comparing Multiple Groups
# Tip by the Day of the Week
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)
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
```

- **t.test(data.1, data.2)** – The basic method of applying a t-test is to compare two vectors of numeric data.
- **alternative = "two.sided"** – It sets the alternative hypothesis. The default value for this is "two.sided" but a greater or lesser value can also be assigned. You can abbreviate the instruction.
- **conf.level = 0.95** – It sets the confidence level of the interval (default = 0.95).
- **paired = FALSE** – If set to TRUE, a matched pair T-test is carried out.

The one-way analysis of variance (ANOVA), also known as one-factor ANOVA, is an extension of independent two-samples t-test for comparing means in a situation where there are more than two groups

This could also be performed in R using aov and summary