Work on 9th August, 2021 - Tuesday

In [ ]:

```
Work on 19th August, 2021 - Thursday
```

Creating Dataframes</a>

Creating Dataframes via lists

Creating Dataframes via files

syntax: `dataframe = read.table(path="<path>", sep)`

In [63]:

```
dataframe = read.table("test.csv", sep=",", header = 1)
```

In [64]:

```
dataframe
```

GadgetName	Category	Price
Mouse	Electronics	250
Key Board	Electronics	300
UPS	Electrical	1000
Switch Board	Electrical	200
Mobile Phone	Electronics	10000

Accessing Rows and Columns to a Dataset

`df[row1, col1]` refers element which corresponds to row **row1** and column **col1** -- Can be number(Index) or string.
row1 or **col1** can also be array of values like **`1:3`** or **`c(1, 4)`** .

Let's access element in first_row and 2nd column -- should result `"Electronics"`

In [11]:

```
dataframe[1,2]
```

Electronics

▶ **Levels**:

Let's try accessing the value `200` in the column_3, row_4

In [12]:

```
dataframe[4, 3]
```

200

Let's try accessing the 2nd and 3rd rows

In [13]:

```
dataframe[2:3, ]   # "Column_field", empty connotates that, take all the columns presetnt..            (WITH Comma)
```

	GadgetName	Category	Price
2	Key Board	Electronics	300
3	UPS	Electrical	1000

Let's try accessing the columns 1st and 2nd

In [15]:

```
dataframe[ , 1:2] # "Row_field" empty connotates that, take all the available rows..               (WITH Comma
```

GadgetName	Category

GadgetName	Category
Mouse	Electronics
Key Board	Electronics
UPS	Electrical
Switch Board	Electrical

This time, lets take 2nd, 3rd, 4th rows and 1st, 2nd columns..

In [18]:

```
dataframe[2:4, 1:2]
```

	GadgetName	Category
2	Key Board	Electronics
3	UPS	Electrical
4	Switch Board	Electrical

In [28]:

```
dataframe['GadgetName']  # Only one value, tells to take only that specific column with all the available rows. (WIT
```

GadgetName
Mouse
Key Board
UPS
Switch Board
Mobile Phone

How to access particular set of rows?
Have a list of those rows..and use as below..

In [30]:

```
dataframe[c(1, 3, 4), ]
```

	GadgetName	Category	Price
1	Mouse	Electronics	250
3	UPS	Electrical	1000
4	Switch Board	Electrical	200

How to get certain instances(rows) based on certain condition?
use `subset()`

Subset

To extract a subset of data based on certain conditions

Get the instance of the gadget `UPS` ..

In [31]:

```
subset(dataframe, GadgetName=="UPS")
```

	GadgetName	Category	Price
3	UPS	Electrical	1000

Get the instances which has **price** of **electrical** goods **>200**

In [51]:

```
subset(dataframe, Category=="Electrical")  # WHY NOT WORKING...................???????????
```

GadgetName	Category	Price

subset(dataframe, Price>200)

In [56]:

```
subset(dataframe, Price>200 | Category=="Electrical")
```

	GadgetName	Category	Price
1	Mouse	Electronics	250
2	Key Board	Electronics	300
3	UPS	Electrical	1000
5	Mobile Phone	Electronics	10000

In [ ]:

```

```

Editing dataframes *(GUI way)*

Tested in RStudio

In [57]:

```
table = data.frame() # Create the instance of DataFrame..
table = edit(table) # Now a table gets opened... enter the data and quit the window ... that's it values gets stored
```

```
Error in edit(table): ‘edit()’ not yet supported in the Jupyter R kernel
Traceback:

1. edit(table)
2. stop(sQuote("edit()"), " not yet supported in the Jupyter R kernel")
```

Can also be used for existing dataframes...

Adding extra Rows and Columns to the dataframe

`rbind()` - Adding extra rows..

In [67]:

```
rbind(dataframe, data.frame(GadgetName="Pen", Category="Stationary", Price=5))
```

GadgetName	Category	Price
Mouse	Electronics	250
Key Board	Electronics	300
UPS	Electrical	1000
Switch Board	Electrical	200
Mobile Phone	Electronics	10000
Pen	Stationary	5

`cbind()` - Adding Extra cols..

In [70]:

```
cbind(dataframe, Stock=c(20, 50, 10, 100, 5))
```

GadgetName	Category	Price	Stock
Mouse	Electronics	250	20
Key Board	Electronics	300	50
UPS	Electrical	1000	10
Switch Board	Electrical	200	100
Mobile Phone	Electronics	10000	5

An Observation:

- For adding row need a dataframe, as only dataframe can hold each element of different type
- For adding column, need to pass a vector, as the whole column will be of same datatype.

Need confirmation..!!

Deleting rows and columns

- There are several ways to delete a row/column. Some are shown below..

Direct deletion

- Deletion via indices

Prefix the `-` sign before the indices. --- Not clear.. take the example to get clear..

Let's try removing the value 2nd row..

In [73]:

```
dataframe[-2,]
```

	GadgetName	Category	Price
1	Mouse	Electronics	250
3	UPS	Electrical	1000
4	Switch Board	Electrical	200
5	Mobile Phone	Electronics	10000

Let's try removing column_1

In [74]:

```
dataframe[-1]
```

Category	Price
Electronics	250
Electronics	300
Electrical	1000
Electrical	200
Electronics	10000

In [75]:

```
dataframe
```

GadgetName	Category	Price
Mouse	Electronics	250
Key Board	Electronics	300
UPS	Electrical	1000
Switch Board	Electrical	200
Mobile Phone	Electronics	10000

Get the row 3, without having column_2..

In [76]:

```
dataframe[3, -2]
```

	GadgetName	Price
3	UPS	1000

NOTE: To make the changes permanent to the dataframe, assign the result to the same dataframe-name.

Conditional Deletion

- Deletion based on certain condition.

Delete the column_3 -- *another view:* Accessing all other columns except the 3rd.

In [87]:

```
# Way to obtain the columns of a dataframe..
names(dataframe)
```

1. 'GadgetName'
2. 'Category'
3. 'Price'

In [86]:

```
# First understand the working of `in` operator...
dataframe[ ,  names(dataframe) %in% c("Price")]
```

1. 250
2. 300
3. 1000
4. 200
5. 10000

In [84]:

```
# Negate the above result with other gives.. the required result..
dataframe [ ,   !names(dataframe) %in% c("Price")]# ! for negation. Connotates that: "No to these columns which sati
```

GadgetName	Category
Mouse	Electronics
Key Board	Electronics
UPS	Electrical
Switch Board	Electrical
Mobile Phone	Electronics

Manipulating Rows

Manipulating Rows -- Understanding the factor issue

R has inbuilt characteristic to assign the data types to the data you enter.

- If entered numeric variable... it knows all the numeric variables that you are available to enter.
- If entered character variable... it takes whatever characters you entered as the **Factors**, and it assumes that these are the only factors available for now.

What are factor variables?

- Factor variables are those, where the character column gets splits into *Categories* or *Factor-levels*.

Let's play with this to get handy...

In [88]:

```
dataframe
```

GadgetName	Category	Price
Mouse	Electronics	250
Key Board	Electronics	300
UPS	Electrical	1000
Switch Board	Electrical	200
Mobile Phone	Electronics	10000

Let's try to assign some invalid value. i.e., a numerical value in a categorical column..

In [1...

```
dataframe[3, 2] = 1000
```

```
Warning message in `[<-.factor`(`*tmp*`, iseq, value = 1000):
“invalid factor level, NA generated”
```

In [1...

```
dataframe
```

GadgetName	Category	Price
Mouse	Electronics	250
Key Board	Electronics	300
UPS	NA	1000
Switch Board	Electrical	200
Mobile Phone	Electronics	10000

Let's try assigning some value that are not in the column `Category` .. say `Object` ..

In [1...

```
dataframe[4, 2] = "Object"
```

```
Warning message in `[<-.factor`(`*tmp*`, iseq, value = "Object"):
“invalid factor level, NA generated”
```

In [1...

```
dataframe
```

GadgetName	Category	Price
Mouse	Electronics	250
Key Board	Electronics	300
UPS	NA	1000
Switch Board	NA	200
Mobile Phone	Electronics	10000

Lesson: When tried to give a value other than existing *Category* or *Factor level*.. results in loss of that value in the dataframe. -- i.e, `NA` gets inserted at that element position.

NOTE: This warning arises only when we try to *Manipulate* the existing value, not when already exists.

As in above *Inserting rows and columns*, this issue didn't arised. --- Please Correct this, if not.

Manipulating rows -- with resolve of factor issue

First know the **reason** for the issue:

- New entries need to be consistent with the factor levels which are fixed when the dataframe is first created.
- When this gets violated, it results in Warning as above.

FIX:

- Medicine for this lies at the creation of dataframe.
    - While creating the dataframe, pass `F` to the parameter `stringsAsFactors` . i.e., `df = data.frame(v1, v2, v3, ..., stringsAsFactors=F)`

In [1...

```
# here showing for read.Table, but same applies for the data.frame() too..
test_df = read.table("test.csv", sep=",", header=1, stringsAsFactors=F)
test_df
```

GadgetName	Category	Price
Mouse	Electronics	250
Key Board	Electronics	300
UPS	Electrical	1000
Switch Board	Electrical	200
Mobile Phone	Electronics	10000

In [1...

```
test_df[3, 2] = "Object"
test_df
```

GadgetName	Category	Price
Mouse	Electronics	250
Key Board	Electronics	300
UPS	Object	1000
Switch Board	Electrical	200
Mobile Phone	Electronics	10000

See, now neither such warning or improper value insertion (`NA`).. it got successfully inserted.

Work on 20th August, 2021 - Friday

Recasting Dataframes

It is the process of manipulating a dataframe in terms of its variables. Why need to re-cast..?? It helps in re-shaping the data.,

In [1]:

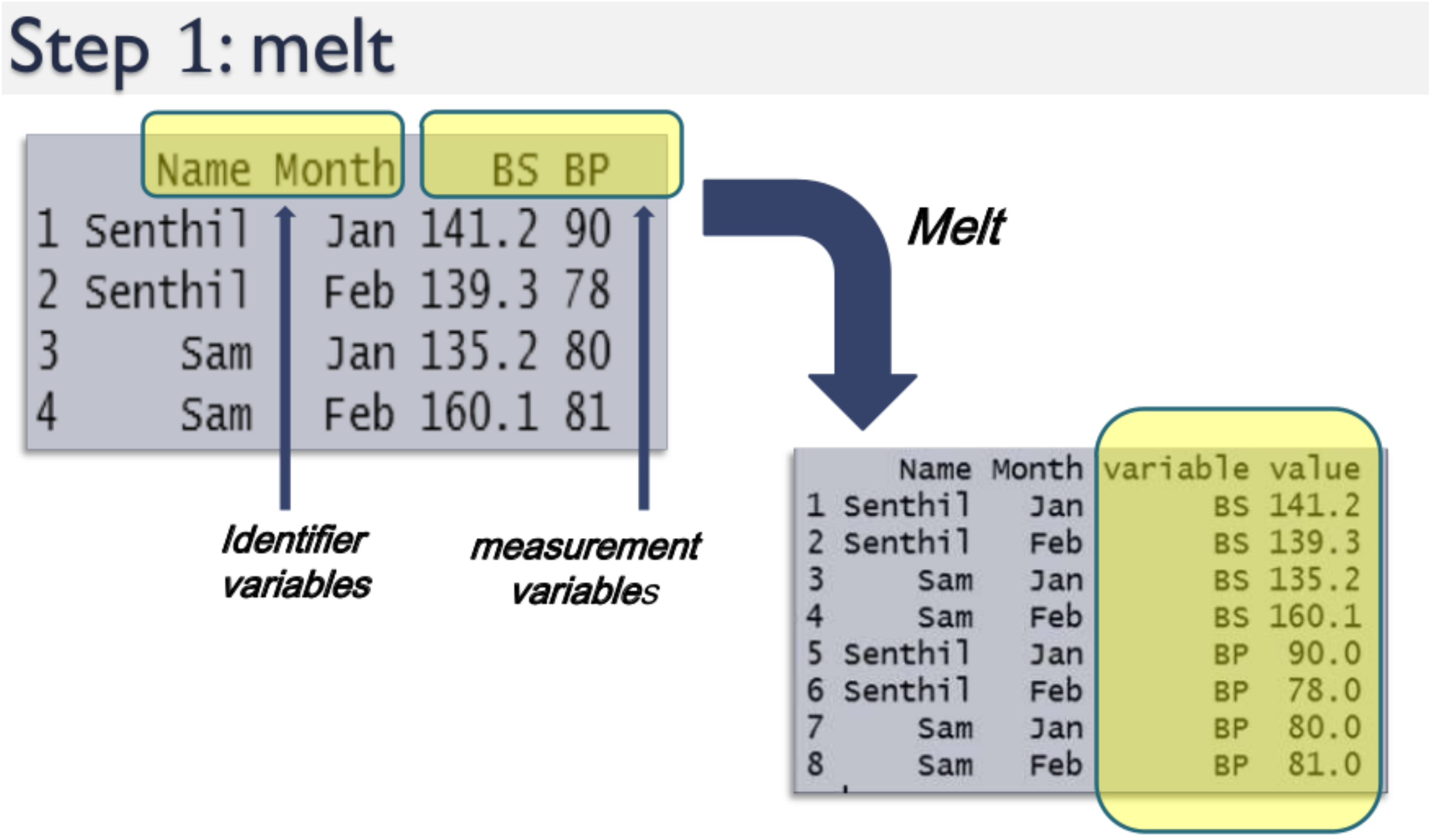
```
soldInMonth = c("January", "February", "January", "March", "January", "February")
productName = c("Oil Pastels", "Brushes", "Erasers", "Sharpeners", "Papers", "Acrylic Colors")
price = c(150, 100, 5, 5, 260, 250)
quantity = c(20, 40, 20, 10, 30, 50)

df = data.frame(productName, soldInMonth, price, quantity)
df
```

productName	soldInMonth	price	quantity
Oil Pastels	January	150	20
Brushes	February	100	40
Erasers	January	5	20
Sharpeners	March	5	10
Papers	January	260	30
Acrylic Colors	February	250	50

Recasting in 2 steps

some work pending at the end..

1. `melt` - available in `reshape2` library.
   - Install as `install.package("reshape2")` next, `library(reshape2)` to load the library..
   - **Syntax**: `melt(data, id.vars, measure.vars, variable.name="variable", value.name="value")`
   - Except `data` , all the arguments are positional arguments.
     - `data` , `id.vars` , are mandatory to be passed, rest are taken as by default as the numerical variables.

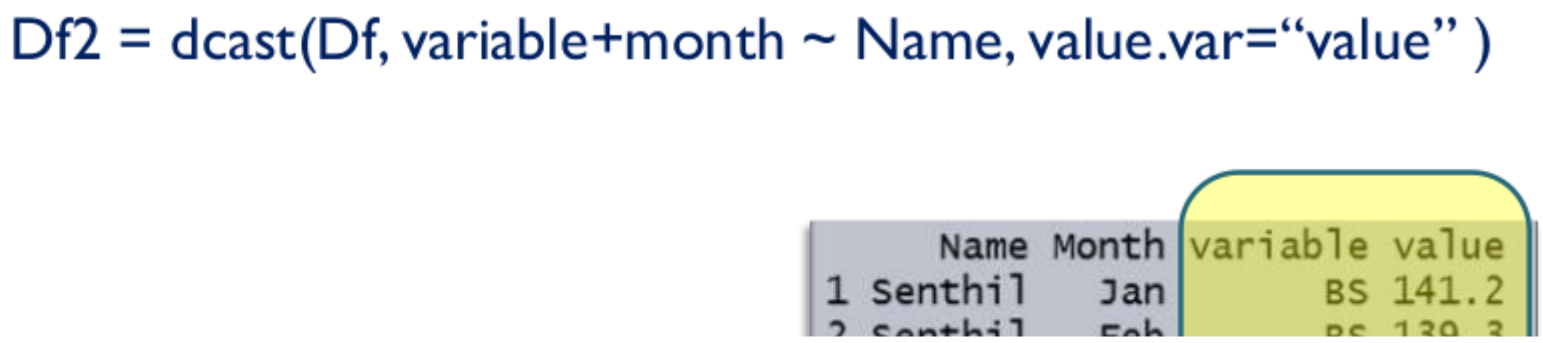


Step 1: melt

```
  Name    Month BS    BP
1 Senthil Jan   141.2 90
2 Senthil Feb   139.3 78
3     Sam Jan   135.2 80
4     Sam Feb   160.1 81
```

```
     Name Month variable value
1 Senthil   Jan       BS 141.2
2 Senthil   Feb       BS 139.3
3     Sam   Jan       BS 135.2
4     Sam   Feb       BS 160.1
5 Senthil   Jan       BP  90.0
6 Senthil   Feb       BP  78.0
7     Sam   Jan       BP  80.0
8     Sam   Feb       BP  81.0
```

2. `dcast`
   - **P2N**: Need to classify the variables of the dataframe as before heading to melt the dataframe..
   - Identifier variables(Discrete type variables or Categorical variables)
   - Measurements (Numerical variables)
     - **NOTE**: Categorical and Date variables cannot be the measurements.
   - **Syntax**: `dcast(data, formula, value.var=col with values)`



Df2 = dcast(Df, variable+month ~ Name, value.var="value")

```
     Name Month variable value
1 Senthil   Jan       BS 141.2
```

In [40]:

```
library("reshape2")    # Loading the library..
# STEP-1: Melt the dataframe..
temp = melt(df, id.vars=c("productName", "soldInMonth"))#, measure.vars=c("price", "quantity"))  # Try out here..
temp
```

productName	soldInMonth	variable	value
Oil Pastels	January	price	150
Brushes	February	price	100
Erasers	January	price	5
Sharpeners	March	price	5
Papers	January	price	260
Acrylic Colors	February	price	250
Oil Pastels	January	quantity	20
Brushes	February	quantity	40
Erasers	January	quantity	20
Sharpeners	March	quantity	10
Papers	January	quantity	30
Acrylic Colors	February	quantity	50

In [41]:

```
# STEP-2: Cast the dataframe..
temp = dcast(temp,                                 # Dataframe
             variable+soldInMonth~productName,     # Formula: Columns "variable", "soldInMonth" to remain as is, catego
             )#value.var="value")                  #   Columns of dataframe from which the values are to be taken from.
                                                   #    - No of categories in `productName` will become those many vari
temp
```

variable	soldInMonth	Acrylic Colors	Brushes	Erasers	Oil Pastels	Papers	Sharpeners
price	February	250	100	NA	NA	NA	NA

variable	soldInMonth	Acrylic Colors	Brushes	Erasers	Oil Pastels	Papers	Sharpeners
price	January	NA	NA	5	150	260	NA
price	March	NA	NA	NA	NA	NA	5
quantity	February	50	40	NA	NA	NA	NA
quantity	January	NA	NA	20	20	30	NA

In [42]:

```
# STEP-2: Cast the dataframe..
temp = dcast(temp,                              # Dataframe
             variable+soldInMonth~productName,  # Formula: Columns "variable", "soldInMonth" to remain as is, catego
             value.val=1:2)                 # Columns of dataframe from which the values are to be taken from..
                                                #    - No of categories in `productName` will become those many vari

temp
```

```
Using Sharpeners as value column: use value.var to override.
```

variable	soldInMonth	Acrylic Colors	Brushes	Erasers	Oil Pastels	Papers	Sharpeners
price	February	NA	NA	NA	NA	NA	NA
price	January	NA	NA	NA	NA	NA	NA
price	March	NA	NA	5	NA	NA	NA
quantity	February	NA	NA	NA	NA	NA	NA
quantity	January	NA	NA	NA	NA	NA	NA
quantity	March	10	NA	NA	NA	NA	NA

Why getting this way..?? lets checkout with the sir's example..

In [36]:

```
Name = c("Senthil", "Senthil", "Sam", "Sam")
Month = c("Jan", "Fev", "Jan", "Feb")
BloodSugar = c(141.2, 139.3, 135.2, 160.1)
BloodPressure = c(90, 78, 80, 81)
pd = data.frame(Name, Month, BloodSugar, BloodPressure)
pd
```

Name	Month	BloodSugar	BloodPressure
Senthil	Jan	141.2	90
Senthil	Fev	139.3	78
Sam	Jan	135.2	80
Sam	Feb	160.1	81

In [38]:

```
df_melt = melt(pd, id.vars=c("Name", "Month"))
df_melt
dcast(df_melt, variable+Month~Name, value.var="value")
```

Name	Month	variable	value
Senthil	Jan	BloodSugar	141.2
Senthil	Fev	BloodSugar	139.3
Sam	Jan	BloodSugar	135.2
Sam	Feb	BloodSugar	160.1
Senthil	Jan	BloodPressure	90.0
Senthil	Fev	BloodPressure	78.0
Sam	Jan	BloodPressure	80.0
Sam	Feb	BloodPressure	81.0

variable	Month	Sam	Senthil
BloodSugar	Feb	160.1	NA
BloodSugar	Fev	NA	139.3
BloodSugar	Jan	135.2	141.2
BloodPressure	Feb	81.0	NA
BloodPressure	Fev	NA	78.0
BloodPressure	Jan	80.0	90.0

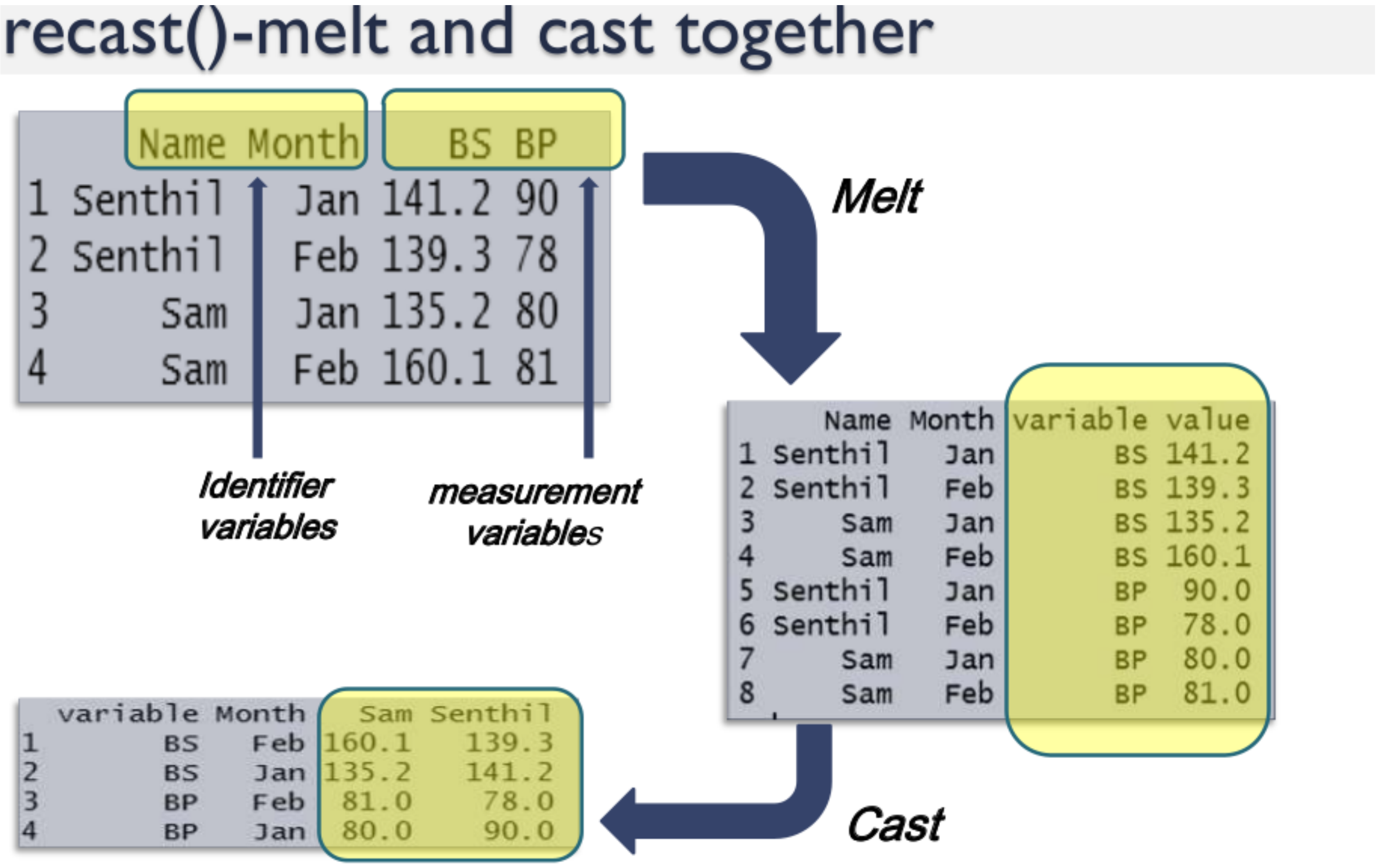
But for sir, its getting as...

```
BloodSugar   Feb      160.1    139.3
BloodSugar   Jan      135.2    141.2
BloodPressure    Feb      81.0     78.0
BloodPressure    Jan      80.0     90.0
```

Need some workout.. please go for that in revision session..

Recasting in single step

- Applying the `recast()` function performs `melt` and `cast` in single step..
- **Syntax**: `recast(data, formula, ..., id.var, measure.var)`



recast()-melt and cast together

	Name	Month	BS	BP
1	Senthil	Jan	141.2	90
2	Senthil	Feb	139.3	78
3	Sam	Jan	135.2	80
4	Sam	Feb	160.1	81

	Name	Month	variable	value
1	Senthil	Jan	BS	141.2
2	Senthil	Feb	BS	139.3
3	Sam	Jan	BS	135.2
4	Sam	Feb	BS	160.1
5	Senthil	Jan	BP	90.0
6	Senthil	Feb	BP	78.0
7	Sam	Jan	BP	80.0
8	Sam	Feb	BP	81.0

	variable	Month	Sam	Senthil
1	BS	Feb	160.1	139.3
2	BS	Jan	135.2	141.2
3	BP	Feb	81.0	78.0
4	BP	Jan	80.0	90.0

In [49]:

```
recast(df, variable+soldInMonth~productName, id.var=c("productName", "soldInMonth"))
```

variable	soldInMonth	Acrylic Colors	Brushes	Erasers	Oil Pastels	Papers	Sharpeners
price	February	250	100	NA	NA	NA	NA
price	January	NA	NA	5	150	260	NA
price	March	NA	NA	NA	NA	NA	5
quantity	February	50	40	NA	NA	NA	NA
quantity	January	NA	NA	20	20	30	NA
quantity	March	NA	NA	NA	NA	NA	10

let's checkout with the sir's...

In [50]:

```
recast(pd,
       variable+Month~Name,       # This parameter refers to the "cast" section of command
       id.var=c("Name", "Month")) #                              "melt"                   ,
                                  #   as measurement varaibles are taken excluding the categorical, didn' passed.
```

variable	Month	Sam	Senthil
BloodSugar	Feb	160.1	NA
BloodSugar	Fev	NA	139.3
BloodSugar	Jan	135.2	141.2
BloodPressure	Feb	81.0	NA
BloodPressure	Fev	NA	78.0
BloodPressure	Jan	80.0	90.0

Still, the output is different.. as like in the *Recasting in 2 steps*

Adding new variable to dataframe based on existing ones

via `mutate()`

- Need `dplyr` library. Load as `library(dplyr)`

In [54]:

```
library(dplyr)
mutate(pd,
       log_BP=log(BloodPressure))  # A new variable `log_BP` will be created, and it gets filled with some transform
                                   #    here using "Logarthmic"..
```

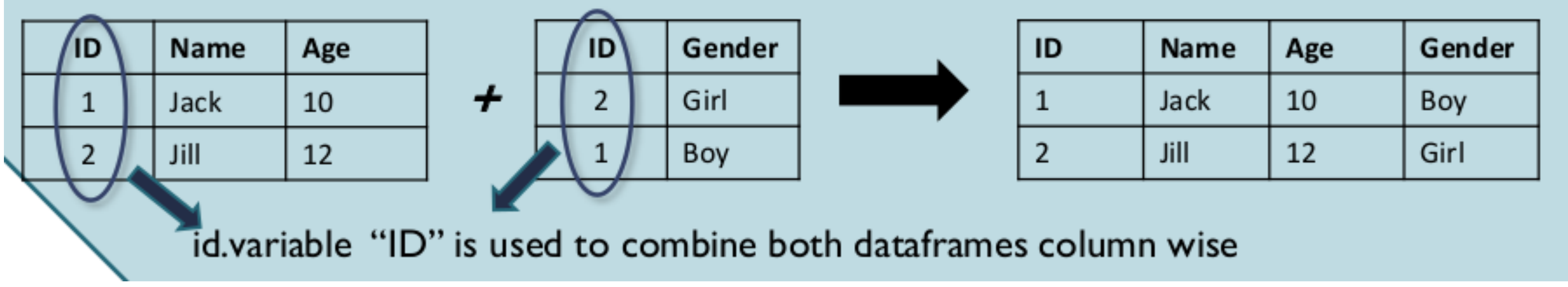
Name	Month	BloodSugar	BloodPressure	log_BP
Senthil	Jan	141.2	90	4.499810
Senthil	Fev	139.3	78	4.356709
Sam	Jan	135.2	80	4.382027
Sam	Feb	160.1	81	4.394449

Joining DataFrames

Why??

- We often get data in chunks from different sources. Now when we need to merge these data having some common ids.. -- How do we do this?
- Need `dplyr` package.
- Common syntax: `function(dataframe1, dataframe2, by=id.variable`)
    - Based on the nature of combination, changes `function`, like `inner_join`, `left_join`...
    - `dataframe1` and `dataframe2` are the two dataframes to be joined.
    - `by=id.variable` - provides the identifiers common in both for combining.

A Sample Illustration



ID	Name	Age
1	Jack	10
2	Jill	12

+

ID	Gender
2	Girl
1	Boy

ID	Name	Age	Gender
1	Jack	10	Boy
2	Jill	12	Girl

id.variable “ID” is used to combine both dataframes column wise

Join types

Currently dplyr supports four types of mutating joins, two types of filtering joins, and a nesting join.

Mutating joins combine variables from the two data.frames:

`inner_join()`

return all rows from `x` where there are matching values in `y`, and all columns from `x` and `y`. If there are multiple matches between `x` and `y`, all combination of the matches are returned.

`left_join()`

return all rows from `x`, and all columns from `x` and `y`. Rows in `x` with no match in `y` will have `NA` values in the new columns. If there are multiple matches between `x` and `y`, all combinations of the matches are returned.

`right_join()`

return all rows from `y`, and all columns from `x` and y. Rows in `y` with no match in `x` will have `NA` values in the new columns. If there are multiple matches between `x` and `y`, all combinations of the matches are returned.

`full_join()`

return all rows and all columns from both `x` and `y`. Where there are not matching values, returns `NA` for the one missing.

Filtering joins keep cases from the left-hand data.frame:

`semi_join()`

return all rows from `x` where there are matching values in `y`, keeping just columns from `x`.

A semi join differs from an inner join because an inner join will return one row of `x` for each matching row of `y`, where a semi join will never duplicate rows of `x`.

`anti_join()`

return all rows from `x` where there are not matching values in `y`, keeping just columns from `x`.

Nesting joins create a list column of data.frames:

`nest_join()`

return all rows and all columns from `x`. Adds a list column of tibbles. Each tibble contains all the rows from `y` that match that row of `x`. When there is no match, the list column is a 0-row tibble with the same column names and types as `y`.

`nest_join()` is the most fundamental join since you can recreate the other joins from it. An `inner_join()` is a `nest_join()` plus an `tidyr::unnest()`, and `left_join()` is a `nest_join()` plus an `unnest(.drop = FALSE)`. A `semi_join()` is a `nest_join()` plus a `filter()` where you check that every element of data has at least one row, and an `anti_join()` is a `nest_join()` plus a `filter()` where you check every element has zero rows.

In [60]:

```
# Dataframe1
dataframe1 = pd
dataframe1
```

Name	Month	BloodSugar	BloodPressure
Senthil	Jan	141.2	90
Senthil	Fev	139.3	78
Sam	Jan	135.2	80
Sam	Feb	160.1	81

In [58]:

```
#Dataframe2
Name=c("Senthil", "Ramesh", "Sam")
Department=c("PSE", "Data Analytics", "PSE")
dataframe2 = data.frame(Name, Department)
dataframe2
```

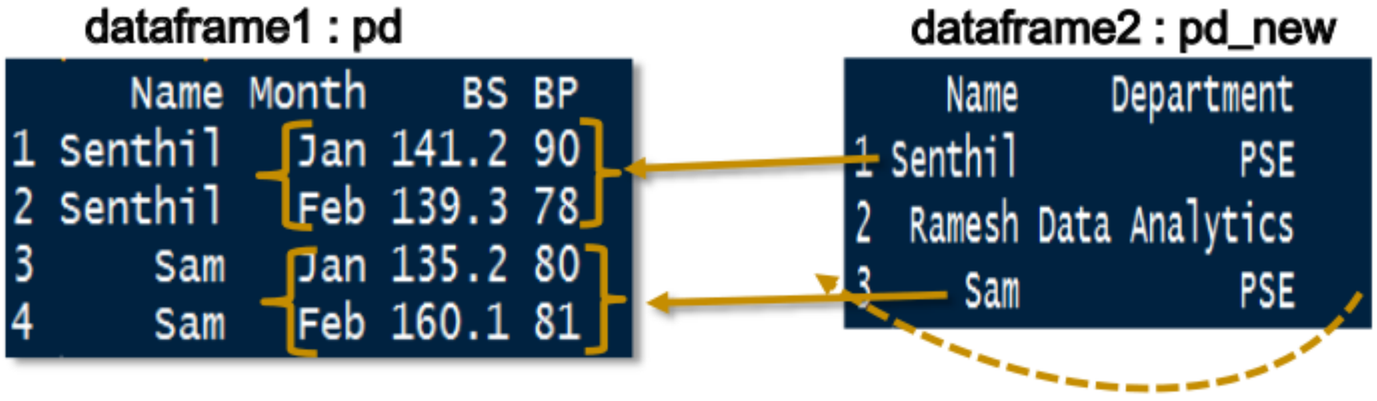
Name	Department
Senthil	PSE
Ramesh	Data Analytics
Sam	PSE

In [57]:

```
library(dplyr)
```

LeftJoin

- Takes the **Left dataframe** (`dataframe1`) as the reference and compares with another one, based on the `by=<id-variable>`



dataframe1 : pd

```
   Name Month    BS BP
1 Senthil   Jan 141.2 90
2 Senthil   Feb 139.3 78
3     Sam   Jan 135.2 80
4     Sam   Feb 160.1 81
```

dataframe2 : pd_new

```
     Name     Department
1 Senthil            PSE
2  Ramesh Data Analytics
3     Sam            PSE
```

Technically..

> return all rows from `x`, and all columns from `x` and `y`. Rows in `x` with no match in `y` will have `NA` values in the new columns. If there are multiple matches between `x` and `y`, all combinations of the matches are returned.

In [64]:

```
left_join(dataframe1,dataframe2, by="Name")
```

```
Warning message:
“Column `Name` joining factors with different levels, coercing to character vector”
```

Name	Month	BloodSugar	BloodPressure	Department
Senthil	Jan	141.2	90	PSE
Senthil	Fev	139.3	78	PSE
Sam	Jan	135.2	80	PSE
Sam	Feb	160.1	81	PSE

In [62]:

```
dataframe1
```

Name	Month	BloodSugar	BloodPressure
Senthil	Jan	141.2	90
Senthil	Fev	139.3	78
Sam	Jan	135.2	80
Sam	Feb	160.1	81

RightJoin

- Takes the **Rightdataframe** (dataframe2) as the reference and compares with another one, based on the by= Technically..

> return all rows from `y`, and all columns from `x` and `y`. Rows in `y` with no match in `x` will have `NA` values in the new columns. If there are multiple matches between `x` and `y`, all combinations of the matches are returned.

In [65]:

```
right_join(dataframe1, dataframe2, by="Name")
```

```
Warning message:
“Column `Name` joining factors with different levels, coercing to character vector”
```

Name	Month	BloodSugar	BloodPressure	Department
Senthil	Jan	141.2	90	PSE
Senthil	Fev	139.3	78	PSE
Ramesh	NA	NA	NA	Data Analytics
Sam	Jan	135.2	80	PSE
Sam	Feb	160.1	81	PSE

In [67]:

```
# A try...
right_join(dataframe2, dataframe1, by="Name")  # FOCUS on the order...
```

```
Warning message:
“Column `Name` joining factors with different levels, coercing to character vector”
```

Name	Department	Month	BloodSugar	BloodPressure
Senthil	PSE	Jan	141.2	90
Senthil	PSE	Fev	139.3	78
Sam	PSE	Jan	135.2	80
Sam	PSE	Feb	160.1	81

See, its as same as the LeftJoin..

So, what do learn from this..

- Order matters..
- Left and Right joins can be used interchangeably, by changing the order of dataframes.

InnerJoin

Merges and retains those rows with IDs present in boht the dataframes.

i.e. (From the understanding of DBMS subject in academics)

- Takes the ones **common** in both Left and Right Join...
- Like, the **intersection operation** of the LeftJoin and the RightJoin

Technically..

> return all rows from `x` where there are matching values in `y`, and all columns from `x` and `y`. If there are multiple matches between `x` and `y`, all combination of the matches are returned.

In [68]:

```
inner_join(dataframe1, dataframe2, by="Name")
```

```
Warning message:
“Column `Name` joining factors with different levels, coercing to character vector”
```

Name	Month	BloodSugar	BloodPressure	Department
Senthil	Jan	141.2	90	PSE
Senthil	Fev	139.3	78	PSE
Sam	Jan	135.2	80	PSE
Sam	Feb	160.1	81	PSE

In [69]:

```
inner_join(dataframe2, dataframe1, by="Name")  # Changed the order..
```

```
Warning message:
“Column `Name` joining factors with different levels, coercing to character vector”
```

Name	Department	Month	BloodSugar	BloodPressure
Senthil	PSE	Jan	141.2	90
Senthil	PSE	Fev	139.3	78
Sam	PSE	Jan	135.2	80
Sam	PSE	Feb	160.1	81

Full Join

Intuitively..

> UNION of LeftJoin and RightJoin

Technically..

> return all rows and all columns from both `x` and `y`. Where there are not matching values, returns `NA` for the one missing.

In [70]:
```
full_join(dataframe1, dataframe2, by="Name")
```

```
Warning message:
“Column `Name` joining factors with different levels, coercing to character vector”
```

Name	Month	BloodSugar	BloodPressure	Department
Senthil	Jan	141.2	90	PSE
Senthil	Fev	139.3	78	PSE
Sam	Jan	135.2	80	PSE
Sam	Feb	160.1	81	PSE
Ramesh	NA	NA	NA	Data Analytics

Arithmetic, Logical and Matrix operations

Arithmetic Operators

Symbols	Operation
=, <-	Assignment
+	Addition
-	Subtraction
*	Multiplication
/	Division
^, **	Exponent
%%	Remainder
%/%	Integer Division

NOTE: In R only `<-` is valid, but in RStudio both `=` and `<-` will work.

Order of preference	Operation
Bracket	()
Exponent	^, **
Division	/
Multiplication	*
Addition and Subtraction	+, -

Like the **BODMAS** rule

`A = 7-2x^(27/3^2)+4`

```
- First, exponent - `27/3^2`, then Division in between those.. next exponent of Dr.,, then
Mulitplication of x with 2.
  then SUB then ADD (Following Left-to-Right associativity)
```

Logical Operators

Supported Logical Operators

Symbols	Operation
<	Less than
<=	Less than equal to
>	Greater than
>=	Greater than or Equal to
==	Exactly equal
!=	Not equal to
!	Logical NOT
|	Logical OR
&	Logical AND

Matrix Operations

Creating Matrices

Signature: `matrix(data = NA, nrow = 1, ncol = 1, byrow = FALSE, dimnames = NULL)`

- **FOCUS**: `byrow=FALSE`, so the passed vector just becomes a single column. To form a matrix, this need to be set to `TRUE` explicitly. -- *as said by sir..*
    - Its when passed only `ncol` parameter like: `matrix(c(1:9),ncol=3, byrow=TRUE)`
- When passed the `nrow` prop, without `byrow`, it fills column-wise. *Refer to the below second example*

In [29]:

```
matrix(c(1:9),nrow=3, byrow=TRUE)  #  == matrix(c(1:9),nrow=3, ncol=3, byrow=TRUE)
```

```
1  2  3
4  5  6
7  8  9
```

In [31]:

```
matrix(c(1:9), nrow=3)
```

```
1  4  7
2  5  8
3  6  9
```

Special Matrices

Matrix having all elements filled with `k`

`matrix(k, m, n)` -- fills `k` in the matrix of size `m x n`

In [20]:

```
matrix(5, 4, 3)   # Filling 5 in 4x3 matrix..
```

```
5  5  5
5  5  5
5  5  5
5  5  5
```

Diagonal Matrix

`diag(k, m, n)` - Fills the diagonal elements with `k` in the matrix of `m x n` dimensions.

In [21]:

```
diag(3, 2, 6)
```

```
3  0  0  0  0  0
0  3  0  0  0  0
```

In [22]:

```
diag(3, 5, 5)
```

```
3  0  0  0  0
0  3  0  0  0
0  0  3  0  0
0  0  0  3  0
0  0  0  0  3
```

Identity Matrix

simply take `k=1` in `diag(k, m, n)`

In [23]:

```
diag(1, 4, 4)
```

```
1  0  0  0
0  1  0  0
0  0  1  0
0  0  0  1
```

Exercise

In [24]:

```
matrix(c(3, 5, -2, 0), nrow=2)
```

```
3  -2
```

```
5   0
```

In [28]:

```
matrix(c(1, 10, 3, -1, 7, 5), nrow=3, byrow=TRUE)
```

```
1   10
3   -1
7    5
```

In [30]:

```
matrix(c(2, 3, 4, 0, 1, 2, -1, -2, -3, 5, 4, 3), nrow=4, byrow=TRUE)
```

```
 2   3   4
 0   1   2
-1  -2  -3
 5   4   3
```

Matrix Metrics

- `dim(A)` : Returns the dimensional size of the matrix.
- `nrow(A)` : Returns the rows of the matrix.
- `ncol(A)` : Returns the cols of the matrix.
- `prod(dim(A))` or `length(A)` : Returns no. of elements in the matrix.

In [39]:

```
A = matrix(c(2:13), ncol=4)
A
```

```
2  5   8  11
3  6   9  12
4  7  10  13
```

In [40]:

```
dim(A)
```

1. 3
2. 4

In [42]:

```
nrow(A)
```

3

In [43]:

```
ncol(A)
```

4

In [44]:

```
prod(dim(A))
```

12

In [45]:

```
length(A)
```

12

Accessing and deleting matrix elements

Follows the same convention of the dataframes

- **Accessing rows**: array/value **before** `,`
- **Accessing cols**: array/value **after** `,`
- **Removing rows/cols**: prefix '-' sign
- Strings can be assigned to rows and column names via `rownames()` and `colnames()`.

In [46]:

```
A
```

```
2  5   8  11
3  6   9  12
4  7  10  13
```

In [47]:

```
# Let's try accessing element "9"..
A[2, 3]
```

9

In [48]:

```
# Let's try accessing the rows 2 and 3
A[2:3,]
```

3	6	9	12
4	7	10	13

In [50]:

```
# Let's try accessing columns 1, 3 and 4
A[ , c(1, 3, 4)]
```

2	8	11
3	9	12
4	10	13

In [52]:

```
# Let's try assigning the names to the rows and cols..
colnames(A) = c("1st", "2nd", "3rd", "4th")
rownames(A) = c("i", "ii", "iii")
A
```

	1st	**2nd**	**3rd**	**4th**
i	2	5	8	11
ii	3	6	9	12
iii	4	7	10	13

In [56]:

```
# Now let's try accessing the "1st", "2nd" and "4th" columns along with "i" and "iii" rows..
A[ c("i", "iii"), c("1st", "2nd", "4th")]
```

	1st	**2nd**	**4th**
i	2	5	11
iii	4	7	13

In [57]:

```
# Now, get the 1st and 3rd row..
A[c(1, 3), ]
```

	1st	**2nd**	**3rd**	**4th**
i	2	5	8	11
iii	4	7	10	13

In [58]:

```
# Now get the 4th column
A[, 4]
```

i	11
ii	12
iii	13

In [59]:

```
# Get the 2nd row..
A[2, ]
```

1st	3
2nd	6
3rd	9
4th	12

In [60]:

```
# Get all the rows, except the 2nd..
A[-2, ]
```

	1st	**2nd**	**3rd**	**4th**
i	2	5	8	11
iii	4	7	10	13

In [61]:

```
# Get all the cols except 2nd and 3rd..
A[, -c(2, 3)]
```

	1st	4th
i	2	11
ii	3	12
iii	4	13

In [62]:

```
A
```

	1st	2nd	3rd	4th
i	2	5	8	11
ii	3	6	9	12
iii	4	7	10	13

In [64]:

```
# Update the (2, 3) to 100..
A[2, 3] = 100
A
```

	1st	2nd	3rd	4th
i	2	5	8	11
ii	3	6	100	12
iii	4	7	10	13

Colon operator: Sub matrices selection

In [67]:

```
4:10
7:2
```

1. 4
2. 5
3. 6
4. 7
5. 8
6. 9
7. 10

1. 7
2. 6
3. 5
4. 4
5. 3
6. 2

In [68]:

```
A
```

	1st	2nd	3rd	4th
i	2	5	8	11
ii	3	6	100	12
iii	4	7	10	13

In [69]:

```
# Get the First-3 columns, and last two rows..
A[2:3, 1:3]
```

	1st	2nd	3rd
ii	3	6	100
iii	4	7	10

In [70]:

```
# Get the 1st and 3rd rows being only 2nd, 3rd cols elements..
A[c(1, 3), 2:3]
```

	2nd	3rd
i	5	8
iii	7	10

Matrix Concatenation

Merging of a row and column to a matrix.

- `rbind()` : Concatenation of a row.
- `cbind()` : Concatenation of a column.

NOTE: Check the dimensional consistency before concatenation.

`rbind()` : Concatenation of rows..

Let, $A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$

$B = \begin{bmatrix} 10 & 11 & 12 \end{bmatrix}$

and required as $C = \begin{bmatrix} A \\ B \end{bmatrix}$

In [73]:

```
A = matrix(1:9, nrow=3, byrow=T)
A
B = matrix(10:12, nrow=1, byrow=T)
B
```

```
1  2  3
4  5  6
7  8  9

10  11  12
```

In [74]:

```
rbind(A, B)
```

```
 1   2   3
 4   5   6
 7   8   9
10  11  12
```

`cbind()` : Concatenation of column(s)

Let, $A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$

$B = \begin{bmatrix} 10 \\ 11 \\ 12 \end{bmatrix}$

and required as $C = \begin{bmatrix} A & B \end{bmatrix}$.. now..

In [77]:

```
A
B = matrix(10: 12) # By default takes as column..
B
```

```
1  2  3
4  5  6
7  8  9

10
11
12
```

In [78]:

```
cbind(A, B)
```

```
1  2  3  10
4  5  6  11
7  8  9  12
```

Dimensional Inconsitency..

Test on `rbind()` :

$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$

$$B = \begin{bmatrix} 10 \\ 11 \\ 12 \end{bmatrix}$$

and required as $C = \begin{bmatrix} A \\ B \end{bmatrix}$ (i.e., `rbind()`) -- will this work..? **NO**

> as A has dimension of $3x3$, where as B had $3x1$. **For `rbind()` , columns in both must match** right..??? here `3 != 1` -- *i.e., outer values in dimensions aren't same.*

In [84]:

```
A = matrix(1:9, nrow=3, byrow=T)
A
B = matrix(10: 12) # By default takes as column..
B
rbind(A, B)
```

```
1  2  3
4  5  6
7  8  9
```

```
10
11
12
```

```
Error in rbind(A, B): number of columns of matrices must match (see arg 2)
Traceback:

1. rbind(A, B)
```

Test on `cbind()` :

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

$$B = \begin{bmatrix} 10 & 11 & 12 \end{bmatrix}$$

and required as $C = \begin{bmatrix} A & B \end{bmatrix}$ (i.e., `cbind()`) -- will this work..? **NO**

> as A has dimension of $3x3$, where as B had $1x3$. **For `cbind()` , rows in both must match** right..??? here `3 != 1` -- *i.e., inner values in dimensions aren't same.*

In [80]:

```
B = matrix(10:12, nrow=1, byrow=T)
B
```

```
10  11  12
```

In [81]:

```
cbind(A, B)
```

```
Error in cbind(A, B): number of rows of matrices must match (see arg 2)
Traceback:

1. cbind(A, B)
```

Deleting a column

Prefix the `-` sign before the column..

Ex:

In [87]:

```
A
```

```
1  2  3
4  5  6
7  8  9
```

In [88]:

```
# Try deleting the column 2
A[, -2]
```

```
1  3
4  6
7  9
```

Deleting a row

In [89]:

```
# Try deleting the row 2
A[-2, ]
```

```
1  2  3
7  8  9
```

Matrix Algebra

In [92]:

```
P = matrix(c(3, 4, 6, 7, 2, 3, 5, 6, 5, 8, 3, 5), nrow=3, byrow=T)
P
Q = matrix(c(5, 4, 3, 7, 2, 8, 9, 2, 4, 5, 7, 1), nrow=3, byrow=T)
Q
```

```
3  4  6  7
2  3  5  6
5  8  3  5
```

```
5  4  3  7
2  8  9  2
4  5  7  1
```

Matrix Addition

In [96]:

```
P+Q
```

```
8   8   9  14
4  11  14   8
9  13  10   6
```

Matrix Subtraction

In [97]:

```
P-Q
```

```
-2   0   3  0
 0  -5  -4  4
 1   3  -4  4
```

In [98]:

```
Q-P
```

```
 2   0  -3   0
 0   5   4  -4
-1  -3   4  -4
```

Matrix Multiplication

In [99]:

```
P*Q   # Peforms element-wise.. not the dot-product..
```

```
15  16  18  49
 4  24  45  12
20  40  21   5
```

In [1...

```
P%*%Q  # Performs actual dot-product
# --- WHY not working..??
```

```
Error in P %*% Q: non-conformable arguments
Traceback:
```

In [1...

```
#install.packages("geometry")
library(geometry)
dot(P, Q)
```

```
also installing the dependencies ‘abind’, ‘magic’, ‘lpSolve’, ‘linprog’, ‘RcppProgress’

Updating HTML index of packages in '.Library'
Making 'packages.html' ... done
```

1. 39
2. 80
3. 84

4. 66

Matrix division

In [1...

```
P/Q  # Performed Element-Wise.. not the inverse o matrix..
```

```
0.60   1.000   2.0000000   1
1.00   0.375   0.5555556   3
1.25   1.600   0.4285714   5
```

Functions in R

- Created using `function()` command. **Syntax**:

```
function_name = function(arguments)
        {
            statements
        }
```

In [1...

```
adder = function(a=0, b=0)  # with default-arguments..
{
    return (a+b);
}
```

In [1...

```
result = adder(4, 5)
result
```

9

In RStudio: *(a bit different)*

- Need to create the functions in a file (i.e., in a RScript file)
- Once done, save it. Load via **Source** button on top of script-window (or) use `script(<path>)`.
  - When done successfully, can see the function being appearing in the *Variable Browser*.
  - NOTE: Loading will not execute the function.
- **WARNING**: Whenever the file or function is updated or restarted RStudio, it has to be loaded again, else it considers the previously-loaded ones, and yields incorrect results.

Passing arguments to the function

- Passing in the same order as in the definition.
  - `adder(3, 5) # returns 8`
- Passing no arguments to the function.
  - `adder() # return 0`
  - As the function contains *default arguements* this works. What if not..?? it's ahead..
- Passing in different order.
  - `adder(b=5, a=70)  # returns 75`
  - i.e., By specifying the argument name, can pass in any order. But when without name, need to pass in the order.

Lazy evaluation of functions

- Functions are lazily evaluated in R. i.e., Even if some arguments are missing *(excluding the default ones)*, the function still gets exectued **as long as the function doesn't involve these arguments.**

Hold on...!! See the R's cleverness..

```
> volcylinder = function(dia, len, rad){
```

Summary of creating functions in R

- Create a function file, like a RScript file. First line of function_file should be `R function_name=function(arguments)`. Then define the body of it.
    - *(There can be >1 functions defined in a single file).*
- Save the function file and load it by clicking **Source** *(Which will be at the top of editor-window).* or via `source(<path>)`.
- Invoke it by its `function_name` and proper arguments.

WARNING: Need to load the function file when performed any changes in it or re-started RStudio. -- else may get incorrect results or error.

MIMO: Functions with *Multiple Inputs and Multiple outputs.*

- Already familiar that, one can pass mulitple arguments to the function. But also know that, a function can return only one value.
- To overcome that, we make a vector or a matrix *(any grouping thing)* of all those values, and simply return that one value.

In [1...

```
arithmetic = function(a, b){
    return (c("+"=a+b,
              "-"=a-b,
              "*"=a*b,
              "/"=a/b,
              "%"=a%%b))
}
```

In [1...

```
arithmetic(4, 5)
```

```
+                      9
-                      -1
*                      20
/                      0.8
%                      4
```

Inline functions...

Instead of creating a file -> Loading it -> Executing it... can adopt a simple approach, if had a simple task.

```
function_name = function(arguments) <body>
```

In [1...

```
work = function(x, y) x+(y*10)/(x*0.2);
```

In [1...

```
work(3, 4)
```

69.6666666666667

with multiple values.. simply use any collection..

In [1...

```
work = function(x, y) c(x+(y*10)/(x*0.2), x*y)
```

In [1...

```
work(5, 6)
```

1. 65
2. 30

Looping over objects.

- `apply()` : Apply a function over the margins of an array or matrix.
- `lapply()` : Apply a function over a list or a vector. `l` in `lapply()` for *list.*
- `mapply` : Multivariate version of `lapply()` . ....oOo. `m` in `mapply()` for *multi-variate.*
- `tapply()` : Apply a function over a ragged array.
- `xxply()` : plyr package. -- sir din't explained this.

`apply()` function..

- Apply a function over the margins of an array or matrix.
- **Syntax**: `R apply(array, margins, function, ...)`. -- Here `margins` refers to the **dimensions of the matrix/vector upon which the function to be evaluated.**

In [1...

```
M = matrix(2: 10, 3, 3)
M
```

```
2  5   8
3  6   9
4  7  10
```

In [1...

```
# Find the sum of each ROW..
apply(M, 1, sum)  # margin=1, tells to operate over rows..
```

```
1. 15
2. 18
3. 21
```

In [1...

```
# Find the sum of COLUMN..
apply(M, 2, sum)   # margin=2, tells to operate over columns..
```

```
1. 9
2. 18
3. 27
```

In [1...

```
apply(M, 3, diff)
```

```
Error in if (d2 == 0L) {: missing value where TRUE/FALSE needed
Traceback:

1. apply(M, 3, diff)
```

`lapply()` function

- Used to apply a function over a list/vector.
- It always returns the list of the length (as passed).
  - Think.....oO) As with each value in the list, the function gets called, takes its results and places in the list.
  - When this happens for the entire list, we get the results of all the functions, whose size will be equal to the size of list passed as an argument right...??.
- **Syntax**: `lapply(list, function, ...)`.

In [1...

```
a = matrix(1:5)
b = matrix(6:10)
c = list(a, b)
# find the sum of each list..
lapply(c, sum)
```

```
1. 15
2. 40
```

In [1...

```
F = matrix(1:9, 3, 3)
G = matrix(10:18, 3, 3)
H = matrix(20:18, 3, 3)

# Calculate the determinant of each matrix..
lapply(list(F, G, H), det) # or, we can use a loop and use apply, store each in a list..
```

```
1. 0
2. 0
3. 0
```

For `G` sir got as 5.329071e-15... why this way then..??

`mapply()` function

- It's a multivariate version of the `lapply().
- A function can be applied over several lists simultaneously.
- **Syntax**: `mapply(function, list1, list2)`. **FOCUS**: the position of the argument `function`..!!

In [1...

```
o = matrix(1:9)
p = matrix(9:1)

# Get the sum, by forming a pair by picking one from each list.
mapply(sum, o, p)
```

1. 10
2. 10
3. 10
4. 10
5. 10
6. 10
7. 10
8. 10
9. 10

`tapply()` function

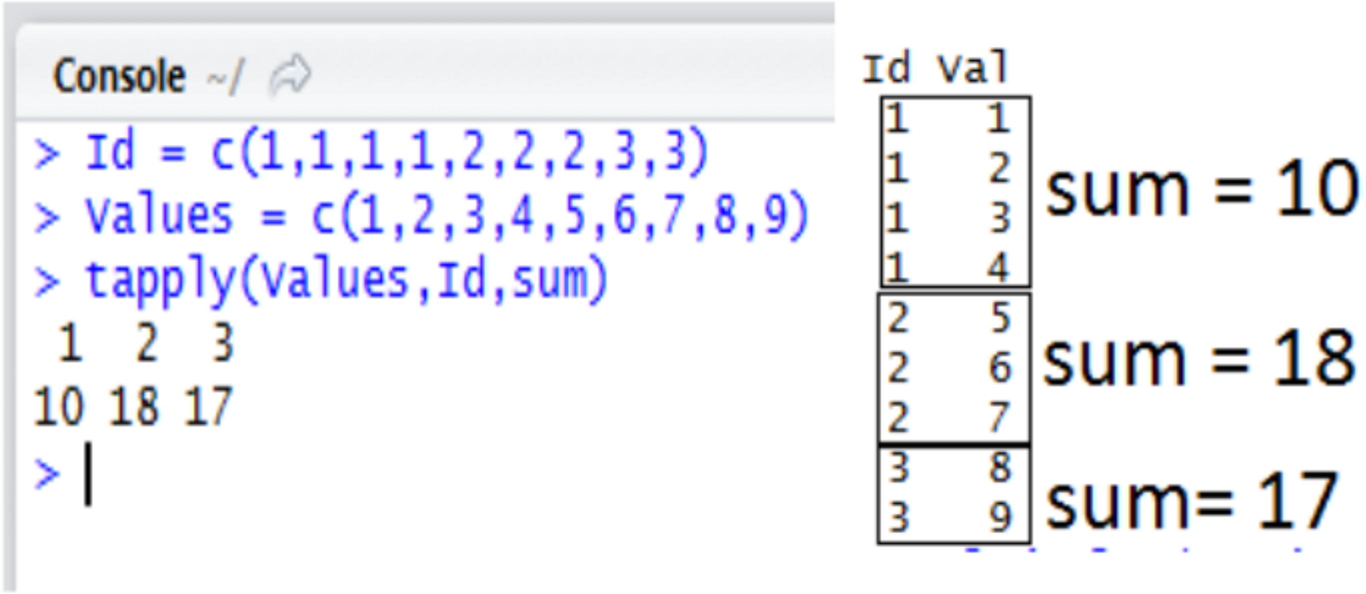
- It's used to apply a function over a subset of vectors given by a combination of factors.
- **Syntax**: `tapply(vector, factors, function, ...)`

In [1...

```
id = c(1, 1, 1, 1, 2, 2, 2, 3, 3)
values = 1:9
# Add those values which are having same id's..
tapply(values, id, sum)
```

1	10
2	18
3	17

Interpret as:



```
> Id = c(1,1,1,1,2,2,2,3,3)
> Values = c(1,2,3,4,5,6,7,8,9)
> tapply(Values,Id,sum)
 1  2  3
10 18 17
> |
```

Id	Val	
1	1	sum = 10
1	2	
1	3	
1	4	
2	5	sum = 18
2	6	
2	7	
3	8	sum= 17
3	9	

Control Structures

Can be classified into two categories:

1. Execute certain statements, only when certain condition(s) are satisfied. Like `if-else` ...
2. Execute certan statments repeatedly and use a certain logic to stop the iteration. Like `for` , `while` ..

`if`

```
if(condition)
{
        statements
}
```

`if-else`

```
if(condition)
{
        statements
}
else
{
        alternate_statments
}
```

`if-else construct or ladder`

```
if(condition)
{
        statements
}
else if(condition)
{
        statements
}
else if(condition)
{
    statements
}
else
{
        statements
}
```

`seq()` function

Its one of the components of the `for` loop.

- Syntax: `seq(from, to, by, length)` where
  - `from` : starting number.
  - `to` : ending number
  - `by` : increment or decrement (width)
  - `length` : number of elements required.

In [1...

```
seq(from=1, to=10, by=2)
```

1. 1
2. 3
3. 5
4. 7
5. 9

In [1...

```
seq(from=1, to=10, length=3)  # When skipped `by`, uses length to make divisions.
```

1. 1
2. 5.5
3. 10

In [1...

```
seq(from=2, to=15, by=3, length=2)
```

```
Error in seq.default(from = 2, to = 15, by = 3, length = 2): too many arguments
Traceback:

1. seq(from = 2, to = 15, by = 3, length = 2)
2. seq.default(from = 2, to = 15, by = 3, length = 2)
3. stop("too many arguments")
```

`for` loop

```
for(iterator in sequence)
    {
            statements
    }
```

where:

- `iterator` : (generally) loop-variable
- `sequence` : could be a vector or a list.

In [1...

```
for ( i in 1:10)
    print(i)
```

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

In [1...

```
sum = 0
for( i in seq(1, 5, by=1))
{
    sum = sum+i

    print(i)
}
print(sum)
```

```
[1] 1
[1] 2
[1] 3
[1] 4
[1] 5
[1] 15
```

with `break` statements..

In [1...

```
for( i in seq(1, 20, 3))
{
    print(i)
    if(i>10)
        break
}
```

```
[1] 1
[1] 4
[1] 7
[1] 10
[1] 13
```

`while` loop

- Required in a context, where we need to keep on iterating until some condition is met.

Syntax:

```
while(condition)
    {
        statements
    }
```

In [1...

```
i=0
while(i<10)  # keep running, as long as i<10
{
    print(i)
    i = i+2
}
```

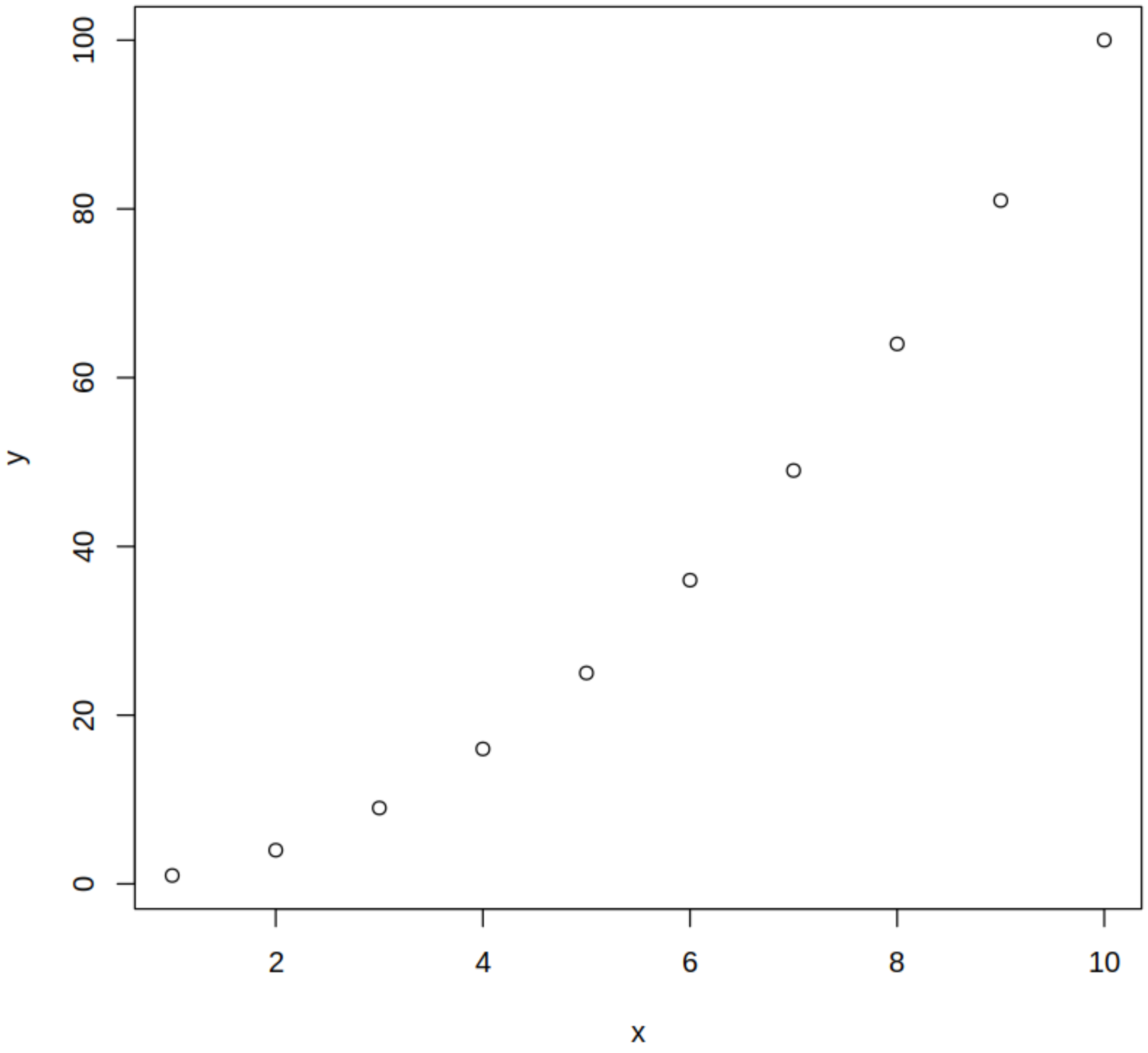
```
[1] 0
[1] 2
[1] 4
[1] 6
[1] 8
```

Graphics in R

Scatter Plot

In [1...

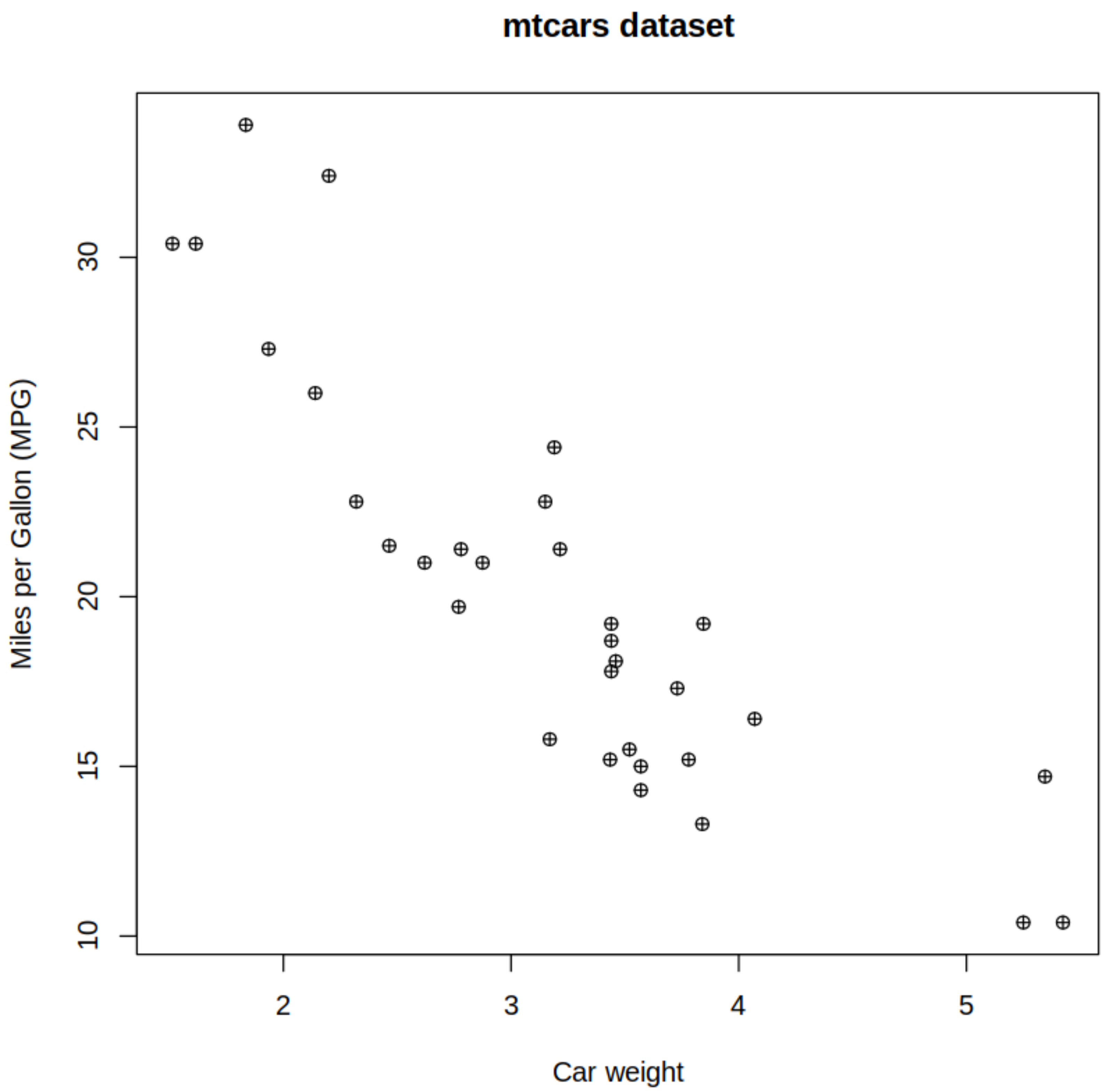
```
x = 1:10
y = x^2
plot(x, y)
```



lets work on in-built dataset: `mtcars`

In [2...

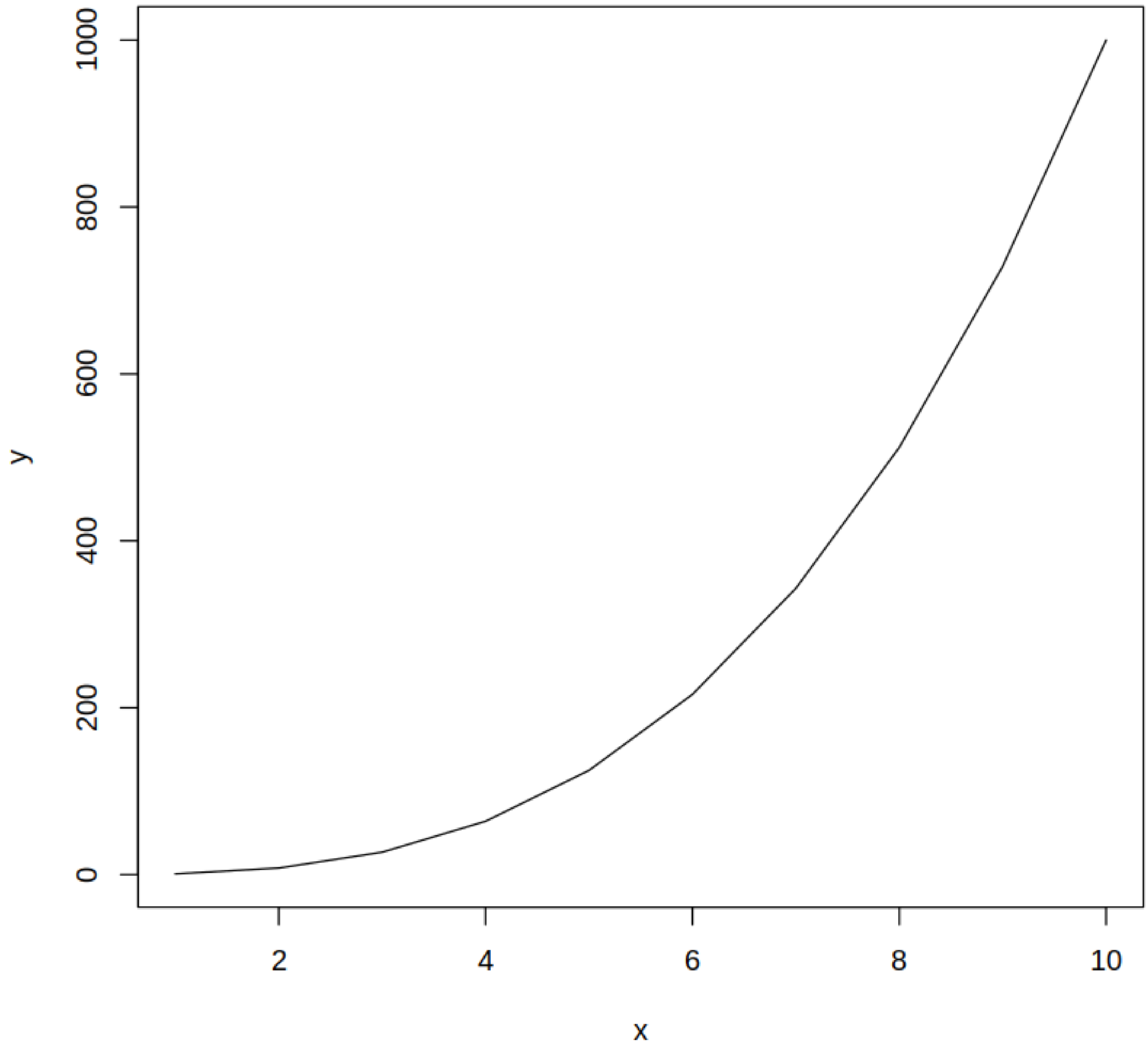
```
plot(mtcars$wt, mtcars$mpg,
    main="mtcars dataset",              # Graph label (title)
    xlab="Car weight",                  # X-label..
    ylab="Miles per Gallon (MPG)",      # Y-axis label..
    pch=10)                             # shape of marker. here 19 refers to the filled-circle
```



Line Plot

In [2...

```
x = 1:10
y = x^3
plot(x, y, type='l')  # Line plot..
```



Barplot

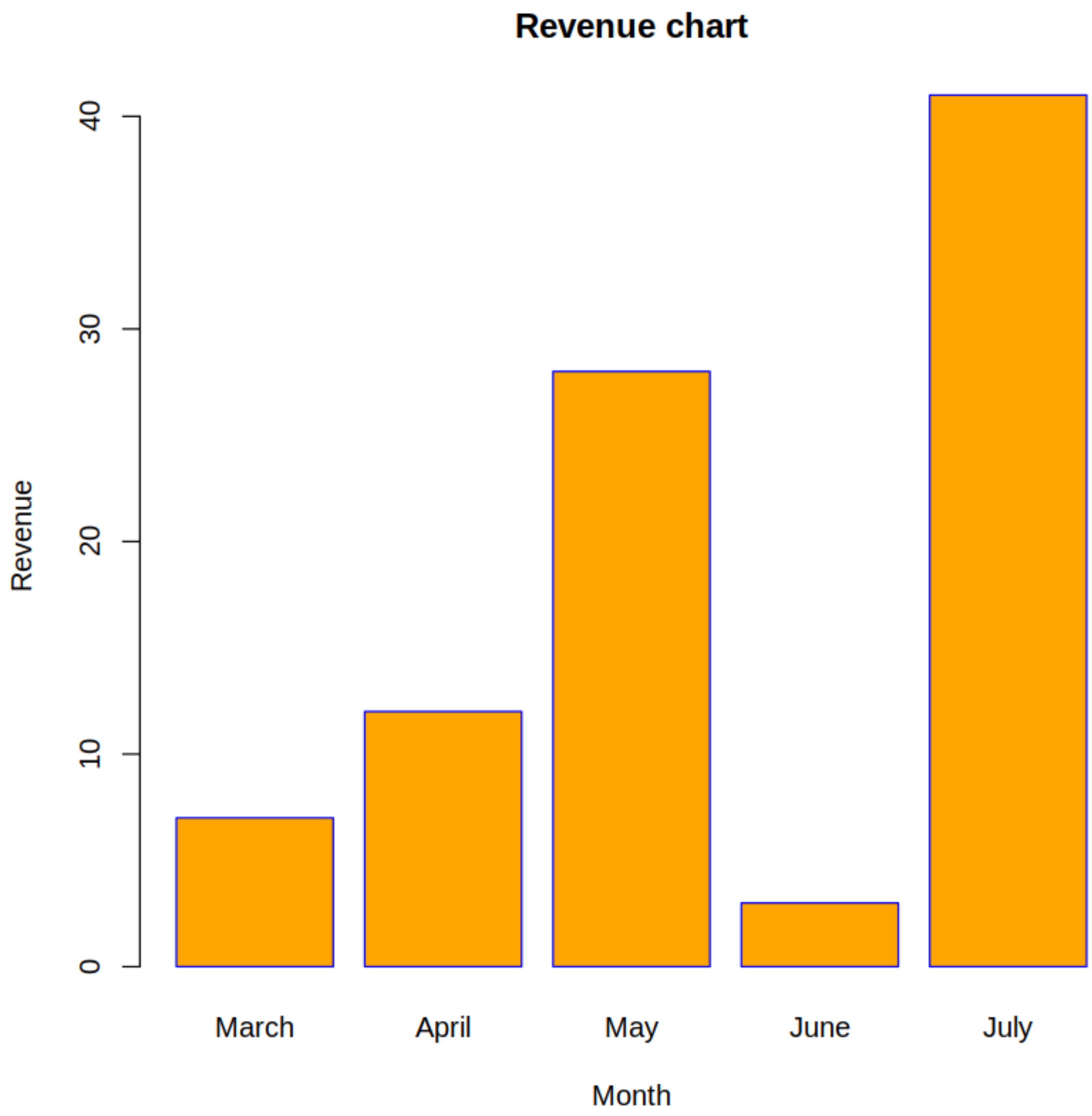
```
barplot(H, names.arg, xlab, main, names.arg, col)
```

Where:

- `H` : heights - can be vectors or matrix. (but we'll deal with the vectors for simple..)
- `names.arg` : It prints the names under each bar.
- `xlab` & `ylab` : X-axis label and Y-axis label.
- `main` : title of the plot
- `names.arg` : ??
- `col` : color

In [2...

```
H <- c(7, 12, 28, 3, 41)
M <- c("March", "April", "May", "June", "July")
barplot(H, names.arg=M, xlab="Month", ylab="Revenue", col="orange", main="Revenue chart", border="blue")
```



In [2...

```
par(mfrow=c(2,4))
days <- c("Thur", "Fri", "Sat", "Sun")
sexes <- unique(tips$sex)
for (i in 1:length(sexes)) {
for (j in 1:length(days)) {
currdata <- tips[tips$day == days[j] & tips$sex == sexes[i],]
plot(currdata$total_bill, currdata$tip/currdata$total_bill,
main=paste(days[j], sexes[i], sep=", "), ylim=c(0,0.7), las=1)
}
}
```

```
Error in unique(tips$sex): object 'tips' not found
Traceback:

1. unique(tips$sex)
```

Challenges

- Knowing when to introducye a for loop
- Which columns of the dataframe to be selected.
- The positioning of each graph in the grid..

even though, we could try manage the above, at end we back at

- Less pleasing visuals

This need introduces the `ggplot2` library, which produce good plotting.

In [ ]: