Introduction To R

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What is R?

- The R statistical programming language is a free open source package based on the S language

  (developed by Bell Labs).
- R was created by Ross Ihaka and Robert Gentleman at the university of Auckland, New Zealand
- The language is very powerful for writing programs.
- Many statistical functions are already built in.
- Contributed packages expand the functionality to cutting edge research.

Basic Features of R

- R is for data analysis and data visualization tool.
  - Visualization in the form of charts, plots and graphs
- It is supported with number of graphical, statistical techniques.
- There are several GUI editors of R language, out of which RGui and Rstudio are commonly used.
- Common characteristics of R
  - Effective and powerful data handling
  - Arrays and Matrices related operations
  - Graphical representations of the analysis

Basic Features of R – Statistical Features

- R provides various statistical and graphical techniques, such as
  - Linear and non-linear modeling,
  - Classical statistical tests,
  - Time-series analysis,
  - Classification, Clustering etc.

- R has various predefined packages. User can also install packages.

- R can generate static graphs. To generate dynamic and interactive graphics, user has to install additional packages

Basic Features of R - Programming Features

- R supports following
  - Basic Math operations
  - Vector Operations
  - Matrix Operations
  - Some other data structures like data frames and lists.

- It can be used with other programming languages such as Python, Perl, Ruby, Julia and on Hadoop & Spark

Basic Features of R - Packages

- A Package is a collection of functions and datasets.
- To access the contents of package you have to first install (if it is not in-built) and load it.
- R provides 2 types of packages
  - Standard Packages (in-built) part of R source code
  - Contributed Packages (user-defined)
- CRAN (Comprehensive R Archive Network) – Collection on R packages.
- These packages widely used in Finance, Genetics, HPC, Machine Learning, Medical Imaging, Social Sciences and Spatial Statistics

Basic Features of R – Graphical User Interface

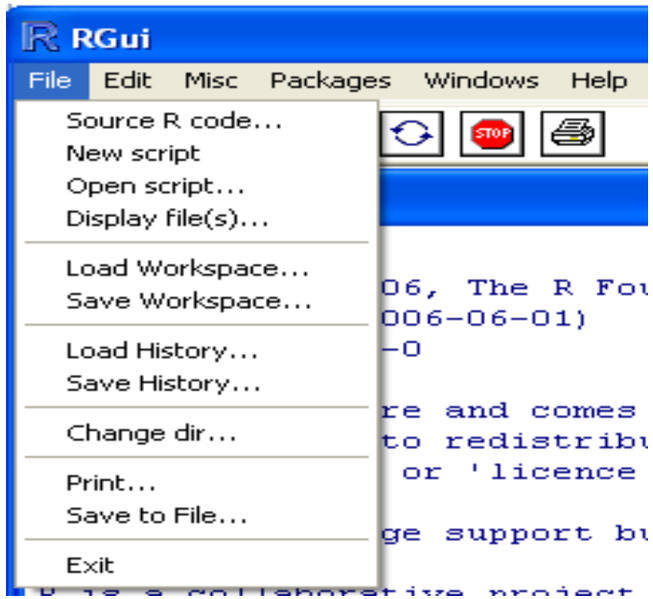
- Some popular text editors and Integrated Development Environments (IDEs) that support R programming are
  - ConTEXT
  - Eclipse
  - Emacs (Emacs Speaks Statistics)
  - Vim editor
  - jEdit
  - Rstudio
  - WinEdit

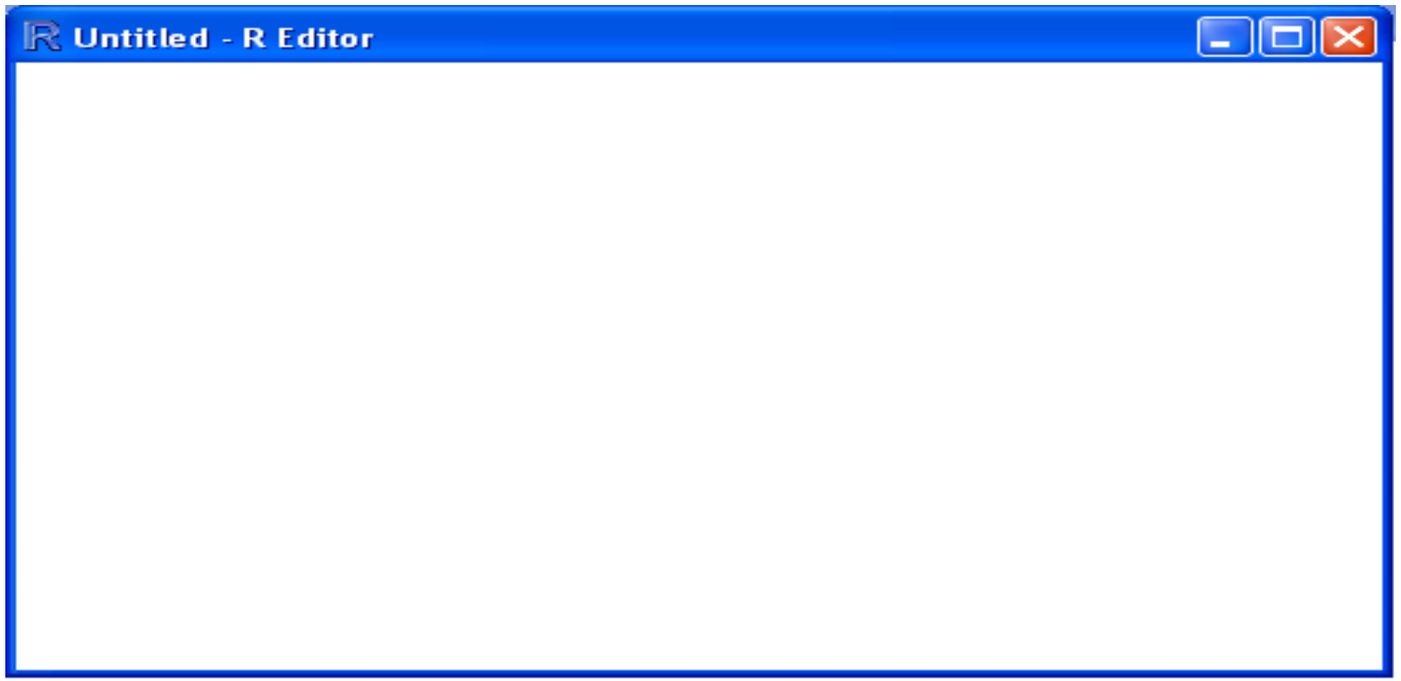
Getting Started

- Where to get R?
- Go to www.r-project.org
- Downloads: CRAN (The Comprehensive R Archive Network)
- Set your Mirror: Any of the mirror site can be selected.

Getting Started

- Opening a script.
- This gives you a script window.





Getting Started

- Basic assignment and operations.
  - Arithmetic Operations:
    - +, -, *, /, ^ are the standard arithmetic operators.
  - Matrix Arithmetic.
    - * is element wise multiplication
    - %*% is matrix multiplication
  - Assignment
    - To assign a value to a variable use “<-” or “=”

Getting Started

- How to use help in R?
  - R has a very good built-in help system.
  - If you know which function you want help with simply use ?_____ with the function in the blank.
    - Ex: `?hist`.
  - If you don't know which function to use, then use help.search("_____").
    - Ex: `help.search("histogram")`

PACKAGES

- Packages are collections of
  - **R** functions,
  - Data and
  - compiled code in a well-defined format.
- The directory where packages are stored is called the library.
- To access and use the package, it has to be loaded first.

PACKAGES

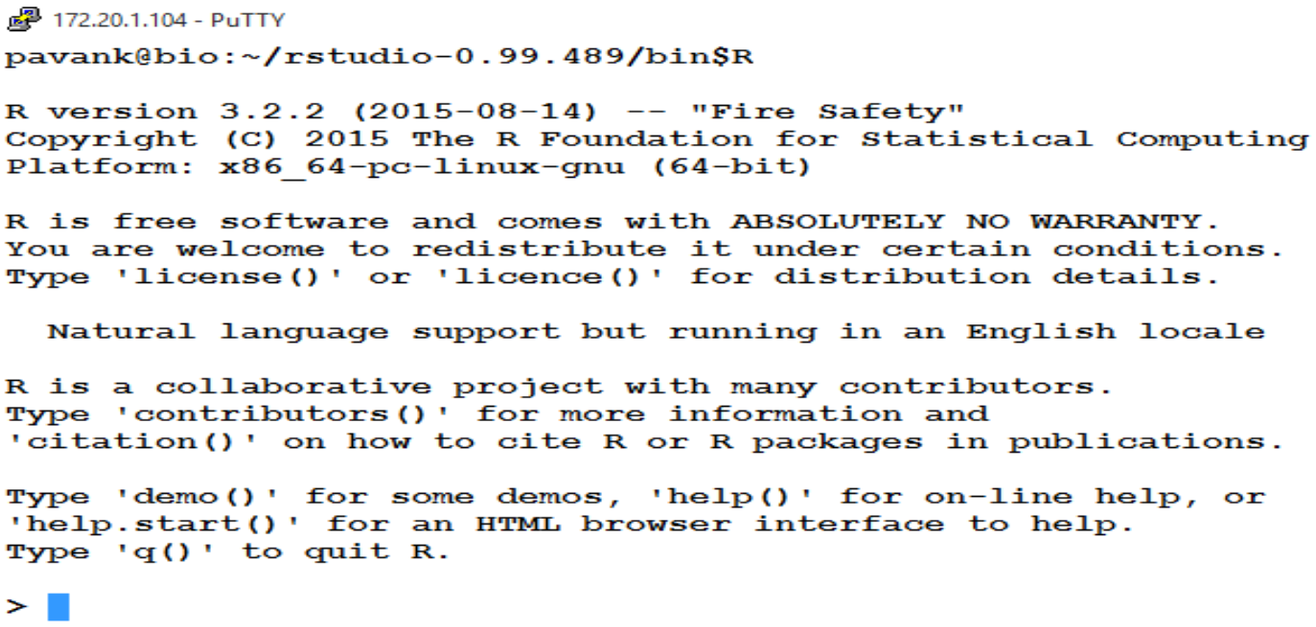
- **R** comes with a standard set of packages. Others are available for download and installation. Once installed, they have to be loaded into the session to be used.
- To install or add new R packages
  - `install.packages("package_name")`
- To load the package
  - `library(package_name)`
- To see default packages on R
  - `library()`
- To see installed packages on R
  - `installed.packages()`
- You can create your own package

CRAN

- It is A Comprehensive R Archive Network, contains many packages which can be used in many domains like
  - Genetics, Bioinformatics
  - Finance
  - HPC (High Performance Computing)
  - Machine Learning
  - Medical Imaging
  - Big data

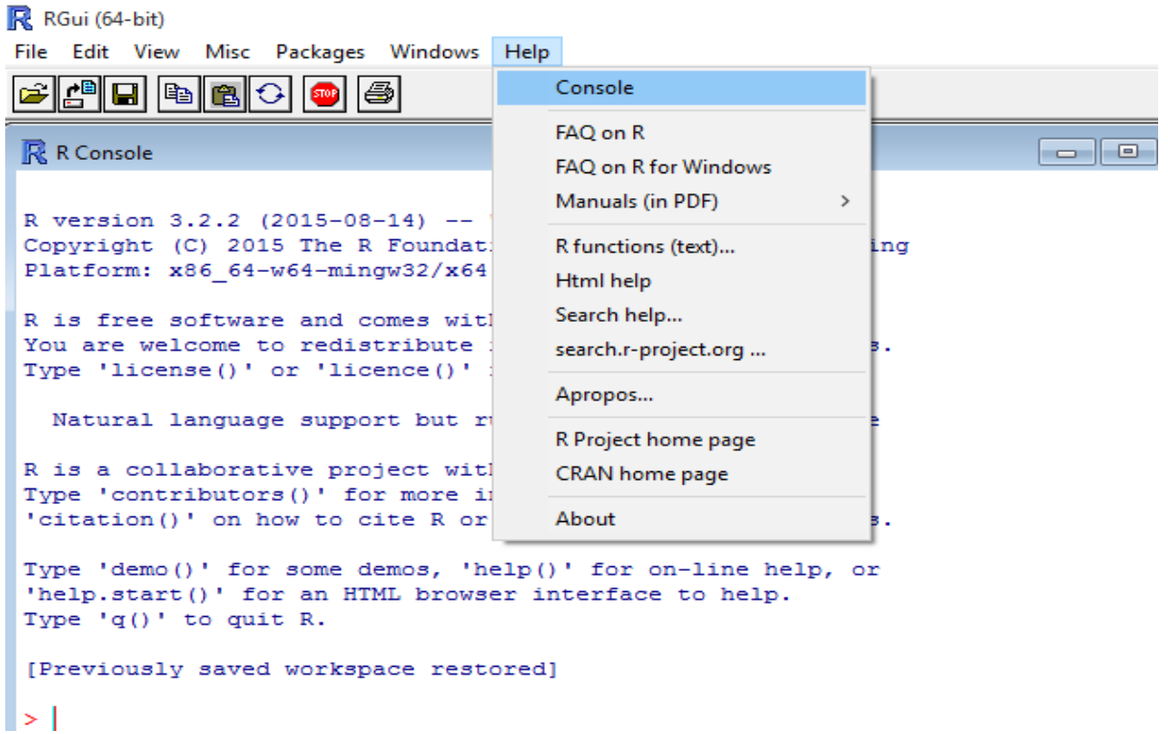
R CONSOLE

- After installing R on the Linux machine. Just type R on the command line
- After R console is opened, it shows some basic information about R, such as R version, date of release, licensing



R Console

- In the previous figure, notice “>” symbol.
- This is called R prompt, which allows users to write commands and then press ENTER key to execute the command.
- To get more information about the console, go to Help->Console.



Developing a Simple Program

- Sample program for printing
  - Here, we are using the `print()` function to display “Hello World” on the R console

```
>print(“Hello World”)
[1] “Hello World”
```

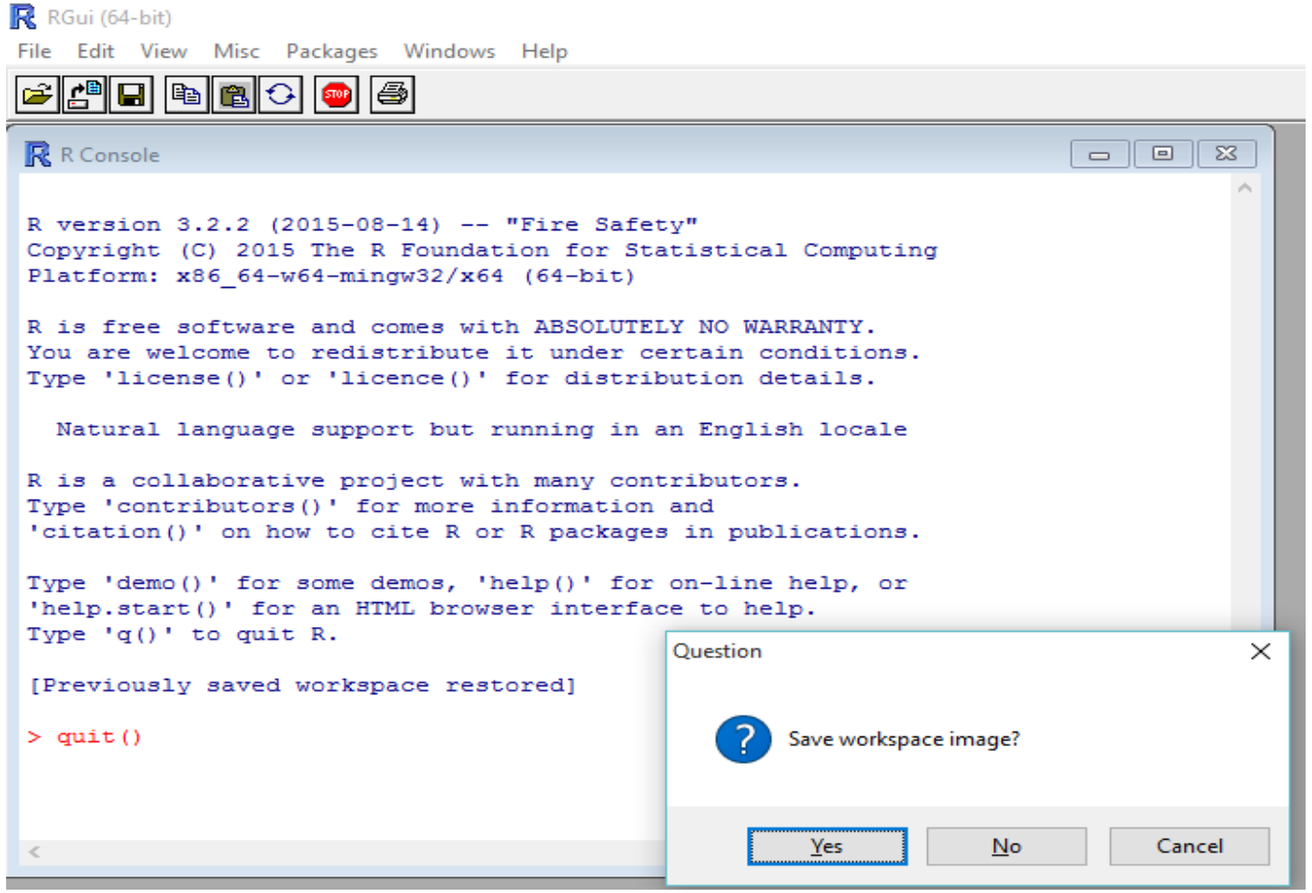
  - Here, we are doing simple math

```
>2+3
[1] 5
```

- Code begins with ‘>’ symbol and output begins with [1]

QUITTING R

- You can quit an active session of R by entering `q()` command
- After executing the `q()` command, the question dialogue box appears asking whether to save the work space.



Handling Basic Expressions

- Anything that you type on R console, it executes immediately on pressing the ENTER key.
- **Basic Arithmetic in R**

```
>12+45+9-7
[1] 59
```

R executes the expression in the following order

12+45+9=66

66-7=59

Lets look at complex mathematical operation

```
>18+23/2-5/4*3.5
[1] 25.125
```

Handling Basic Expressions

- To calculate such complex mathematical expressions, R uses BODMAS (Brackets of Division Multiplication Addition Subtraction)

```
>18+22/2-4/4*3.5
[1] 25.5

>(18+22/2-4/4)*3.5
[1] 98.875
```

Handling Basic Expressions

- **Mathematical Operators in R**
  - +, -, *, () - Simple Mathematical operations
  - pi - Stands for Pie value
  - X^Y - X raised to Y
  - sqrt(x) - square root of x
  - abs(x) - Absolute value of x
  - factorial(x) - Factorial of x
  - log(x) - logarithm of x
  - exp(x) - Exponent of x
  - cos(x), sin(x), tan(x) - Trigonometric functions

Declaring Variables in R

- Variables are symbols that are used to contain and store the values.
- Two ways to assign the values
  - Using "=" symbol

```
>MyVar=10
```

  - Using "<-" symbol

```
>MyVar<-10
```

Here, `MyVar` is a object and it is assigned with the value 10.

Any of the above mentioned can used to assign the values.

VARIABLE TYPES IN R

- **Numbers**
  - Real numbers
  - R organizes numbers in 3 formats
    - **Scalar** : Represents a single number (0 dimensional)
    - **Vector** : Represents row of numbers (1 dimensional)
    - **Matrix**: Represents the table like format (2 dimensional)
  - **Working with Vectors**
    - It consists of ordered collection of numbers or strings
    - Numerical Vector
    - String vector

VARIABLE TYPES IN R - VECTORS

- **Constructing the vector in R**
- The `c()` is used to construct the vector (Integer/Character)

  - `c(10,20,20,30,40)`
    - It is a Numerical/Integer vector

  - `c("Hello2", 20, "Hello4", 30)`
    - It is combination of Numerical and Character vector

  - `c("Hello1", "Hello2", "Hello3")`
    - It is a Character vector

VARIABLE TYPES IN R - VECTORS

- Creating the vector using (:) operator

```
>1:15 (generates numbers form 1 to 15)
> c(1:15)
[1]  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15

> sum(1:15) ## it sums the numbers from 1 to 15
[1] 120
```

VARIABLE TYPES IN R

- **Strings (characters)**
  - A string should be specified by using quotes. Both single and double quotes will work

```
a <- "hello"        ## Assigning a string to variable a
a                   ## Printing variable a
"hello"             ## Output of variable a
b <- c("hello","there")      ## Assigning two strings to variable b
b                   ## Printing variable b
"hello" "there"     ## Output of variable b
b[1]                ## Printing first element of variable b
"hello"             ## Output of variable b[1]
```

Variable types in R

- **Factors**
  - Another important way R can store data is in the form of factors
  - Example of Factorial data Yes/No, Male/Female, A/B/C/D

VARIABLE TYPES IN R – DATA FRAMES

- **Data Frames**
  - It is the collection of many vectors of different types, stores in single variable

```
> a<-c(1,2,3,4)
> b<-c(2,4,6,8)
> levels <- factor(c("A","B","A","B"))
> bubba<-data.frame(a, b, levels)
> bubba
  a b levels
1 1 2      A
2 2 4      B
3 3 6      A
4 4 8      B
```

Calling Functions in R

- Many predefined functions are there in R.
- To invoke, user has to type their names
- For example

```
> sum(10,20,30)
1] 60
> rep("Hello",3)
[1] "Hello" "Hello" "Hello"
> sqrt(100)
[1] 10
> substr("example",2,4)
[1] "xam"
```

```
> sum(10,20,30)
[1] 60
> ## Replicate Function
> rep("Hello", 3)
[1] "Hello" "Hello" "Hello"
> rep("1", 3)
[1] "1" "1" "1"
> ## Squaring the Number
> sqrt(100)
[1] 10
> ## Substring
> substr("example", 2,4)
[1] "xam"
>
```

CREATING AND USING OBJECTS

- R uses objects to store the results of a computation

```
> myobj<-25+12/2-16+(7*pi/2)
> myobj
[1] 25.99557
```

Assigns a mathematical expression to an object called **myobj**

Invokes the **myobj** object

- R is case sensitive – that is, it treats data15 and Data15 as completely different objects.

CREATING AND USING OBJECTS

- An object can be assigned a set of numbers, as for example:

```
> x12 <- c(10,6,8)
> x12
[1] 10  6  8
```

```
> x12<-c(10,12,14)
> x12*2
[1] 20 24 28
>
```

- Operations can then be performed on the whole set of numbers.
  - For example, for the object **x12** created above, check the results of the following:

```
> x12 * 10
[1] 100  60  80
```

READING DATASETS

- Using the `c()` command:
  - `c()` function is used to combine or concatenate two or more values. Here example shown is concatenating 2 numerical vectors.
  - Syntax for the `c()` command

```
> a<-c(1:100)
> b<-c(1:100)
> d<-c(a,b)
> d
  [1]   1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18
 [19]  19  20  21  22  23  24  25  26  27  28  29  30  31  32  33  34  35  36
 [37]  37  38  39  40  41  42  43  44  45  46  47  48  49  50  51  52  53  54
 [55]  55  56  57  58  59  60  61  62  63  64  65  66  67  68  69  70  71  72
 [73]  73  74  75  76  77  78  79  80  81  82  83  84  85  86  87  88  89  90
 [91]  91  92  93  94  95  96  97  98  99 100   1   2   3   4   5   6   7   8
[109]   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25  26
[127]  27  28  29  30  31  32  33  34  35  36  37  38  39  40  41  42  43  44
[145]  45  46  47  48  49  50  51  52  53  54  55  56  57  58  59  60  61  62
[163]  63  64  65  66  67  68  69  70  71  72  73  74  75  76  77  78  79  80
[181]  81  82  83  84  85  86  87  88  89  90  91  92  93  94  95  96  97  98
[199]  99 100
```

Handling Data in R workspace

- Here are some functions that allows us to handle data in R workspace

  - `ls()` function: Used to view all the created variables in current active space

```
> ls()
 [1] "a"   "b"   "bubba"   "fun"   "levels"    "msg"
 [7] "myobj"   "n"   "x12"   "yourname"
```

HANDLING DATA IN R WORKSPACE

- The `rm()` function :rm() function is used to remove the variables that are not required anymore in a session

```
> ls()
[1] "a"   "b"    "bubba"     "fun"        "levels"    "msg"
[7] "myobj"     "n"          "x12"        "yourname"

> rm(a)

> ls()
[1] "b"    "bubba"   "fun"  "levels"  "msg"   "myobj"     "n"
[8] "x12"        "yourname"
```

HANDLING DATA IN R WORKSPACE

- getwd() function: Function used to display the current working directory of the user

```
> getwd()
[1] "/home/bioinfo/pavank/rstudio-0.99.489/bin"
```

- save() function: Function used to save the objects created in the active session.

```
> save(x12, file="x12.rda")
```

  - It will save in the current working directory with the name “x12.rda”
  - You can also save entire working image `save.image()`

HANDLING DATA IN R WORKSPACE

- load() function : Function used to retrieve the saved data

```
yourname<-"mary"
> ls()
[1] "b" "fun" "levels" "msg" "myobj" "n" "x12"  "yourname"
> save(yourname, file="yourname.rda")
> rm(yourname)
> ls()
[1] "b" "fun" "levels" "msg" "myobj" "n" "x12"
> load("yourname.rda")
> ls()
[1] "b" "fun" "levels" "msg" "myobj" "n" "x12" "yourname"
```

Executing R Scripts

- Creating and Executing R script on Windows:
  - Open Notepad, and write R commands
  - Save it has “filename.R”
  - From the Rgui, file->Open script. It opens a window for browsing the Rscript
  - Click Open

Executing R Scripts

- Creating and Executing R script on Linux:
- R script is the series of commands written and saved in .R extension
- To run a script "`/home/bioinfo/pavank/R/use1.R`"
- You may either use:
  - From R Shell

    ```
    source("/home/bioinfo/pavank/R/use1.R") ##
    ```

  - On the Linux Shell

    ```
    R CMD BATCH /home/bioinfo/pavank/R/use1.R
    ```
    (OR)
    ```
    Rscript use1.R
    ```

ACCESSING HELP AND DOCUMENTATION IN R

- Function used to get help pages of the in-built functions are `help()` and `example()`

  `> help(ls)` or `?ls()`

  `> example(ls)` – It shows the examples of ls function

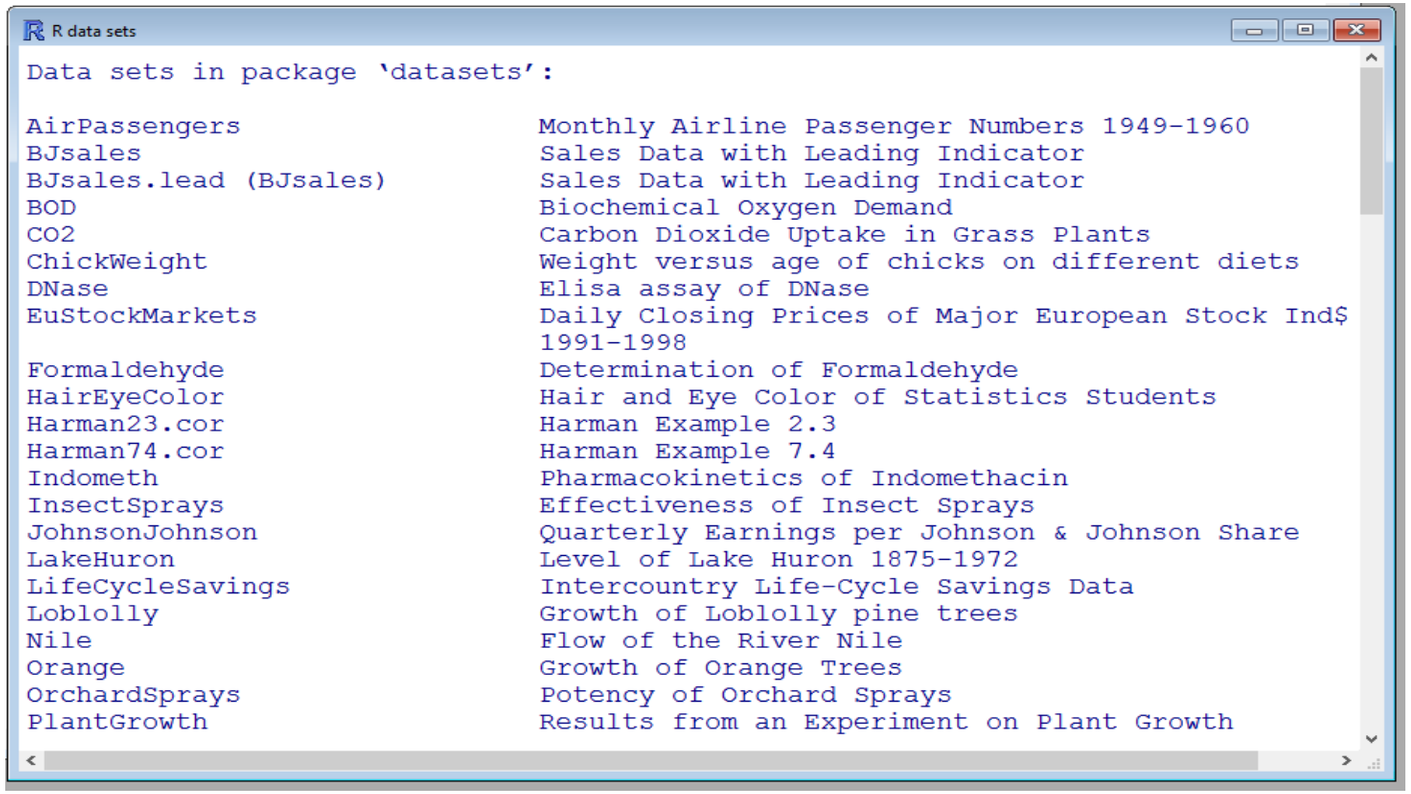
- Sample datasets : R has many in-built datasets

  `> data()`

Using Built-in Datasets in R

- There many built-in data sets which can be viewed by `data()` command. The output is shown

  `>data()` ##Generates the list of built-in datasets



Using Built-in Datasets in R

- There is a command for viewing all the data sets that are user-built or contributed packages.

```
data(package=(all.available=TRUE))
```

```
Data sets in package 'boot':

acme                            Monthly Excess Returns
aids                            Delay in AIDS Reporting in England and Wales
aircondit                       Failures of Air-conditioning Equipment
aircondit7                      Failures of Air-conditioning Equipment
amis                            Car Speeding and Warning Signs
aml                             Remission Times for Acute Myelogenous Leukaemia

Data sets in package 'cluster':

agriculture                     European Union Agricultural Workforces
animals                         Attributes of Animals
chorSub                         Subset of C-horizon of Kola Data
flower                          Flower Characteristics
plantTraits                     Plant Species Traits Data
pluton                          Isotopic Composition Plutonium Batches
```

THANK YOU !!!