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Statistical Lab using R-Programming

LAB MANUAL AND WORKBOOK

Year	**:**	**2020 – 2021**
Subject Code	**:**	**U18MAI4201-Probability and Statistics**
Regulation	**:**	**R2018**
Year/Branch/Course	**:**	**B.E CSE/B.E ISE/ B.Tech IT**

Department of Mathematics

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Certificate

This is to certify that it is a bonafide record of practical work done by **Deksha H** *bearing the Roll No.***19BIT027** *of Second year* **Information Technology** *Branch in the* **R - Programming** *laboratory during the academic year* **2020-2021** *under our supervision.*

Faculty In-Charge **Internal Examiner**

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STATISTICAL LAB USING R-PROGRAMMING - MARKS BREAK UP STATEMENT

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1		Introduction to R programming				
2		Application of descriptive statistics – Mean, Median, Mode and standard deviation				
3		Applications of Correlation and Regression				
4		Application of Normal distribution				
5		Application of Student – t test				
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10		Control charts for variables (mean and range chart)				

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LABORATORY MANUAL

Experiment Number: 1

Lab Code	**: U18MAI4201**
Lab	**: Probability and Statistics**
Course / Branch	**: B.Tech / Information Technology**
Title of the Experiment	**: Introduction to R programming**

STEP 1: INTRODUCTION

OBJECTIVES OF THE EXPERIMENT

1. To understand the basics of R-Programming and R Studio
2. To understand the representations of basic data
3. To create a data frame using given data
4. To import data from a given MS-Excel file

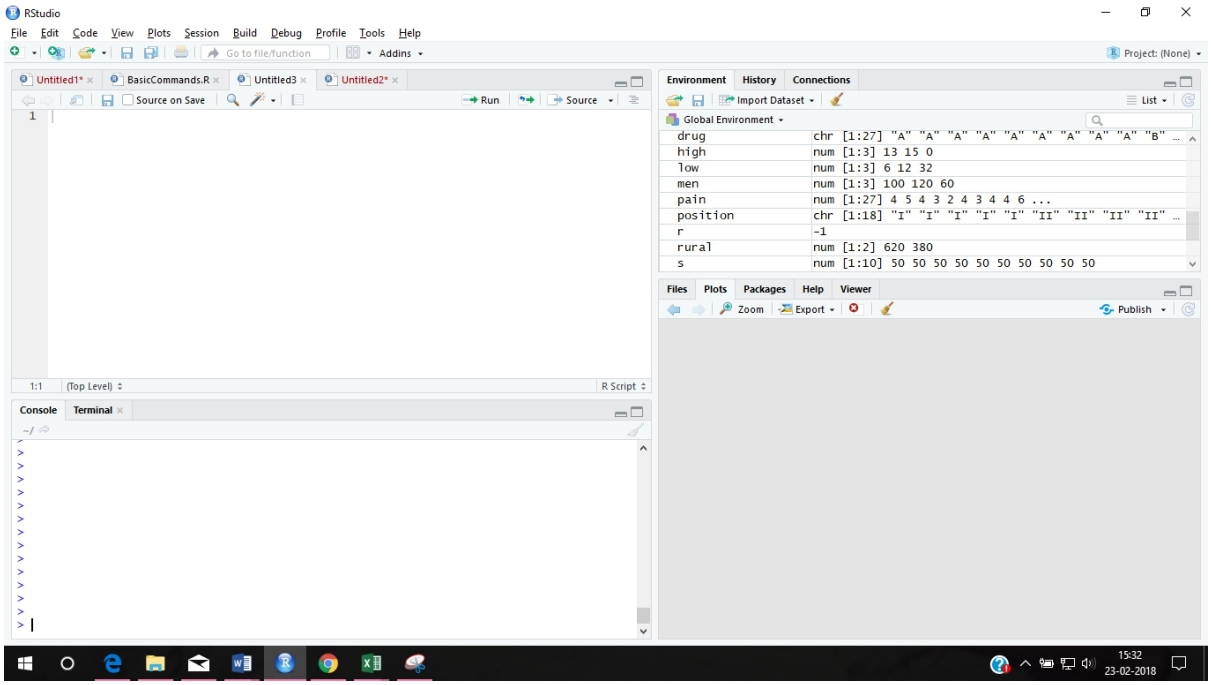
STEP 2: ACQUISITION

I. INTRODUCTION TO R PROGRAMMING

- R is a programming language and software environment for statistical analysis, graphics representation and reporting. R was created by Ross Ihaka and Robert Gentleman at the University of Auckland, New Zealand
- This programming language was named R, based on the first letter of first name of the two R authors (Robert Gentleman and Ross Ihaka)
- R allows integration with the procedures written in the C, C++, .Net, Python or FORTRAN languages for efficiency.
- R is a well-developed, simple and effective programming language which includes conditionals, loops, user defined recursive functions and input and output facilities.
- R has an effective data handling and storage facility
- R provides a suite of operators for calculations on arrays, lists, vectors and matrices.

- R provides a large, coherent and integrated collection of tools for data analysis.
- R provides graphical facilities for data analysis and display either directly at the computer or printing at the papers.
- R is the world's most widely used statistics programming language.

The four windows



Editor	Command History (Environment)
Console	Instructions Packages Plot

Important note: R is case sensitive

R-objects:

There are many types of R-objects.

- Vectors
- Lists
- Matrices

- Arrays
- Factors
- Data Frames

Vector: a <- c(1,2,3,4,5,6)

(or) a = c(1,2,3,4,5,6)

Data frames :

- Tabular data objects.
- Each column can contain different modes of data. The first column can be numeric while the second column can be character and third column can be logical.
- It is a list of vectors of equal length.
- Data Frames are created using the data.frame() function.

Example:

BMI = data.frame(gender = c("Male", "Male","Female"), height = c(152, 171.5, 165), weight = c(61,83, 68), Age =c(42,38,26))

Print (BMI)

When we execute the above code, it produces the following result:

	Gender	Height	Weight	Age
1	Male	152.0	81	42
2	Male	171.5	93	38
3	Female	165.0	78	26

Some basic commands

1. **To generate a sequence with common difference 1**

R code: seq(1,10)

Output : 1 2 3 4 5 6 7 8 9 10

2. **To generate a sequence with common difference 2**

R code :seq(1,15,by=2) :

Output: 1 3 5 7 9 11 13 15

3. **To find the square root of a number**

R code:

#square root y=2

sqrt(2) (or) x=sqrt(y)

Output:

[1] 1.414214 [1] 1.414214

4. To perform addition of two numbers

R-code R-codeR-code

```
a=2                c=a+b          c=2+3
b=3                a=2            c
c=a+b      (or)    b=3      (or)
c                  c
```

Output OutputOutput

[1] 5 [1] 5 [1] 5

Data frames :

- Tabular data objects.
- Each column can contain different modes of data. The first column can be numeric while the second column can be character and third column can be logical.
- It is a list of vectors of equal length.
- Data Frames are created using the data.frame() function.

II. To create a data frame using given data

Procedure for doing the Experiment:

1.	Represent the various columns of the data frame by the vectors x, y, z ……
2.	A=data.frame(x,y,z,…..) creates the data frame.

Example

R code:

```
A =data.frame(    name=c("A","B","C"),
```

```
gender = c("Male", "Male","Female"),

height = c(152, 171.5, 165),

weight = c(81,93, 78),

age =c(42,38,26))

  A
```

(OR)

```
name=c("A","B","C")

gender = c("Male", "Male","Female")

height = c(152, 171.5, 165)

weight = c(81,93, 78)

age =c(42,38,26)

  A=data.frame(name,gender,height,weight,age)

  A
```

Output

```
name gender height    weight age
1       A      Male       152.0         81      42
2       B      Male       171.5         93      38
3       C    Female    165.0          78      26
```

Task 1

Create a data frame from the following details regarding babies' frocks (Given: size, season. material, decoration, pattern type, price)

1. **L, spring, silk, embroidery, dot, 650**
2. **M, summer, chiffon, bow, print, 275**
3. **M, summer, cotton, null, animal, 380**
4. **M, Winter, cotton, null, patchwork, 450**
5. **L, autumn, linen, ruffles, animal, 420**

R Code:

```
size =c("L","M","M","M","L")
                    season=c("Spring","Summer","Summer","Winter","Autumn")
                    material=c("silk","chiffon","cotton","cotton","linen")
decoration=c("Embroidery","Bow","Null","Null","Ruffles")
patterntype=c("dot","print","animal","patchwork","animal")
```

```
price=c(650,275,380,450,420)
                D=data.frame(size,season,material,decoration,patterntype,price)
                D
```

Output:

```
     size  season     material     decoration          pattern  type    price
1       L    Spring        silk           Embroidery                dot                 650
2       M  Summer    chiffon            Bow                      print               275
3       M  Summer    cotton          Null           animal     380
4       M  Winter         cotton          Null           patchwork        450
5L    Autumn      linen             Ruffles         animal           420
```

III. To import data from a given MS-Excel file

1.	**To locate current working directory**
	# Get and print current working directory.
	print(getwd( ))

2.	**To import data from Excel sheet** To import data from Excel sheet 'abc', first save the file as .csv(comma delimited) in the current working directory. Then execute the following command data = read.csv("abc.csv") data
3.	**$ symbol is used to extract a specific field.**

Example:
To import data from Excel sheet

To import data from Excel sheet 'Testmarks', first save the file as .csv (comma delimited) in the current working directory. Then execute the following command

```
data = read.csv("Testmarks.csv")

data
```

Output:

Output is

```
Sl.No Name IT.1 IT.II
1     1    A   26    32
2     2    B   25    25
3     3    C   19    31
4     4    D   14    26
5     5    E   25    28
6     6    F   32    32
7     7    G   29    42
8     8    H   25    26
```

```
9     9    I   31    38
10    10    J   35    39
11    11    K   33    31
12    12    L   35    36
```

To get the list of students who have passed in Internal test 1

pass= subset(data, IT.1 >= 25)

print(pass)

Output is

```
Sl.No Name IT.1 IT.II
1     1    A   26    32
2     2    B   25    25
5     5    E   25    28
6     6    F   32    32
7     7    G   29    42
8     8    H   25    26
9     9    I   31    38
10    10    J   35    39
11    11    K   33    31
12    12    L   35    36
```

To get the list of students who have secured 30 or more marks in both tests

Good= subset(data, IT.1 >= 30&IT.II>=30)

Good

Output

```
Sl.No Name IT.1 IT.II

6     6    F   32    32
9     9    I   31    38
10    10    J   35    39
11    11    K   33    31
12    12    L   35    36
```

Task 2

Import the excel file 'Studentdetails1'from your directory to create a dataframe

details = read.csv("Studentdetails1.csv")

details

Output:

```
X STUDENTNAME GENDER SEATCATG        CITYNAME TOTALMARKS CUTOFFMARKS
1   1         A1   Male      MQ   TIRUVANNAMALAI       967     177.00
2   2         A2 Female      MQ      COIMBATORE      1097     183.75
```

3	3	A3	Female	MQ	COIMBATORE	1096	183.50
4	4	A4	Female	MQ	COIMBATORE	1085	187.50
5	5	A5	Male	MQ	COIMBATORE	1056	179.00
6	6	A6	Male	MQ	OOTY	1091	184.00
7	7	A7	Female	MQ	KARUR	1088	180.75
8	8	A8	Male	MQ	COIMBATORE	1009	171.75
9	9	A9	Male	MQ	COIMBATORE	906	145.50
10	10	A10	Male	MQ	SALEM	977	159.25
11	11	A11	Male	MQ	COIMBATORE	1052	168.25
12	12	A12	Female	MQ	THE NILGIRIS	1125	190.50
13	13	A13	Male	MQ	BANGALORE	391	68.25
14	14	A14	Female	MQ	COIMBATORE	1003	158.00
15	15	A15	Male	MQ	SALEM	959	168.00
16	16	A16	Male	MQ	TIRUCHIRAPPALLI	1140	188.00
17	17	A17	Female	MQ	COIMBATORE	963	162.00
18	18	A18	Female	GQ	COIMBATORE	1135	195.50
19	19	A19	Male	GQ	ERODE	1139	195.75
20	20	A20	Female	GQ	TIRUPPUR	1158	195.25
21	21	A21	Male	GQ	PATTUKOTTAI	1153	195.25
22	22	A22	Female	MQ	COONOOR	1115	189.50
23	23	A23	Female	GQ	TRICHIRAPPALLI	1114	192.25
24	24	A24	Male	GQ	TIRUNELVELI	1145	195.75
25	25	A25	Male	GQ	SALEM	1164	196.00
26	26	A26	Male	GQ	ERODE	1152	195.75
27	27	A27	Female	GQ	DHARAPURAM	1159	194.50
28	28	A28	Female	GQ	COIMBATORE	1112	195.50
29	29	A29	Male	GQ	TIRUPPUR	1112	179.50
30	30	A30	Male	GQ	SIVAGANGAI	1147	194.25
31	31	A31	Female	GQ	CUDDALORE	1127	195.00
32	32	A32	Female	GQ	TIRUCHIRAPPALLI	1152	192.75
33	33	A33	Female	GQ	ERODE	1135	194.50
34	34	A34	Male	GQ	KRISHNAGIRI	1143	192.50
35	35	A35	Male	GQ	THIRUVALLUR	1125	195.00
36	36	A36	Male	GQ	VIRUDHUNAGAR	1143	195.75
37	37	A37	Male	GQ	MADURAI	1041	181.25
38	38	A38	Male	MQ	COIMBATORE	1047	170.75
39	39	A39	Female	MQ	SIVAGANGAI	1038	168.00
40	40	A40	Male	GQ	METTUPALAYAM	1094	187.00
41	41	A41	Male	MQ	TIRUPPUR	1084	186.50
42	42	A42	Male	MQ	KANYAKUMARI	1043	177.50
43	43	A43	Male	MQ	CHAMRAJNAGAR	433	68.00
44	44	A44	Male	MQ	SIVAGANGA	884	139.00
45	45	A45	Male	MQ	SALEM	926	152.25
46	46	A46	Male	MQ	COIMBATORE	936	153.00
47	47	A47	Male	GQ	COIMBATORE	1129	193.00
48	48	A48	Female	GQ	DINDIGUL	1101	188.75
49	49	A49	Female	GQ	THE NILGIRIS	1134	192.75
50	50	A50	Female	GQ	ERODE	1117	193.75
51	51	A51	Male	GQ	CUDDALORE	1129	188.75
52	52	A52	Male	GQ	RAMANATHAPURAM	1137	194.25
53	53	A53	Female	GQ	THENI	1115	193.25
54	54	A54	Male	GQ	ERODE	1144	190.25
55	55	A55	Male	GQ	VELLORE	1124	193.50

Task 3:

Import the excel file 'Cotton prices-International and Domestic' from your directory to create a data frame

details = read.csv("Cotton prices-International and Domestic.csv")

details

Output:

	Cotlook.A.Minimum	Cotlook.A.Maximum	Range	Cotlook.A...Average
1	79.85	85.30	5.45	81.95
2	79.40	82.20	2.80	80.87
3	81.85	84.80	2.95	83.37
4	83.10	90.35	7.25	85.51
5	88.80	90.90	2.10	89.71
6	91.40	98.85	7.45	94.45
7	90.60	95.70	5.10	92.68
8	89.40	95.10	5.70	92.74
9	88.80	96.65	7.85	93.08
10	91.15	93.95	2.80	92.60
11	89.15	97.35	8.20	92.59
12	88.35	91.45	3.10	89.95
13	85.40	93.15	7.75	89.33
14	83.75	85.60	1.85	84.64
15	85.15	89.70	4.55	87.49
16	88.05	94.45	6.40	90.96
17	91.95	95.75	3.80	94.05
18	93.30	98.90	5.60	96.93
19	92.20	97.75	5.55	94.20
20	89.40	95.80	6.40	92.71
21	89.30	93.70	4.40	90.90
22	79.60	88.40	8.80	83.84
23	72.15	76.05	3.90	74.04
24	69.95	76.15	6.20	73.38
25	69.65	71.45	1.80	70.35
26	65.90	70.00	4.10	67.53
27	66.00	70.25	4.25	68.38
28	65.30	68.75	3.45	67.35
29	67.05	71.75	4.70	69.84
30	67.20	71.25	4.05	69.35
31	69.55	73.95	4.40	71.72
32	71.05	74.70	3.65	72.86
33	71.25	74.35	3.10	72.36
34	70.65	74.80	4.15	72.35
35	69.85	74.10	4.25	71.82
36	66.40	70.25	3.85	68.74
37	66.65	70.85	4.20	69.03
38	68.30	70.55	2.25	69.22
39	69.50	71.70	2.20	70.39
40	67.70	69.95	2.25	68.75
41	65.05	68.95	3.90	66.57
42	64.05	66.50	2.45	65.46
43	66.40	71.70	5.30	69.28
44	68.80	72.95	4.15	70.28
45	71.80	76.15	4.35	74.10
46	74.85	85.39	10.54	81.07
47	75.70	85.85	10.15	80.26
48	75.00	80.65	5.65	77.87
49	76.55	80.35	3.80	78.52
50	76.95	81.15	4.20	78.92
51	78.20	80.70	2.50	79.53
52	79.65	84.25	4.60	82.33
53	84.10	86.80	2.70	85.16
54	85.75	88.10	2.35	86.84
55	84.60	88.80	4.20	87.04
56	86.40	94.90	8.50	88.64
57	82.60	87.70	5.10	84.66
58	82.20	85.05	2.85	84.09
59	77.40	81.35	3.95	79.36
60	78.55	84.70	6.15	80.59
61	77.60	80.40	2.80	78.60

62	79.00	81.60	81.60	61.80

	Shankar.6.Minimum	Shankar.6.Maximum	Range.1	Shankar.6.Average
1	32900	34400	1500	33450
2	33000	33800	800	33564
3	33300	34200	900	33764
4	33600	34300	700	33771
5	33900	37200	3300	35013
6	37000	39300	2300	38275
7	36700	39400	2700	38139
8	37000	38600	1600	37742
9	38500	41500	3000	39892
10	41000	43200	2200	42370
11	42400	49000	6600	45968
12	46900	48900	2000	47805
13	41000	48500	7500	44776
14	38800	40900	2100	39935
15	38500	40400	1900	39284
16	40200	42800	2600	42015
17	41800	43200	1400	42565
18	41500	42400	900	41943
19	41400	42900	1500	42038
20	40700	43200	2500	42065
21	41200	42900	1700	42044
22	39500	42900	3400	41542
23	39000	40500	1500	39835
24	34700	39900	5200	38360
25	32700	34000	1300	33448
26	32400	33200	800	32812
27	32900	33300	400	33146
28	29800	32900	3100	31300
29	30100	31300	1200	30678
30	30700	32600	1900	31122
31	32200	34200	2000	33296
32	34200	35500	1300	34922
33	33200	35000	1800	34232
34	33800	34600	800	34293
35	33500	34700	1200	33992
36	33000	35500	2500	34672
37	31800	32900	1100	32472
38	32000	32500	500	32209
39	32400	34000	1600	33223
40	33400	34000	600	33672
41	33100	33800	700	33452
42	32100	33200	1100	32676
43	32800	34700	1900	33975
44	34700	36800	2100	35315
45	36700	42700	6000	39456
46	42700	48500	5800	45896
47	43900	47800	3900	46269
48	43000	48000	5000	45125
49	37700	44500	6800	41233
50	37700	40000	2300	38728
51	38600	39600	1000	39007
52	40000	42600	2600	41256
53	41900	43000	1100	42482
54	42600	43700	1100	43085
55	42100	44000	1900	42967
56	41600	43000	1400	42396
57	42300	43100	800	42642
58	41800	43300	1500	42362
59	42200	42600	400	42323
60	38700	42300	3600	40829
61	37800	39000	1200	38468
62	37200	38100	900	35861

Task 4:

Import the excel file 'Height and weight'from your directory to create a data frame

PROGRAM:

```
details = read.csv("Height and weight.csv")

details
```

OUTPUT:

```
Name Weight Height
1    X1   69.1  152.0
2    X2   80.2  176.0
3    X3   80.1  166.0
4    X4   84.1  168.0
5    X5   81.0  161.0
6    X6   85.5  174.0
7    X7   72.2  153.0
8    X8   55.3  154.0
9    X9   72.3  161.0
10  X10   64.0  162.5
11  X11   52.0  154.0
12  X12   71.7  156.0
13  X13   74.6  171.0
14  X14   80.0  162.0
15  X15   75.2  167.0
16  X16   50.0  140.0
17  X17   40.0  130.0
18  X18   65.0  160.0
19  X19   70.0  180.0
20  X20   80.0  190.0
21  X21   76.0  176.0
22  X22   67.0  165.0
23  X23   57.0  164.0
24  X24   67.0  175.0
25  X25   75.0  183.0
26  X26   80.0  185.0
27  X27   80.0  182.0
28  X28   80.0  178.0
29  X29   40.0  150.0
30  X30   59.0  151.0
31  X31   53.0  153.0
32  X32   54.0  158.0
33  X33   58.0  157.0
34  X34   54.0  154.0
35  X35   64.0  164.0
36  X36   60.0  162.0
37  X37   60.0  163.0
38  X38   70.0  159.0
39  X39   60.0  170.0
40  X40   50.0  160.0
41  X41   68.0  165.0
42  X42   60.0  168.0
43  X43   68.0  169.0
44  X44   57.0  159.0
45  X45   80.0  180.0
46  X46   76.0  176.0
```

STEP 3: PRACTICE/TESTING

1. What is a dataframe?

A data frame is a table or a two-dimensional array-like structure in which each column contains values of one variable and each row contains one set of values from each column.

2. Mention some characteristics of a data frame.

Following are the characteristics of a data frame.

- The column names should be non-empty.
- The row names should be unique.
- The data stored in a data frame can be of numeric, factor or character type.
- Each column should contain same number of data items.

3. How would you extract the subsets of all MQ students from the data frame in task 2?

```
Extract = subset(data, SEATCATG)
Extract
```

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LABORATORY MANUAL

Experiment Number: 2

Lab Code	**: U18MAI4201**
Lab	**: Probability and Statistics**
Course / Branch	**: B.Tech / Information Technology**
Title of the Experiment	**: Application of descriptive statistics – Mean, Median, Mode and standard deviation**

STEP 1: INTRODUCTION

OBJECTIVES OF THE EXPERIMENT

To find arithmetic mean,median, mode and standard deviation.

STEP 2: ACQUISITION

1. To find the Arithmetic Mean

```
A=c(54,55,53,56,52,52,58,49,50,51)
Mean1=mean(A)
Mean1
[1] 53
```

2. To find the Median

```
A=c(54,55,53,56,52,52,58,49,50,51)
Med=median(A)
Med
[1] 52.5
```

3. To find the mode

Create the function.

```
mode=function(x){
ux= unique(x)
ux[which.max(tabulate(match(x,ux)))]
}
# Find the mode of the numbers 2,1,2,3,1,2,3,4,1,5,5,3,2,3
x = c(2,1,2,3,1,2,3,4,1,5,5,3,2,3)
```

```
# Calculate the mode using the user function.
result= mode(x)
print(result)
```

4. To find the standard deviation

```
A=c(54,55,53,56,52,52,58,49,50,51)
Std=sd(A)
Std
Output:
[1] 2.788867
```

Task 1: To find the average set length in a sizing unit

The following set lengths are used in a sizing unit in a factory during a month. Compute the arithmetic mean and median: 1780, 1760, 1690, 1750, 1840, 1920, 1100, 1810, 1050, 1950.

```
R Code:

A= c(1780, 1760, 1690, 1750, 1840, 1920, 1100, 1810, 1050, 1950)
Mean = mean(A)
Mean

Output:

[1] 1665


R Code:

A= c(1780, 1760, 1690, 1750, 1840, 1920, 1100, 1810, 1050, 1950)

Median = median(A)
Median

Output:

[1] 1770
```

Task 2: Find the average export of steel in a month from the data given below (in millions of kgs) using mean and median:

```
Jan'16          105.26
Feb'16          101.05
Mar '16         113.60
```

```
Apr'16          105.97
May'16          95.05
Jun'16          93.58
Jul'16          76.21
Aug'16          67.42
Sep'16          77.88
Oct'16          77.97
Nov'16          104.44
Dec'16        174.11
```

R-Code:

```
A=c(105.26,101.05,113.60,105.97,95.05,93.58,76.21,67.42,77.88,77.97,104.44,174.11)
Mean2=mean(A)
Mean2
```

Output:

```
[1] 99.37833
```

R-Code:

```
A= c(105.26,101.05,113.60,105.97,95.05,93.58,76.21,67.42,77.88,77.97,104.44,174.11)
Median2 = median(A)
Median2
```

Output:

```
[1] 98.05
```

Task 3: To find the average export of raw cotton per year

The following list gives the export quantity of raw cotton (in million kg.) for five consecutive years 2012-2013 to 2016-17: 1945.63, 1864.69, 1093.11, 1297.27, 918. 15. Find the mean and median.

PROGRAM:

```
A= c(1945.63, 1864.69, 1093.11, 1297.27, 918.15)
Mean3=mean(A)
Mean3
Median3 = median(A)
Median3
```

OUTPUT:

```
[1] 1423.77
```

[1] 1297.27

To find the Arithmetic mean,median, standard deviation for a frequency distribution

Example

```
d=read.table(header=TRUE,text="Marks                Frequency
+                                                    5
 15
+                                                   15
20
+                                                   25
30
+                                                   35
20
+                                                   45
17
+                                                   55
6")
d2= rep(d$Marks, d$Frequency)
multi.fun = function(x) {
c(mean = mean(x), median = median(x), sd = sd(x))
}
multi.fun(d2)
Output:
mean      median   sd
27.03704    25.00000      14.25792
```

Task 4
Find the mean and standard deviation of the frequency distribution:

x:	1	2	3	4	5	6	7
f:	5	9	12	17	14	10	6

PROGRAM:

```
d=read.table(header=TRUE,text="x f
1 5
2 9
3 12
4 17
5 14
6 10
7 6")
d2= rep(d$x, d$f)
multi.fun = function(x) {
c(mean = mean(x), sd = sd(x))
}
```

```
multi.fun(d2)
```

OUTPUT:

```
mean           sd
4.095890 1.668036
```

Task 5

The following data related to the distance traveled by 520 villagers to buy their weekly requirements.
Miles Traveled: 2 4 6 8 10 13 14 16 18 20
No of Villagers: 38 104140 78 48 42 28 24 16 2
Calculate the arithmetic mean and median.

PROGRAM:

```
d=read.table(header=TRUE,text="miles Noofvillagers
 2 38
4 104
6 140
8 78
10 48
13 42
14 28
 16 24
18 16
 20 2")
d2= rep(d$miles, d$Noofvillagers)
multi.fun = function(x) {
c(mean = mean(x), median = median(x))
}
multi.fun(d2)
```

OUTPUT:

```
 mean      median
 7.857692 6.000000
```

Task 6
Calculate the mean and standard deviation for the following:
Size : 6 7 8 9 10 11 12
Frequency: 3 6 9 13 8 5 4

PROGRAM:

```
d=read.table(header=TRUE,text="Size Frequency
 6 3
 7 6
 8 9
 9 13
 10 8
 11 5
 12 4")
d2= rep(d$Size, d$Frequency)
multi.fun = function(x) {
   c(mean = mean(x),    sd = sd(x))
}
multi.fun(d2)
```

OUTPUT:

```
   mean            sd
9.000000 1.624284
```

Task 7

Find the mean, median and mode for the following data.

14.8, 14.2, 13.8, 13.5, 14.0, 14.2, 14.3, 14.6, 13.9, 14.0, 14.1, 13.2, 13.0, 14.2, 13.5, 13.0, 12.8, 13.9, 14.8, 15.0, 12.8, 13.4, 13.2, 14.0, 13.8, 13.9, 14.0, 14.0, 13.9, 14.8

PROGRAM:

```
 A=c(14.8, 14.2, 13.8, 13.5, 14.0, 14.2, 14.3, 14.6, 13.9, 14.0, 14.1, 13.2, 13.0, 14.2, 13.5,
13.0,
      12.8, 13.9, 14.8, 15.0, 12.8, 13.4, 13.2, 14.0, 13.8, 13.9, 14.0, 14.0, 13.9, 14.8)
Mean7=mean(A)
Mean7
Median7=median(A)
Median7
mode=function(A){
ux= unique(A)
ux[which.max(tabulate(match(A,ux)))]
}
Mode7= mode(A)
```

Mode7

OUTPUT:

[1] 13.88667

[1] 13.95

[1] 14

To import data from a given MS-Excel file and to find arithmetic mean, median, mode and standard deviation

1.	**To locate current working directory**
	# Get and print current working directory.
	print(getwd( ))

2.	**To import data from Excel sheet** To import data from Excel sheet 'abc', first save the file as .csv (comma delimited) in the current working directory. Then execute the following command data = read.csv("abc.csv") data
3.	**$ symbol is used to extract a specific field.**
4.	**mean(data$-----)**
5.	**Median(data$----)**

6.	**Mode** :
	mode = function(x) {
	ux = unique(x)
	ux[which.max(tabulate(match(x, ux)))]
	}
	x = data$ ------
	# Calculate the mode using the user function.
	v = mode(x)
	print(v)

7.	**Standard Deviation** z=sd(data$ ----) z
8.	summary(data)

Example:
To import data from Excel sheet

To import data from Excel sheet 'Test marks', first save the file as .csv(comma delimited) in the current working directory. Then execute the following command

```
data = read.csv("Testmarks.csv")

data
```

Output:

```
Sl.No. Name IT.1 IT.II
1      1    A   26    32
2      2    B   25    25
3      3    C   19    31
4      4    D   14    26
5      5    E   25    28
6      6    F   32    32
7      7    G   29    42
8      8    H   25    26
9      9    I   31   38
10    10    J   35    39
11    11    K   33    31
12    12    L   35    36
```

To find the average marks of all students in Internal test 1

```
mean(data$IT.1)
```

Output:

27.41667

Task 8

Import the excel file 'Studentdetails1'from your directory to create a dataframe and find:

1. **The mean, median, mode of cut-off marks**
2. **The summary of all details in the file.**
3. **The mean of total marks**
4. **The city from which maximum number of students have come.**
5. **The list of GQ students and their mean cutoff marks**
6. **The list of girl students and their average cutoff.**

PROGRAM:

details = read.csv("Studentdetails1.csv")

Details

OUTPUT:

X	STUDENTNAME	GENDER	SEATCATG	CITYNAME	TOTALMARKS	CUTOFFMARKS
1	1	A1	Male	MQ	TIRUVANNAMALAI	967	177.00
2	2	A2	Female	MQ	COIMBATORE	1097	183.75
3	3	A3	Female	MQ	COIMBATORE	1096	183.50
4	4	A4	Female	MQ	COIMBATORE	1085	187.50
5	5	A5	Male	MQ	COIMBATORE	1056	179.00
6	6	A6	Male	MQ	OOTY	1091	184.00
7	7	A7	Female	MQ	KARUR	1088	180.75
8	8	A8	Male	MQ	COIMBATORE	1009	171.75
9	9	A9	Male	MQ	COIMBATORE	906	145.50
10	10	A10	Male	MQ	SALEM	977	159.25
11	11	A11	Male	MQ	COIMBATORE	1052	168.25
12	12	A12	Female	MQ	THE NILGIRIS	1125	190.50
13	13	A13	Male	MQ	BANGALORE	391	68.25
14	14	A14	Female	MQ	COIMBATORE	1003	158.00
15	15	A15	Male	MQ	SALEM	959	168.00
16	16	A16	Male	MQ	TIRUCHIRAPPALLI	1140	188.00
17	17	A17	Female	MQ	COIMBATORE	963	162.00
18	18	A18	Female	GQ	COIMBATORE	1135	195.50
19	19	A19	Male	GQ	ERODE	1139	195.75
20	20	A20	Female	GQ	TIRUPPUR	1158	195.25
21	21	A21	Male	GQ	PATTUKOTTAI	1153	195.25
22	22	A22	Female	MQ	COONOOR	1115	189.50
23	23	A23	Female	GQ	TRICHIRAPPALLI	1114	192.25
24	24	A24	Male	GQ	TIRUNELVELI	1145	195.75
25	25	A25	Male	GQ	SALEM	1164	196.00
26	26	A26	Male	GQ	ERODE	1152	195.75
27	27	A27	Female	GQ	DHARAPURAM	1159	194.50
28	28	A28	Female	GQ	COIMBATORE	1112	195.50
29	29	A29	Male	GQ	TIRUPPUR	1112	179.50
30	30	A30	Male	GQ	SIVAGANGAI	1147	194.25
31	31	A31	Female	GQ	CUDDALORE	1127	195.00
32	32	A32	Female	GQ	TIRUCHIRAPPALLI	1152	192.75
33	33	A33	Female	GQ	ERODE	1135	194.50
34	34	A34	Male	GQ	KRISHNAGIRI	1143	192.50
35	35	A35	Male	GQ	THIRUVALLUR	1125	195.00
36	36	A36	Male	GQ	VIRUDHUNAGAR	1143	195.75
37	37	A37	Male	GQ	MADURAI	1041	181.25
38	38	A38	Male	MQ	COIMBATORE	1047	170.75
39	39	A39	Female	MQ	SIVAGANGAI	1038	168.00
40	40	A40	Male	GQ	METTUPALAYAM	1094	187.00
41	41	A41	Male	MQ	TIRUPPUR	1084	186.50
42	42	A42	Male	MQ	KANYAKUMARI	1043	177.50
43	43	A43	Male	MQ	CHAMRAJNAGAR	433	68.00
44	44	A44	Male	MQ	SIVAGANGA	884	139.00
45	45	A45	Male	MQ	SALEM	926	152.25
46	46	A46	Male	MQ	COIMBATORE	936	153.00
47	47	A47	Male	GQ	COIMBATORE	1129	193.00
48	48	A48	Female	GQ	DINDIGUL	1101	188.75
49	49	A49	Female	GQ	THE NILGIRIS	1134	192.75
50	50	A50	Female	GQ	ERODE	1117	193.75
51	51	A51	Male	GQ	CUDDALORE	1129	188.75
52	52	A52	Male	GQ	RAMANATHAPURAM	1137	194.25
53	53	A53	Female	GQ	THENI	1115	193.25
54	54	A54	Male	GQ	ERODE	1144	190.25

```
55 55        A55   Male      GQ         VELLORE      1124      193.50
```

CODING:

1. To find mean , median, mode of cutoff marks

Mean:

```
mean(details$CUTOFFMARKS)
```

Output:

[1] 179.0318

Median

```
median(details$CUTOFFMARKS)
```

Output:

[1] 188.75

Mode

```
mode=function(A){
  ux= unique(A)
  ux[which.max(tabulate(match(A,ux)))]
}
A=details$CUTOFFMARKS
mode8= mode(A)
mode8
```

Output:

[1] 195.75

Standard Deviation:

```
sd8=sd(details$CUTOFFMARKS)
sd8
```

Output:

[1] 26.0761

2. Summary of all details:

Summary (details)

Output:

```
X        STUDENTNAME    GENDER   SEATCATG      CITYNAME    TOTALMARKS  Min. :
1.0   A1  : 1   Female:21   GQ:29    COIMBATORE:14   Min.   : 391  1st Qu.:14.5
 A10: 1   Male  :34   MQ:26    ERODE     : 5  1st Qu.:1042   Median :28.0 A11
 : 1                  SALEM     : 4   Median :1112  Mean   :28.0 A12    : 1
             TIRUPPUR  : 3   Mean   :1060
3rd Qu.:41.5 A13    : 1                  CUDDALORE : 2   3rd Qu.:1136  Max.   :
55.0A14    : 1                 SIVAGANGAI: 2   Max.   :1164
(Other):49               (Other)   :25
 CUTOFFMARKS
 Min.   : 68.0
 1st Qu.:174.4
Median :188.8
 Mean   :179.0
 3rd Qu.:194.2
 Max.   :196.0
```

2. The mean of total marks

Mean

mean(details$TOTALMARKS)

Output:

[1] 1059.836

Standard Deviation:

sd(details$TOTALMARKS)

Output:

[1] 145.9606

3. To find the city from which maximum number of students have come.

```
mode = function(x) {
ux = unique(x)
ux[which.max(tabulate(match(x, ux)))]
                    }
                      x = details$CITYNAME
                                  # Calculate the mode using the user function.
maxcity = mode(x)
print(maxcity)
```

Output:

[1] "COIMBATORE"

5. The list of GQ students and their mean cutoff marks

R Code:

```
a=subset(details,SEATCATG=="GQ")
a
```

OUTPUT:

X	STUDENTNAME	GENDER	SEATCATG	CITYNAME	TOTALMARKS	CUTOFFMARKS
18	18	A18	Female	GQ	COIMBATORE	1135	195.50
19	19	A19	Male	GQ	ERODE	1139	195.75
20	20	A20	Female	GQ	TIRUPPUR	1158	195.25
21	21	A21	Male	GQ	PATTUKOTTAI	1153	195.25
23	23	A23	Female	GQ	TRICHIRAPPALLI	1114	192.25
24	24	A24	Male	GQ	TIRUNELVELI	1145	195.75
25	25	A25	Male	GQ	SALEM	1164	196.00
26	26	A26	Male	GQ	ERODE	1152	195.75
27	27	A27	Female	GQ	DHARAPURAM	1159	194.50
28	28	A28	Female	GQ	COIMBATORE	1112	195.50
29	29	A29	Male	GQ	TIRUPPUR	1112	179.50
30	30	A30	Male	GQ	SIVAGANGAI	1147	194.25
31	31	A31	Female	GQ	CUDDALORE	1127	195.00
32	32	A32	Female	GQ	TIRUCHIRAPPALLI	1152	192.75
33	33	A33	Female	GQ	ERODE	1135	194.50
34	34	A34	Male	GQ	KRISHNAGIRI	1143	192.50
35	35	A35	Male	GQ	THIRUVALLUR	1125	195.00
36	36	A36	Male	GQ	VIRUDHUNAGAR	1143	195.75
37	37	A37	Male	GQ	MADURAI	1041	181.25
40	40	A40	Male	GQ	METTUPALAYAM	1094	187.00
47	47	A47	Male	GQ	COIMBATORE	1129	193.00
48	48	A48	Female	GQ	DINDIGUL	1101	188.75
49	49	A49	Female	GQ	THE NILGIRIS	1134	192.75
50	50	A50	Female	GQ	ERODE	1117	193.75
51	51	A51	Male	GQ	CUDDALORE	1129	188.75
52	52	A52	Male	GQ	RAMANATHAPURAM	1137	194.25
53	53	A53	Female	GQ	THENI	1115	193.25
54	54	A54	Male	GQ	ERODE	1144	190.25
55	55	A55	Male	GQ	VELLORE	1124	193.50

Meancutoff

```
mean(a$CUTOFFMARKS)
```

OUTPUT:
[1] 192.6638

6.To get the list of girl students and their average cutoff.

R Code:

```
b=subset(details,GENDER=="Female")
b
```

OUTPUT:

```
X STUDENTNAME GENDER SEATCATG      CITYNAME TOTALMARKS CUTOFFMARKS
2   2         A2 Female      MQ      COIMBATORE      1097     183.75
3   3         A3 Female      MQ      COIMBATORE      1096     183.50
4   4         A4 Female      MQ      COIMBATORE      1085     187.50
7   7         A7 Female      MQ           KARUR      1088     180.75
12 12        A12 Female      MQ    THE NILGIRIS      1125     190.50
14 14        A14 Female      MQ      COIMBATORE      1003     158.00
17 17        A17 Female      MQ      COIMBATORE       963     162.00
18 18        A18 Female      GQ      COIMBATORE      1135     195.50
20 20        A20 Female      GQ        TIRUPPUR      1158     195.25
22 22        A22 Female      MQ         COONOOR      1115     189.50
23 23        A23 Female      GQ  TRICHIRAPPALLI      1114     192.25
27 27        A27 Female      GQ     DHARAPURAM      1159     194.50
28 28        A28 Female      GQ      COIMBATORE      1112     195.50
31 31        A31 Female      GQ       CUDDALORE      1127     195.00
32 32        A32 Female      GQ TIRUCHIRAPPALLI      1152     192.75
33 33        A33 Female      GQ           ERODE      1135     194.50
39 39        A39 Female      MQ      SIVAGANGAI      1038     168.00
48 48        A48 Female      GQ        DINDIGUL      1101     188.75
49 49        A49 Female      GQ    THE NILGIRIS      1134     192.75
50 50        A50 Female      GQ           ERODE      1117     193.75
53 53        A53 Female      GQ           THENI      1115     193.25
```

Meancutofffemale

```
mean(b$CUTOFFMARKS)
```

OUTPUT:

```
[1] 187.0119
```

Task 9:

Import the excel file 'Cotton prices-International and Domestic.xlsx'from your directory to create a dataframe and find:

i) **The mean, median, mode of Cotlook.A.Minimum, Cotlook.A.Maximum, Cotlook.A…Average,Shankar.6.Maximum,Shankar.6.Minimum, Shankar.6.Average.**
ii) **The summary of all details in the file.**

R Code:

```
details = read.csv("Cotton prices-International and Indian.csv")

details
```

Output:

	Cotlook.A.Minimum	Cotlook.A.Maximum	Range	Cotlook.A...Average
1	79.85	85.30	5.45	81.95
2	79.40	82.20	2.80	80.87
3	81.85	84.80	2.95	83.37
4	83.10	90.35	7.25	85.51
5	88.80	90.90	2.10	89.71
6	91.40	98.85	7.45	94.45
7	90.60	95.70	5.10	92.68
8	89.40	95.10	5.70	92.74
9	88.80	96.65	7.85	93.08
10	91.15	93.95	2.80	92.60
11	89.15	97.35	8.20	92.59
12	88.35	91.45	3.10	89.95
13	85.40	93.15	7.75	89.33
14	83.75	85.60	1.85	84.64
15	85.15	89.70	4.55	87.49
16	88.05	94.45	6.40	90.96
17	91.95	95.75	3.80	94.05
18	93.30	98.90	5.60	96.93
19	92.20	97.75	5.55	94.20
20	89.40	95.80	6.40	92.71
21	89.30	93.70	4.40	90.90
22	79.60	88.40	8.80	83.84
23	72.15	76.05	3.90	74.04
24	69.95	76.15	6.20	73.38
25	69.65	71.45	1.80	70.35
26	65.90	70.00	4.10	67.53
27	66.00	70.25	4.25	68.38
28	65.30	68.75	3.45	67.35
29	67.05	71.75	4.70	69.84
30	67.20	71.25	4.05	69.35
31	69.55	73.95	4.40	71.72
32	71.05	74.70	3.65	72.86
33	71.25	74.35	3.10	72.36
34	70.65	74.80	4.15	72.35
35	69.85	74.10	4.25	71.82
36	66.40	70.25	3.85	68.74
37	66.65	70.85	4.20	69.03
38	68.30	70.55	2.25	69.22
39	69.50	71.70	2.20	70.39
40	67.70	69.95	2.25	68.75
41	65.05	68.95	3.90	66.57
42	64.05	66.50	2.45	65.46
43	66.40	71.70	5.30	69.28
44	68.80	72.95	4.15	70.28
45	71.80	76.15	4.35	74.10
46	74.85	85.39	10.54	81.07
47	75.70	85.85	10.15	80.26
48	75.00	80.65	5.65	77.87
49	76.55	80.35	3.80	78.52
50	76.95	81.15	4.20	78.92
51	78.20	80.70	2.50	79.53
52	79.65	84.25	4.60	82.33
53	84.10	86.80	2.70	85.16
54	85.75	88.10	2.35	86.84
55	84.60	88.80	4.20	87.04
56	86.40	94.90	8.50	88.64
57	82.60	87.70	5.10	84.66
58	82.20	85.05	2.85	84.09
59	77.40	81.35	3.95	79.36
60	78.55	84.70	6.15	80.59
61	77.60	80.40	2.80	78.60
62	79.00	81.60	81.60	61.80

	Shankar.6.Minimum	Shankar.6.Maximum	Range.1	Shankar.6.Average
1	32900	34400	1500	33450
2	33000	33800	800	33564
3	33300	34200	900	33764
4	33600	34300	700	33771

5	33900	37200	3300	35013
6	37000	39300	2300	38275
7	36700	39400	2700	38139
8	37000	38600	1600	37742
9	38500	41500	3000	39892
10	41000	43200	2200	42370
11	42400	49000	6600	45968
12	46900	48900	2000	47805
13	41000	48500	7500	44776
14	38800	40900	2100	39935
15	38500	40400	1900	39284
16	40200	42800	2600	42015
17	41800	43200	1400	42565
18	41500	42400	900	41943
19	41400	42900	1500	42038
20	40700	43200	2500	42065
21	41200	42900	1700	42044
22	39500	42900	3400	41542
23	39000	40500	1500	39835
24	34700	39900	5200	38360
25	32700	34000	1300	33448
26	32400	33200	800	32812
27	32900	33300	400	33146
28	29800	32900	3100	31300
29	30100	31300	1200	30678
30	30700	32600	1900	31122
31	32200	34200	2000	33296
32	34200	35500	1300	34922
33	33200	35000	1800	34232
34	33800	34600	800	34293
35	33500	34700	1200	33992
36	33000	35500	2500	34672
37	31800	32900	1100	32472
38	32000	32500	500	32209
39	32400	34000	1600	33223
40	33400	34000	600	33672
41	33100	33800	700	33452
42	32100	33200	1100	32676
43	32800	34700	1900	33975
44	34700	36800	2100	35315
45	36700	42700	6000	39456
46	42700	48500	5800	45896
47	43900	47800	3900	46269
48	43000	48000	5000	45125
49	37700	44500	6800	41233
50	37700	40000	2300	38728
51	38600	39600	1000	39007
52	40000	42600	2600	41256
53	41900	43000	1100	42482
54	42600	43700	1100	43085
55	42100	44000	1900	42967
56	41600	43000	1400	42396
57	42300	43100	800	42642
58	41800	43300	1500	42362
59	42200	42600	400	42323
60	38700	42300	3600	40829
61	37800	39000	1200	38468
62	37200	38100	900	35861

Mean:

mean(details$Cotlook.A.Minimum)

Output:

[1] 78.14919

Median:

median(details$Cotlook.A.Minimum)
Output:
[1] 78.375

Mode

```
mode=function(A){
   ux= unique(A)
   ux[which.max(tabulate(match(A,ux)))]
}
A=details$Cotlook.A.Minimum
mode8= mode(A)
mode8
```

Output:

[1] 88.8

Standard deviation:
sd(details$Cotlook.A.Minimum)

Output:

[1] 8.927676

Mean:

mean(details$Cotlook.A.Maximum)

Output:
[1] 82.75226

Median:
median(details$Cotlook.A.Maximum)

Output:

[1] 83.225
Mode:

```
mode=function(A){
```

```
   ux= unique(A)
   ux[which.max(tabulate(match(A,ux)))]
}
A=details$Cotlook.A.Maximum
mode9= mode(A)
mode9
```

Output:

[1] 76.15

Standard deviation:

sd(details$Cotlook.A.Maximum)

Output:

[1] 9.65965

Mean:

mean(details$Cotlook.A...Average)

OUTPUT:

[1] 80.04806

Median:

median(details$Cotlook.A...Average)

Output:

[1] 80.425

Mode:

```
mode=function(A){
   ux= unique(A)
   ux[which.max(tabulate(match(A,ux)))]
}
A=details$Cotlook.A...Average
mode8= mode(A)
mode8
```

Output:

[1] 81.95

Standard deviation

sd(details$Cotlook.A...Average)

Output:

[1] 9.470624

Mean:
mean(details$Shankar.6.Average)

Output:

[1] 38249.15

Median:
median(details$Shankar.6.Average)

Output:

[1] 38598

Mode:

```
mode=function(A){
   ux= unique(A)
   ux[which.max(tabulate(match(A,ux)))]
}
A=details$Shankar.6.Average
mode8= mode(A)
mode8
```

Output:

[1] 3345**0**

Standard deviation:

sd(details$Shankar.6.Average)

Output:

[1] 4585.738

Mean:
mean(details$Shankar.6.Maximum)

Output:
[1] 39335.48

Median:
median(details$Shankar.6.Maximum)

Output:
[1] 39750

Mode:
```
mode=function(x){
   ux= unique(x)
   ux[which.max(tabulate(match(x,ux)))]
}
x = details$Shankar.6.Maximum
Mode= mode(x)
Mode
```

Output:
[1] 43200

Standard deviation:

sd(details$Shankar.6.Maximum)

Output:
[1] 4970.638

Mean:
mean(details$Shankar.6.Minimum)

Output:
[1] 37158.06

Median:
median(details$Shankar.6.Minimum)

Output:
[1] 37450

Mode:

```
mode=function(x){
   ux= unique(x)
   ux[which.max(tabulate(match(x,ux)))]
}
x = details$Shankar.6.Minimum
Mode= mode(x)
Mode
```

Output:
[1] 32900

Standard deviation:

```
sd(details$Shankar.6.Minimum)
```

Output:
[1] 4234.153

Summary:

summary(data)

```
Cotlook.A.MinimumCotlook.A.Maximum    Range       Cotlook.A...Average
 Min.   :64.05    Min.   :66.50    Min.   : 1.800   Min.   :61.80
 1st Qu.:69.70    1st Qu.:73.99    1st Qu.: 3.100   1st Qu.:70.72
 Median :78.38    Median :83.22    Median : 4.200   Median :80.42
 Mean   :78.15    Mean   :82.75    Mean   : 5.877   Mean   :80.05
 3rd Qu.:85.66    3rd Qu.:90.76    3rd Qu.: 5.638   3rd Qu.:88.35
 Max.   :93.30    Max.   :98.90    Max.   :81.600   Max.   :96.93
 Shankar.6.Minimum Shankar.6.Maximum   Range.1    Shankar.6.Average
 Min.   :29800    Min.   :31300    Min.   : 400   Min.   :30678
 1st Qu.:33125    1st Qu.:34325    1st Qu.:1100   1st Qu.:33766
 Median :37450    Median :39750    Median :1650   Median :38598
 Mean   :37158    Mean   :39335    Mean   :2177   Mean   :38249
 3rd Qu.:41150    3rd Qu.:42975    3rd Qu.:2575   3rd Qu.:42060
 Max.   :46900    Max.   :49000    Max.   :7500Max.   :47805
```

Task 10

Import the excel file 'Height and weight' from your directory to create a data frame

And find the mean , median, mode for Height and Weight.

CODING:

```
details = read.csv("Height and weight.csv")
```

details

OUTPUT:

```
Name Weight Height
1    X1   69.1  152.0
2    X2   80.2  176.0
3    X3   80.2  166.0
4    X4   84.1  168.0
5    X5   81.0  161.0
6    X6   85.5  174.0
7    X7   72.2  153.0
8    X8   55.3  154.0
9    X9   72.3  161.0
10  X10   64.0  162.5
11  X11   52.0  154.0
12  X12   71.7  156.0
13  X13   74.6  171.0
14  X14   80.0  162.0
15  X15   75.2  167.0
```

Mean:

mean(details$Height)
Output:

[1] 162.5
Mean:
mean(details$Weight)

Output:

[1] 73.15333

Median:
median(details$Height)

Output:
[1] 162

Median:

median(details$Weight)

Output:

[1] 74.6

Mode:
mode=function(x){

```
   ux= unique(x)
   ux[which.max(tabulate(match(x,ux)))]
}
x = details$Weight
Mode= mode(x)
Mode
```

Output:
[1] 69.1

Mode:

```
mode=function(x){
   ux= unique(x)
   ux[which.max(tabulate(match(x,ux)))]
}
x = details$Height
Mode= mode(x)
Mode
```

Output:
[1] 161

Standard deviation:

```
sd(details$Weight)
```

Output:
[1] 9.838254

Standard deviation:

```
sd(details$Height)
```

Output:
[1] 7.75288

Summary:

```
summary(data)
Name      Weight         Height
 X1     :1   Min.   :52.00   Min.   :152.0
 X10    :1   1st Qu.:70.40   1st Qu.:155.0
 X11    :1   Median :74.60   Median :162.0
 X12    :1   Mean   :73.15   Mean   :162.5
 X13    :1   3rd Qu.:80.15   3rd Qu.:167.5
 X14    :1   Max.   :85.50   Max.   :176.0
(Other):9
```

STEP 3: PRACTICE/TESTING

1.Write the code to find the arithmetic mean of the cut off marks of all male students.

```
data = read.csv("Studentdetails1.csv")
data
d= subset(data,GENDER=="Male")
d
mean(d$CUTOFFMARKS)
```

2.State the merits and demerits of mean.
Merits:

1. It can be easily calculated; and can be easily understood. It is the reason that it is the most used measure of central tendency.

2. As every item is taken in calculation, it is effected by every item.

Demerits:

1. It cannot be located graphically.

2. Its value will be effective only if the frequency is normally distributed. Otherwise in case skewness is more, the results become ineffective.

3.State the merits and demerits of median.

Merits:
1.Median is rigidly defined as in the case of Mean.
2.It can be located graphically.
3.For open end intervals, it is also suitable one. As taking any value of the intervals, value of Median remains the same.

Demerits:
1.Even if the value of extreme items is too large, it does not affect too much, but due to this reason, sometimes median does not remain the representative of the series.
2.It is affected much more by fluctuations of sampling than A.M

4.Give the merits of mode.
Merits or Uses of Mode:

1. Mode is the term that occur most in the series hence it is not an isolated value like Median nor it is value like mean that may not be there in the series.

2. It is not affected by extreme values hence is a good representative of the series.

3. It can be found graphically also.

5.What are the merits and demerits of Standard Deviation?

Merits

1.It is rigidly defined and free from any ambiguity.

2.Its calculation is based on all the observations of a series and it cannot be correctly calculated ignoring any item of a series.

3.It strictly follows the algebraic principles, and it never ignores the + and – signs like the mean deviation.

Demerits

1.It is not understood by a common man.

2.Its calculation is difficult as it involves many mathematical models and processes.

3.It is affected very much by the extreme values of a series in as much as the squares of deviations of big items proportionately bigger than the squares of the smaller items.

KUMARAGURU COLLEGE OF TECHNOLOGY
LABORATORY MANUAL

Experiment Number: 3

Lab Code	**: U18MAI4201**
Lab	**: Probability and Statistics**
Course / Branch	**: B.Tech / Information Technology**
Title of the Experiment	**: Applications of Correlation and Regression**

STEP 1: INTRODUCTION

OBJECTIVES OF THE EXPERIMENT

1. To construct the scatter plot and to visualize the relationship between two quantitative variables.
2. To find the correlation between two variables in a data set.
3. To find the coefficient of rank correlation between two variables in a data set by Spearman's method.
4. To determine the equations of the regression lines for variables and to predict the value of one variable when the value of the other variable is given.
5. To construct the regression plot for the given variables.

STEP 2: ACQUISITION

Procedure for doing the Experiment:

1.	**To construct the scatter plot with the variables x and y** x=c(a,b,....) y=c(l,m,....) plot(x,y, xlab = "....",ylab="…",xlim=c(0,10),ylim=c(0,25),col=c("…"),main="…..")
2.	**To find the correlation between x and y** x=c(a,b,....) y=c(l,m,....) r=cor(x,y)

	r
3.	**To find the Spearman's rank correlation coefficient between x and y** x=c(a,b,....) y=c(l,m,....) r=cor(x,y,method="spearman") r
4.	**To find regression line of y on x** regyx=lm(y~x) #lm stands for linear model regyx
5.	**To find regression line of x on y** regxy=lm(x~y) regxy
6.	**To construct the regression plot of y on x** plot(x,y) abline(lm(y ~ x),col="---")

Note:

i) abline(lm(y~x)) --- adds regression line to plot
ii) plot(y~x) --- creates a scatterplot of y versus x
iii) regmodel = lm(y~x) --- fit a regression model

Example

Construct the scatter plot and also find the coefficient of correlation ,Spearman's correlation coefficient between the ends per inch(X) and picks per inch (Y). Also find the two regression lines. Estimate the value of y when x = 26.

x	**23**	**27**	**28**	**28**	**29**	**30**	**31**	**33**	**35**	**36**
y	**18**	**20**	**22**	**27**	**21**	**29**	**27**	**29**	**28**	**29**

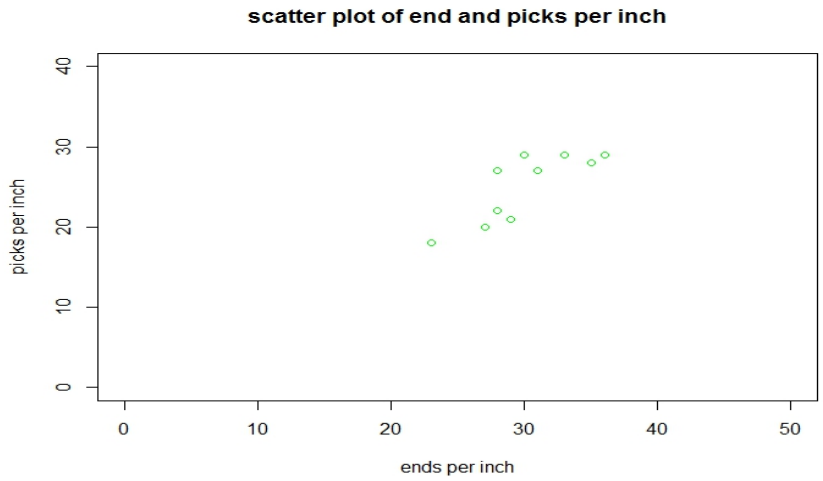
Solution:

R code:

```
x=c(23,27,28,28,29,30,31,33,35,36)
y=c(18,20,22,27,21,29,27,29,28,29)
plot(x,y,xlab ="ends per inch",ylab ="picks per
inch",xlim=c(0,50),ylim=c(0,40),col=c("green"),main="scatter plot of end and picks per
inch")
```

```
r=cor(x,y)
r
rank=cor(x,y,method="spearman")
rank
```

Scatter Plot:



Output:

Correlation Coefficient = 0.8176052
Spearman correlation coefficient= 0.9955947

Conclusion:
The correlation is strong positive between **ends per inch(X) and picks per inch(Y).**

To find the regression line of y on x

```
regyx=lm(y~x)
regyx
```

Output

```
Call:
lm(formula = y ~ x)

Coefficients:
(Intercept)                  x
      -1.7391            0.8913
```

ie, regression line of y on x is y= -1.7391+0.8913x

To find the regression line of x on y:

```
regxy=lm(x~y)
regxy
```

Output:

Call:
lm(formula = x ~ y)

Coefficients:
(Intercept) y
11.25 0.75
ie, regression line of x on y is 11.25+0.75y

To find y when x=26

y1= - 1.7391+0.8913*26

y1

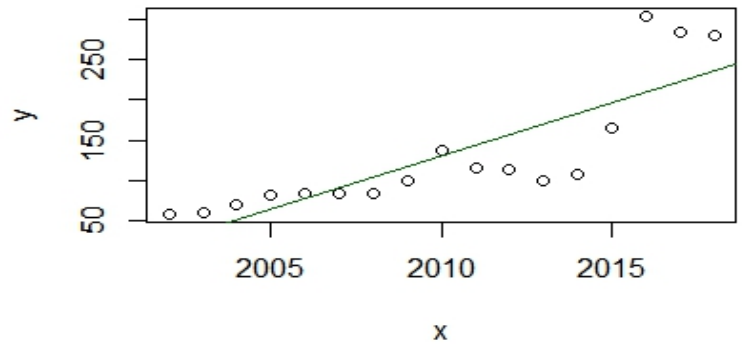
[1] 21.4347

Regression plot of y on x

R Code:

```
plot(x,y)

abline(lm(y ~ x),col="dark green")
```

Plot:



Task 1

Calculate the coefficient of correlation from the following figures relating to the consumption of fertilizer and the output of food grains in a district X:
Chemical fertilizer used (in metric tonnes):100,110,120,130,140,150,160,170,180,190,200,210,220,230
Output of food(in metric tonnes):
1000,1050,1080,1150,1200,1220,1300,1360,1420,1500,1600,1650,1650,1650
Also draw the scatter plot diagram for the above data and justify the result.
Solution:

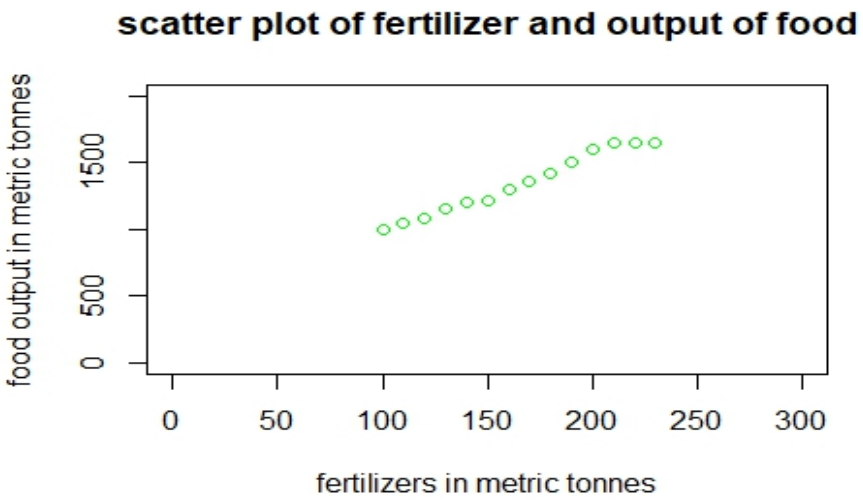
R-Code:

```
x=c(100,110,120,130,140,150,160,170,180,190,200,210,220,230)
y=c(1000,1050,1080,1150,1200,1220,1300,1360,1420,1500,1600,1650,1650,1650)
plot(x,y,xlab ="fertilizers in metric tonnes",ylab ="food output in metric
tonnes",xlim=c(0,300),ylim=c(0,2000),col=c("green"),main="scatter plot of fertilizer and
output of food")
r=cor(x,y)
r
```

Output:

[1] 0.991053

Scatter Plot



Task 2

Below are given the simple index numbers for the price of USB sound card for a number of years. Determine the scatter plot and correlation coefficient for the trend.

Year:2002,2003,2004,2005,2006,2007,2008,2009,2010,2011,2012,2013,2014,2015,2016,2017,2018

I.N:59,59.6,70,82.5,83.4,83.4,83.4,100,138.4,115.6,114.3,99.7,108.3,165,303.7,285.1,280.8

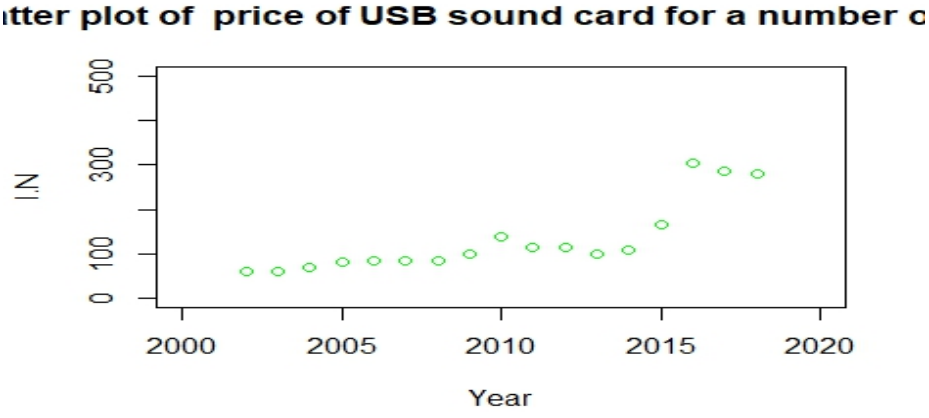
R-CODE:

```
x=c(2002,2003,2004,2005,2006,2007,2008,2009,2010,2011,2012,2013,2014,2015,2016,2017,
2018)

y=c(59,59.6,70,82.5,83.4,83.4,83.4,100,138.4,115.6,114.3,99.7,108.3,165,303.7,285.1,280.8)

plot(x,y,xlab ="Year",ylab ="I.N",xlim=c(2000,2020),ylim=c(0,500),col=c("green"),main="scatter plot of price of USB sound card for a number of years")

r=cor(x,y)

r
```

Output:

```
[1] 0.8306042
```

Scatter Plot:



Task 3

Fifteen dishes in a cooking competition are ranked by 3 judges A, B, C in the following order.

A: 14,15,1,6,5,3,10,2,4,9,7,8,12,13,11

B:15,13,11,3,5,8,4,7,10,2,1,6,9,12,14

C:12,11,6,4,9,8,1,2,3,10,5,7,15,14,13

Find which pair of judges have the nearest approach to common taste in food.

Solution:

R-CODE:

```
A = c(14,15,1,6,5,3,10,2,4,9,7,8,12,13,11)

B = c(15,13,11,3,5,8,4,7,10,2,1,6,9,12,14)

C = c(12,11,6,4,9,8,1,2,3,10,5,7,15,14,13)

r1=cor(A,B,method="spearman")

r2=cor(B,C,method="spearman")

r3=cor(A,C,method="spearman")

r1

r2

r3
```

Output:

```
[1] 0.3857143

[1] 0.5357143

[1] 0.6571429
```

Conclusion:

Judge A and Judge B have common taste

Task 4:

Import the excel file "Cotton prices-International and Domestic2" and the find the correlation between the monthly international average prices and the monthly domestic average prices

R-CODE:

```
data=read.csv("Cotton prices-International and Indian.csv")

data
```

Output:

	Cotlook.A.Minimum	Cotlook.A.Maximum	Range	Cotlook.A...Average
1	79.85	85.30	5.45	81.95
2	79.40	82.20	2.80	80.87
3	81.85	84.80	2.95	83.37
4	83.10	90.35	7.25	85.51
5	88.80	90.90	2.10	89.71
6	91.40	98.85	7.45	94.45
7	90.60	95.70	5.10	92.68
8	89.40	95.10	5.70	92.74
9	88.80	96.65	7.85	93.08
10	91.15	93.95	2.80	92.60
11	89.15	97.35	8.20	92.59
12	88.35	91.45	3.10	89.95
13	85.40	93.15	7.75	89.33
14	83.75	85.60	1.85	84.64
15	85.15	89.70	4.55	87.49
16	88.05	94.45	6.40	90.96
17	91.95	95.75	3.80	94.05
18	93.30	98.90	5.60	96.93
19	92.20	97.75	5.55	94.20
20	89.40	95.80	6.40	92.71
21	89.30	93.70	4.40	90.90
22	79.60	88.40	8.80	83.84
23	72.15	76.05	3.90	74.04
24	69.95	76.15	6.20	73.38
25	69.65	71.45	1.80	70.35
26	65.90	70.00	4.10	67.53
27	66.00	70.25	4.25	68.38
28	65.30	68.75	3.45	67.35
29	67.05	71.75	4.70	69.84
30	67.20	71.25	4.05	69.35
31	69.55	73.95	4.40	71.72
32	71.05	74.70	3.65	72.86
33	71.25	74.35	3.10	72.36
34	70.65	74.80	4.15	72.35
35	69.85	74.10	4.25	71.82
36	66.40	70.25	3.85	68.74
37	66.65	70.85	4.20	69.03
38	68.30	70.55	2.25	69.22
39	69.50	71.70	2.20	70.39
40	67.70	69.95	2.25	68.75
41	65.05	68.95	3.90	66.57
42	64.05	66.50	2.45	65.46
43	66.40	71.70	5.30	69.28
44	68.80	72.95	4.15	70.28
45	71.80	76.15	4.35	74.10
46	74.85	85.39	10.54	81.07
47	75.70	85.85	10.15	80.26
48	75.00	80.65	5.65	77.87
49	76.55	80.35	3.80	78.52
50	76.95	81.15	4.20	78.92
51	78.20	80.70	2.50	79.53
52	79.65	84.25	4.60	82.33
53	84.10	86.80	2.70	85.16
54	85.75	88.10	2.35	86.84
55	84.60	88.80	4.20	87.04
56	86.40	94.90	8.50	88.64
57	82.60	87.70	5.10	84.66

58	82.20	85.05	2.85	84.09
59	77.40	81.35	3.95	79.36
60	78.55	84.70	6.15	80.59
61	77.60	80.40	2.80	78.60
62	79.00	81.60	81.60	61.80

	Shankar.6.Minimum	Shankar.6.Maximum	Range.1	Shankar.6.Average
1	32900	34400	1500	33450
2	33000	33800	800	33564
3	33300	34200	900	33764
4	33600	34300	700	33771
5	33900	37200	3300	35013
6	37000	39300	2300	38275
7	36700	39400	2700	38139
8	37000	38600	1600	37742
9	38500	41500	3000	39892
10	41000	43200	2200	42370
11	42400	49000	6600	45968
12	46900	48900	2000	47805
13	41000	48500	7500	44776
14	38800	40900	2100	39935
15	38500	40400	1900	39284
16	40200	42800	2600	42015
17	41800	43200	1400	42565
18	41500	42400	900	41943
19	41400	42900	1500	42038
20	40700	43200	2500	42065
21	41200	42900	1700	42044
22	39500	42900	3400	41542
23	39000	40500	1500	39835
24	34700	39900	5200	38360
25	32700	34000	1300	33448
26	32400	33200	800	32812
27	32900	33300	400	33146
28	29800	32900	3100	31300
29	30100	31300	1200	30678
30	30700	32600	1900	31122
31	32200	34200	2000	33296
32	34200	35500	1300	34922
33	33200	35000	1800	34232
34	33800	34600	800	34293
35	33500	34700	1200	33992
36	33000	35500	2500	34672
37	31800	32900	1100	32472
38	32000	32500	500	32209
39	32400	34000	1600	33223
40	33400	34000	600	33672
41	33100	33800	700	33452
42	32100	33200	1100	32676
43	32800	34700	1900	33975
44	34700	36800	2100	35315
45	36700	42700	6000	39456
46	42700	48500	5800	45896
47	43900	47800	3900	46269
48	43000	48000	5000	45125
49	37700	44500	6800	41233
50	37700	40000	2300	38728
51	38600	39600	1000	39007
52	40000	42600	2600	41256
53	41900	43000	1100	42482
54	42600	43700	1100	43085
55	42100	44000	1900	42967
56	41600	43000	1400	42396
57	42300	43100	800	42642
58	41800	43300	1500	42362
59	42200	42600	400	42323
60	38700	42300	3600	40829
61	37800	39000	1200	38468
62	37200	38100	900	35861

#The correlation between the monthly international average prices and the monthly domestic average prices

Rcode:

```
x = data$Cotlook.A...Average

y = data$Shankar.6.Average

xy=cor(x,y)

xy
```

Output:

```
[1] 0.6859373
```

Task 5:
The following data are related to the percentage of humidity and the warp breakage rate recorded for a week in a loom shed.

Percentage humidity	**54**	**85**	**86**	**50**	**42**	**75**	**65**	**56**
Warp breakage rate	**2.45**	**1.21**	**1.20**	**2.84**	**3.25**	**1.86**	**1.90**	**2.32**

Find two equations of lines of regression. In addition, find warp breakage rate if humidity percentage on a specific day is 60 and find percentage humidity required for the target warp breakage rate of 1.50%.

R-CODE:

```
x=c(54,85,86,50,42,75,65,56)

y=c( 2.45,1.21,1.20,2.84,3.25,1.86,1.90,2.32)

regyx=lm(y~x)

regyx

regxy=lm(x~y)

regxy

#when x=60

y=4.91906-0.04351*60

y

#when y=1.5

y=111.03-22.03*1.50
```

y

OUTPUT:

```
Call:
lm(formula = y ~ x)

Coefficients:
(Intercept)                  x
    4.91906          -0.04351

Call:
lm(formula = x ~ y)

Coefficients:
(Intercept)                  y
     111.03             -22.03

[1] 2.30846

[1] 77.985
```

Task 6
From the following data, obtain the two regression equations:
Sales: 91,97,108,121,67,124,51,73,111, 57
Purchases: 71,75,69,97,70,91,39,61,80,47
Also compute the most likely purchase when sales = 150 and construct the regression plot of purchases on sales.

R-CODE:

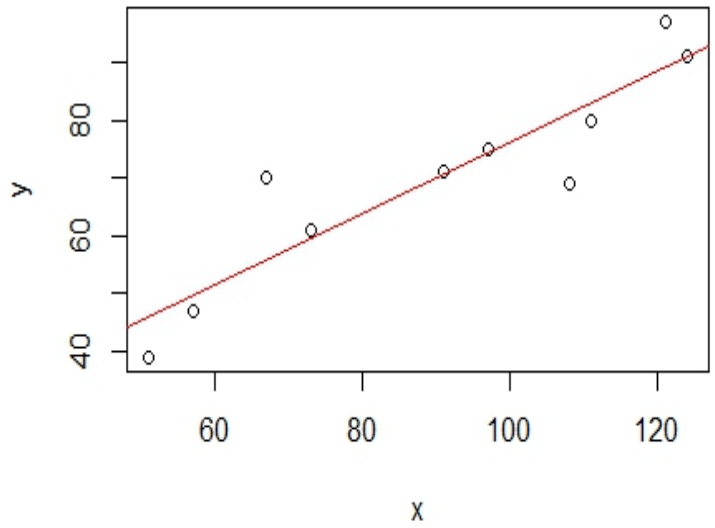
```
x=c(91,97,108,121,67,124,51,73,111, 57)

y=c(71,75,69,97,70,91,39,61,80,47 )

regyx=lm(y~x)

regyx

regxy=lm(x~y)

regxy

plot(x,y)

abline(lm(y~x),col="red")
```

```
#when x=150
y=14.8113+0.6132*150
y
```

OUTPUT:

```
Call:
lm(formula = y ~ x)

Coefficients:
(Intercept)                 x
    14.8113              0.6132

Call:
lm(formula = x ~ y)

Coefficients:
(Intercept)                 y
     -5.188              1.360

[1] 106.7913
```

Plot:



Task 7
Compute the two equations of the regression lines for the following data:
A panel of judges A and B graded seven debaters and independently awarded the following marks:

Marks by A:	**40**	**34**	**28**	**30**	**44**	**38**	**31**
Marks by B:	**32**	**39**	**26**	**30**	**38**	**34**	**28**

An eighth debater was awarded 36, marks by Judge A while Judge B was not present. If Judge B was also present, how many marks would you expect him to award to eighth debater assuming same degree of relationship exists in judgment?

R-CODE:

```
x=c(40,34,28,30,44,38,31)
y=c(32,39,26,30,38,34,28 )
regyx=lm(y~x)
regyx
regxy=lm(x~y)
regxy
y=11.8703+0.5874*36
y
```

OUTPUT:

```
Call:
lm(formula = y ~ x)

Coefficients:
(Intercept)                x
      11.8703           0.5874

Call:
lm(formula = x ~ y)

Coefficients:
(Intercept)                y
       7.6968           0.8419

[1] 33.0167
```

Task 8

The following table gives the ages and blood pressure of 10 men.

Age (X):	**56**	**42**	**36**	**47**	**49**	**42**	**60**	**72**	**63**	**55**
Blood Pressure(Y):	**147**	**125**	**118**	**128**	**145**	**140**	**155**	**160**	**149**	**150**

Find (i) The two regression line equations.

(ii) Estimate the blood pressure of men whose age is 45 years

(iii) Estimate the age of men whose blood pressure is 172.

(iv) Construct the regression plot of blood pressure on age.

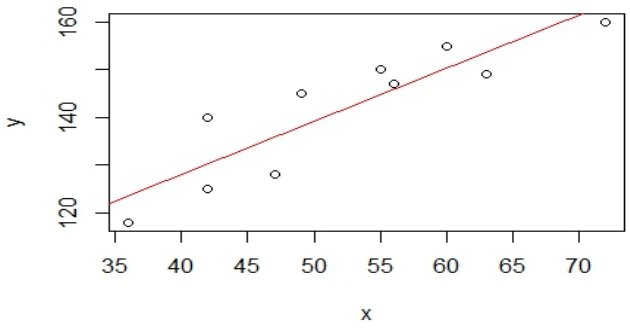
R-CODE:

```
x=c(56,42,36,47,49,42,60,72,63,55)
y=c(147,125,118,128,145,140,155,160,149,150)
regyx=lm(y~x)
regyx
regxy=lm(x~y)
regxy
plot(x,y)
abline(lm(y ~ x),col="red")
# when x=45
y=83.76+1.11*45
y
#when y=172
x = -49.2958+0.7163*172
x
```

OUTPUT:

```
Call:
lm(formula = y ~ x)

Coefficients:
(Intercept)                 x
      83.76                1.11

Call:
lm(formula = x ~ y)

Coefficients:
(Intercept)                 y
   -49.2958              0.7163

[1] 133.71

[1] 73.9078
```

Plot:



STEP 3: PRACTICE/TESTING

1. **Define correlation.**

Correlation refers to the study of relationship between two or more variables.

2. **What are the various methods of studying correlation?**

(i)Scatter diagram method
(ii) Karl Pearson's correlation coefficient
(iii)Spearman's rank correlation coefficient

3. **Explain scatter diagram.**

Scatter Diagrams are convenient mathematical tools to study the correlation between two random variables.As the name suggests, they are a form of a sheet of paper upon which the data points corresponding to the variables of interest, are scattered.

4. **Define regression.**

Regression is the measure of the average relationship between two or more variables in terms of the original units of the data. It provides a mechanism for predicting or forecasting.

5. **What are regression lines? Write their equations.**

Two variables X and Y are correlated, we see that the scatter diagram will be more or less concentrated around a curve, called the curve of regression. If this curve is a straight line, then it is called line of regression.

The **regression line of Y on X** gives the most probable value of Y for given values of X.

The **regression line of X on Y** gives the most probable value of X for given values of Y.

The equation of the line of regression of Y on X is

$y-\bar{y}=\frac{r\sigma_y}{\sigma_x}(x-\bar{x})$ where $b_{yx}=\frac{r\sigma_y}{\sigma_x}$ is the **regression coefficient of y on x.**

The equation of the line of regression of X on Y is

$x-\bar{x}=\frac{r\sigma_x}{\sigma_y}(y-\bar{y})$ where $b_{xy}=\frac{r\sigma_x}{\sigma_y}$ is the **regression coefficient of x on y.**

6.Mention some properties of regression lines.

1. Both the regression coefficients will have the same sign; either both will be positive or both will be negative.
2. Both the regression lines pass through the point (x,y). Hence, by solving the tworegression equations, we can find the means of X and Y.
3. Regression coefficients are independent of the change of origin, but not of scale.

KUMARAGURU COLLEGE OF TECHNOLOGY

LABORATORY MANUAL

Experiment Number: 4

Lab Code : **U18MAI4201**

Lab : **Probability and Statistics**

Course / Branch : **B.Tech / Information Technology**

Title of the Experiment : **Applications of Normal Distribution**

STEP 1: INTRODUCTION

OBJECTIVES OF THE EXPERIMENT

To predict values and computing probabilities using normal distribution

STEP 2: ACQUISITION

The normal distribution is defined by the following probability density function, where μ is the population mean and σ^2 is the variance.

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-(x-\mu)^2/2\sigma^2}$$

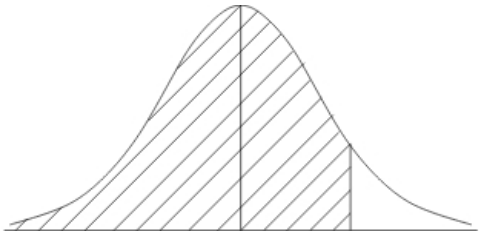
If a random variable X follows the normal distribution, then we write: $X \sim N(\mu, \sigma^2)$
The normal distribution with μ = 0 and σ = 1 is called the standard normal distribution, and is denoted as N(0,1).

Consider a normal distribution with mean μ and standard deviation σ

R-code for doing the Experiment:

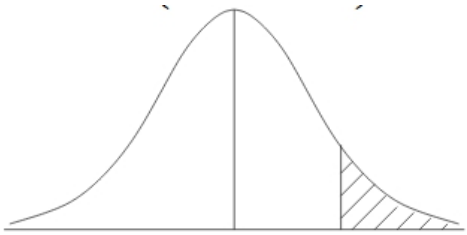
1.	To find $P(X < a) = P(-\infty < X < a)$ **R-code :** pnorm(a, mean = μ, sd = σ)
2.	To find $P(X > a) = P(a < X < \infty)$ R-code: pnorm(a, mean = μ, sd = σ, lower.tail = FALSE)
3.	To find $P(a < X < b)$ R-code: pnorm(b, mean = μ, sd = σ) - pnorm(a, mean = μ, sd = σ)

To find $P(X < a) = P(-\infty < X < a)$



pnorm (a, mean = μ, sd = σ)

To find $P(X > a) = P(a < X < \infty)$



pnorm(a, mean = μ, sd = σ, lower.tail = FALSE)

To find $P(a < X < b)$

pnorm(b, mean = μ, sd = σ) - pnorm(a, mean = μ, sd = σ)

Note:
Use lower.tail=TRUE if you are, e.g., finding the probability at the lower tail of a confidence interval or if you want to the probability of values no larger than z.

Use lower.tail=FALSE if you are, e.g., trying to calculate test value significance or at the upper confidence limit, or you want the probability of values z or larger.

You should use pnorm(z, lower.tail=FALSE) instead of 1-pnorm(z)because the former returns a more accurate answer for large z.

This is really simple issue, and has no inherent complexity associated with it.

Example
A certain type of storage battery lasts on the average 3.0 years with standard deviation of 0.5 year. Assuming that the battery lives are normally distributed, find the probability that a given battery will last

(i) less than 2.3 years (ii) more than 3.1 years (iii) between 2.5 and 3.5 years

Ans:

(i) pnorm(2.3, mean=3.0, sd=0.5)
[1] 0.08075666

(ii) pnorm(3.1, mean=3.0, sd=0.5, lower.tail=FALSE)
[1] 0.1586553

(iii) pnorm(3.5, mean=3.0, sd=0.5) - pnorm(2.5, mean=3.0, sd=0.5)
[1] 0.6826895

Task 1

Suppose the heights of men of a certain country are normally distributed with average 68 inches and standard deviation 2.5, find the percentage of men who are

(i) between 66 inches and 71 inches in height

(ii) approximately 6 feet tall (ie, between 71.5 inches and 72.5 inches)

PROGRAM:

```
a=pnorm(71, mean=68, sd=2.5) - pnorm(66, mean=68, sd=2.5)
a
a*100
b=pnorm(72.5, mean=68, sd=2.5) - pnorm(71.5, mean=68, sd=2.5)
b
b*100
```

OUTPUT:

```
[1] 0.6730749

[1] 67.30749

[1] 0.04482634

[1] 4.482634
```

Task 2

The mean yield for one acre plots is 662 kgs with S.D 32. Assuming normal distribution, how many one acre plots in a batch of 1000 plots. Would you expect to yield .

(i) Over 700 kgs

(ii) Below 650 kgs.

(Note: Find the respective probabilities and multiply the probabilities by the number of plots (= 1000) to get the final answers)

PROGRAM:

```
a=pnorm(700, mean=662, sd=32, lower.tail=FALSE)
a
a*1000
```

```
b=pnorm(650, mean=662, sd=32)
b
b*1000
```

OUTPUT:

[1] 0.1175152

[1] 117.5152

[1] 0.3538302

[1] 353.8302

Task 3

A bore in picking element of a projectile loom part produced is found to have a mean diameter of 2.498 cm. with a SD of 0.012 cm. Determine the percentage of pieces produced you would except to lie within of the drawing limits of 2.5 ± 0.02 **cm.**

PROGRAM:

```
a=pnorm(2.52, mean=2.498, sd=0.012) - pnorm(2.48, mean=2.498, sd=0.012)
a
a*100
```

OUTPUT:

[1] 0.8998163

[1] 89.9816**3**

Task 4

An intelligence test is administered to 1000 children. The average score is 42 and S.D is 24. Assuming the test follows normal distribution

i) **Find the number of children exceeding the score 60.**
ii) **Find the number of children with score lying between 20 and 40.**

PROGRAM:

```
a=pnorm(60, mean=42, sd=24, lower.tail=FALSE)
a
a*1000
b=pnorm(40, mean=42, sd=24) - pnorm(20, mean=42, sd=24)
```

```
b
b*1000
```

OUTPUT:

```
[1] 0.2266274

[1] 226.6274

[1] 0.2871346

[1] 287.1346
```

Task 5

The mean weight of 500 male students in a certain college is 151 *lb* and the standard deviation is 15*lb*. assuming the weights are normally distributed find how many students weight. (i) Between 12 and 155 *lb*. (ii) More than 185 *lb*.

PROGRAM:

```
a=pnorm(155, mean=151, sd=15) - pnorm(12, mean=151, sd=15)
a
a*500
b=pnorm(185, mean=151, sd=15, lower.tail=FALSE)
b
b*500
```

OUTPUT:

```
[1] 0.6051371

[1] 302.5685

[1] 0.0117053

[1] 5.852649
```

Task 6

The saving bank account of a customer showed an average balance of Rs.1500 and a standard deviation of Rs.500 .assuming that the account balances are normally distributed.

(i) What percentage of account is over Rs.2000?

(ii) What percentage of account is between Rs.1200 and Rs.1700?

PROGRAM:

```
a=pnorm(2000, mean=1500, sd=500, lower.tail=FALSE)
a
a*100
b=pnorm(1700, mean=1500, sd=500) - pnorm(1200, mean=1500, sd=500)
b
b*100
```

OUTPUT:

[1] 0.1586553

[1] 15.86553

[1] 0.3811686

[1] 38.11686

STEP 3: PRACTICE/TESTING

1. **What is the p.d.f. of a normal distribution?**

   A continuous random variable X follows normal distribution (or Gaussian distribution)if its p.d.f is

$$\frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}, -\infty < x < \infty, -\infty < \mu < \infty, \sigma > 0$$

2. **Define standard normal distribution.**

   The normal distribution with mean = 0 and variance = 1, is called the standardnormal distribution and is denoted asN(0,1).

3. **Mention some properties of normal distribution.**

1.The graph of the distribution is bell shaped and is called the normal probability curve.

2.The curve is symmetrical about the ordinate at x =μ

3.x –axis is an asymptote to the curve.

4.For the normal distribution, mean = median =mode.

KUMARAGURU COLLEGE OF TECHNOLOGY
LABORATORY MANUAL

Experiment Number: 5

Lab Code	**: U18MAI4201**
Lab	**: Probability and Statistics**
Course / Branch	**: B.Tech / Information Technology**
Title of the Experiment	**: Applications of Student t-test**

STEP 1: INTRODUCTION

OBJECTIVES OF THE EXPERIMENT

1. To apply t-test to test hypothesis about population mean
2. To apply t-test to test hypothesis about two means
3. To apply paired t-test to test hypotheses about means of two dependent samples

STEP 2: ACQUISITION

Student's t – distribution

Student's **t-distribution** has the probability density function given by

$$f(t) = \frac{\Gamma(\frac{\nu+1}{2})}{\sqrt{\nu\pi}\,\Gamma(\frac{\nu}{2})}\left(1+\frac{t^2}{\nu}\right)^{-\frac{\nu+1}{2}}, \quad -\infty < t < \infty$$

where ν is the number of degrees of freedom and Γ is the gamma function. This may also be written as

$$f(t) = \frac{1}{\sqrt{\nu}\,B\left(\frac{1}{2},\frac{\nu}{2}\right)}\left(1+\frac{t^2}{\nu}\right)^{-\frac{\nu+1}{2}}, \quad -\infty < t < \infty$$

Note: (a) The values of $t_\nu(\alpha)$ can be got from the t – table

(b) $t_\nu(2\alpha)$ gives the critical value of t for a single tail test at α LOS and ν d.f

For eg, $t_8(0.05)$ for single tailed test = $t_8(10)$ for two-tailed test = 1.86

Test of Hypothesis about the Population Mean

Test statistic $t = \dfrac{\bar{x} - \mu}{S/\sqrt{n}}$ follows t – distribution with n-1 degrees of freedom.

where $\bar{x} = \dfrac{1}{n}\sum_{i=1}^{n} x_i$ and $S^2 = \dfrac{1}{n-1}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2$

Null hypothesis H_0 : There is no significant difference between the sample mean $\bar{x}$ and the population mean μ.

If $|t| \leq$ tabulated t, then H_0 is accepted and the difference between $\bar{x}$ and μ is not considered significant.

Assumptions for t – test for population mean

1. The parent population from which the sample is drawn is normal.
2. The sample observations are independent
3. The population standard deviation σ is unknown.

Test of Hypothesis about the difference between two means

To test a hypothesis concerning the difference between the means of two normally distributed populations, when the population variances are unknown, t – test is used.

H_0: The samples have been drawn from populations with same means, ie, $\mu_1 = \mu_2$

Test statistic is $t = \dfrac{\bar{x} - \bar{y}}{S\sqrt{\dfrac{1}{n_1} + \dfrac{1}{n_2}}} \sim t_{n_1+n_2-2}$

where $\bar{x} = \dfrac{\sum x}{n_1}, \ \bar{y} = \dfrac{\sum y}{n_2}$,

$$S^2 = \frac{1}{n_1 + n_2 - 2}\left[\sum_i \left(x_i - \bar{x}\right)^2 + \sum_j \left(y_j - \bar{y}\right)^2\right]$$

or $$S^2 = \frac{1}{n_1 + n_2 - 2}\left[n_1 {s_1}^2 + n_2 {s_2}^2\right],$$

where $${s_1}^2 = \frac{1}{n_1}\sum_i \left(x_i - \bar{x}\right)^2, \quad {s_2}^2 = \frac{1}{n_2}\sum_j \left(y_j - \bar{y}\right)^2$$

(Note : S^2 is an unbiased estimate of the population variance σ^2)

The test statistic follows t-distribution with $n_1 + n_2 - 2$ degrees of freedom.

If $|t| \leq$ tabulated t, then H_0 is accepted and the difference between $\bar{x}$ and μ is not considered significant.

Paired t-test for difference of Means

If the two given samples are dependent, ie, each observation in one sample is associated with a particular observation in the second sample, then we use paired t – test to test whether the means differ significantly or not. Here , both the samples will have same number of units.

The test statistic is

$t = \dfrac{\bar{d}}{S/\sqrt{n}}$ where $\bar{d} = \dfrac{1}{n}\sum_{i=1}^{n} d_i$ and $d_i = x_i - y_i$, $S^2 = \dfrac{1}{n-1}\sum\left(d_i - \bar{d}\right)^2$

t follows t – distribution with n-1 d.f. Here n is the number of pairs in the sample

Using R for testing of hypothesis

The R function t.test() can be used to perform both one and two sample t-tests on vectors of data. The function contains a variety of options and can be called as follows:

t.test(x, y = NULL, alternative = c("two.sided", "less", "greater"), mu = 0, paired = FALSE, var.equal = FALSE, conf.level = 0.95)

Here x is a numeric vector of data values and y is an optional numeric vector of data values. If y is excluded, the function performs a one-sample t-test on the data contained in x, if it is included it performs a two-sample t-tests using both x and y.

The option mu provides a number indicating the true value of the mean (or difference in means if you are performing a two sample test) under the null hypothesis. The option alternative is a character string specifying the alternative hypothesis, and must be one of the following: "two.sided" (which is the default), "greater" or "less" depending on whether the alternative hypothesis is that the mean is different than, greater than or less than mu, respectively.

Procedure for doing the Experiment:

1.	To test hypothesis about population mean: (a)For a two-tailed test x = c(a_1 , a_2 ,.....a_N) t.test(x,alternative="two.sided",mu= μ) (b) For a one-tailed test x = c(a_1 , a_2 ,.....a_N) t.test(x,alternative="less"/"greater",mu= μ)
2.	To test hypothesis about two means A= c(a_1 , a_2 ,.....a_m) B = c(b_1 , b_2 ,.....b_n) t.test(A,B,alternative="two.sided"/"less"/"greater",, var.equal=TRUE)
3.	To use paired t-test

	A= c($a_1, a_2, ...a_m$) B = c($b_1, b_2, ...b_n$) t.test(A,B,alternative="greater"/"less"/"two.sided",paired=TRUE)

EXAMPLE – Single mean

Eleven articles produced by a factory were chosen at random and their weights were found to be (in kgs) 63,63,66,67,68,69,70,70,71,71,71 respectively. In the light of the above data, can we assume that the mean weight of the articles produced by the factory is 66 kgs? (Given: the critical value of t for 10 degrees of freedom at 5% LOS is 2.28).

Null Hypothesis : $H_0 : \mu = 66$

Alternative Hypothesis : $H_1 : \mu \neq 66$

R-code

```
x = c(63,63,66,67,68,69,70,70,71,71,71)

t.test(x,alternative="two.sided",mu=66)
```

Output:

One Sample t-test

data: x

t = 2.3, df = 10, p-value = 0.04425

alternative hypothesis: true mean is not equal to 66

95 percent confidence interval:

66.06533 70.11649

sample estimates:

mean of x

68.09091

Conclusion: t-value = 2.3 > 2.228. Hence we reject H_0 and we may conclude that the me an

weight of the articles produced by the factory is not 66

Task 1

Tests made on the breaking strength of 10 pieces of a metal gave the followingresults. 578, 572, 570, 568, 572, 570, 570, 572, 596 and 584 kg.
Test if the mean breaking strength of the wire can be assumed as 577kg.

Null hypothesis:$\mu = 577$

Alternate hypothesis: $\mu \neq 577$

R-code

```
x = c(578, 572, 570, 568, 572, 570, 570, 572, 596, 584)

t.test(x,alternative="two.sided",mu=577)
```

Output:

```
One Sample t-test

data:  x
t = -0.65408, df = 9, p-value = 0.5294
alternative hypothesis: true mean is not equal to 577
95 percent confidence interval:
 568.9746 581.4254
sample estimates:
mean of x
    575.2
```

Conclusion:

t-value = 0.65408 < 2.262 . Hence we accept H_0 and we may conclude that the mean mean breaking strength of the wire can be assumed as 577kg.

Task 2

The heights of 10 men in a given locality are found to be 70, 67, 62, 68, 61, 68, 70, 64, 64, 66 inches. Is it reasonable to believe that the average height is greater than 64 inches?

Null hypothesis $H_0 : \mu = 64$

Alternate hypothesis: H_1 **:** $\mu > 64$

R-code:

```
x = c(70, 67, 62, 68, 61, 68, 70, 64, 64, 66)

t.test(x,alternative="greater",mu=64)
```

Output :

```
One Sample t-test

data:  x
```

t = 2, df = 9, p-value = 0.03828
alternative hypothesis: true mean is greater than 64
95 percent confidence interval:
64.16689 Inf
sample estimates:
mean of x
66

Conclusion:

t-value = 2 > 1.833 . Hence we reject H_0 and we may conclude that the average height is greate r than 64 inches

Example 2: Two means

6 subjects were given a drug (treatment group) and an additional 6 subjects a placebo (control group). Their reaction time to a stimulus was measured (in ms).

Placebo group: 91, 87, 99, 77, 88, 91

Treatment group : 101, 110, 103, 93, 99, 104

Can we conclude that the reaction time of the placebo group is less than that of the treatment group? (Required table value of t = 1.1812)

Null hypothesis H_0 : $\mu_1 = \mu_2$, ie. the reaction times of the two groups are equal.

Alternate hypothesis H_1 : $\mu_1 < \mu_2$ ie, the reaction time of the placebo group is less than that of the treatment group

R-code:

Control = c(91, 87, 99, 77, 88, 91)

Treat = c(101, 110, 103, 93, 99, 104)

t.test(Control,Treat,alternative="less", var.equal=TRUE)

Output:

Two Sample t-test

data: Control and Treat t = -3.4456, df = 10, p-value = 0.003136 alternative hypothesis: true difference in means is less than 0

Conclusion: t-value =-3.4456 , $|t|$ =3.4456 > 1.1812. Hence we may conclude that the reaction time of placebo group is less than that of treatment group.

Task 3

Two independent samples are chosen from two schools A and B and common test is given in a subject. The scores of the students are as follows:

School A: 76 68 70 43 94 68 33

School B: 40 48 92 85 70 76 68 22.

Can we conclude that students of school A performed better than students of school B.

Null hypothesis H_0 : $\mu_1 = \mu_2$, ie, Students of both schools performed equally well.

Alternate hypothesis H_1 : $\mu_1 > \mu_2$ ie, Students of school A performed better than students of school B.

R-code:

```
SchoolA = c(76,68,70,43,94,68,33)

SchoolB = c(40,48,92,85,70,76,68,22)

t.test(SchoolA,SchoolB,alternative="greater", var.equal=TRUE)
```

Output:

```
Two Sample t-test

data: SchoolA and SchoolB
t = 0.16802, df = 13, p-value = 0.4346
alternative hypothesis: true difference in means is greater than 0
95 percent confidence interval:
 -18.56956       Inf
sample estimates:
mean of x mean of y
 64.57143  62.62500
```

Conclusion:

t-value =0.16802 , $|t|$ =0.16802 < 1.771. Hence we may conclude that Students of both schools performed equally well.

Task 4

Two independent samples of sizes 8 and 7 contained the following values.
Sample 1:19 17 15 21 16 18 16 14
Sample 2:15 14 15 19 15 18 16
Is the difference between the sample means significant?

Null hypothesis H_0 **: μ1 = μ2**

Alternate hypothesis H_1 **: μ1 ≠ μ2**

R-code:

```
Sample1 = c(19,17,15,21,16,18,16,14)
Sample2 = c(15,14,15,19,15,18,16)
t.test(Sample1,Sample2,alternative="two.sided", var.equal=TRUE)
```

Output:

```
Two Sample t-test
data:  Sample1 and Sample2
t = 0.93095, df = 13, p-value = 0.3688
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -1.320608  3.320608
sample estimates:
mean of x mean of y
       17        16
```

Conclusion:

t-value =0.93095 , $|t|$ =0.93095 < 2.160. Hence we may conclude that there is no significant difference between sample mean.

Example 3: Paired t-test

A study was performed to test whether cars get better mileage on premium gas than on regular gas. Each of 10 cars was first filled with either regular or premium gas, decided by a coin toss, and the mileage for that tank was recorded. The mileage was recorded again for the same cars using the other kind of gasoline. The relevant mileages : Regular: 16, 20, 21, 22, 23, 22, 27, 25, 27, 28 Premium :19, 22, 24, 24, 25, 25, 26, 26, 28, 32 . Use a paired t test to determine whether cars get significantly better mileage with premium gas.

Null Hypothesis H₀ : $\mu_1 = \mu_2$, ie, the two types of bulbs are identical regarding length of life.

Alternative Hypothesis: $\mathbf{H_1}: \mu_2 > \mu_1$

reg=c(16,20,21,22,23,22,27,25,27,28)

prem=c(19,22,24,24,25,25,26,26,28,32)

t.test(prem,reg,alternative="greater",paired=TRUE)

Paired t-test

data: prem and reg

t = 4.4721, df = 9, p-value = 0.0007749

alternative hypothesis: true difference in means is greater than 0

95 percent confidence interval:

1.180207 Inf

sample estimates:

mean of the differences

2

Conclusion: p-value = 0.0007749 < 0.05 Hence we reject H_0 and we may conclude that cars get significantly better mileage with premium gas.

Task 5

The weight gain in pounds under two systems of feeding of calves of 10 pairs of identical twins is given below.

Twin pair	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Weight gain under System A	**43**	**39**	**39**	**42**	**46**	**43**	**38**	**44**	**51**	**43**
Weight gain under System B	**37**	**35**	**34**	**41**	**39**	**37**	**37**	**40**	**48**	**36**

Discuss whether the difference between the two systems of feeding is significant.

Null Hypothesis H_0 : $\mu 1 = \mu 2$

Alternative Hypothesis: $\mathbf{H_1}$ **:** $\mu 1 \neq \mu 2$

R-code:

A = c(43,39,39,42,46,43,38,44,51,43)

B = c(37,35,34,41,39,37,37,40,48,36)

t.test(A,B,alternative="two.sided",paired=TRUE)

Output:

Paired t-test

data: A and B

t = 6.2644, df = 9, p-value = 0.0001471

alternative hypothesis: true difference in means is not equal to 0

95 percent confidence interval:

2.811113 5.988887

sample estimates:

mean of the differences

4.4

Conclusion:

p-value = 0.0001471 < 0.05 Hence we reject H_0 and we may conclude that there is significant difference between the two systems of feeding

Task 6

Ten persons were appointed in the officer cadre in an office. Their performance was noted by giving a test and the marks were recorded out of 100.

Employee	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Before training	**80**	**76**	**92**	**60**	**70**	**56**	**74**	**56**	**70**	**56**
After training	**84**	**70**	**96**	**80**	**70**	**52**	**84**	**72**	**72**	**50**

By applying t test, can it be concluded that the employees have been benefited by the training?

Null hypothesis: $\mu 1 = \mu 2$

Alternate hypothesis: $\mu 1 < \mu 2$

R-code:

```
A = c(80,76,92,60,70,56,74,56,70,56)

B = c(84,70,96,80,70,52,84,72,72,50)

t.test(A,B,alternative="greater",paired=TRUE)
```

Output:

Paired t-test

data: A and B

t = -1.4142, df = 9, p-value = 0.9045

alternative hypothesis: true difference in means is greater than 0

95 percent confidence interval:

-9.184826 Inf

sample estimates:

mean of the differences

-4

Conclusion:

p-value = 0.9045 > 0.05 Hence we accept H_0 and we may conclude that **t**he employees have been benefited by the training

STEP 3: PRACTICE/TESTING

1. **Write the test statistic for testing hypothesis about a population mean.**

Test statistic $t = \dfrac{\bar{x} - \mu}{S/\sqrt{n}}$ follows t – distribution with n-1 degrees of freedom.

where $\bar{x} = \dfrac{1}{n}\sum_{i=1}^{n} x_i$ and $S^2 = \dfrac{1}{n-1}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2$

2.Write the test statistic for testing of hypothesis about the difference between two means .

Test statistic is $t = \dfrac{\bar{x} - \bar{y}}{S\sqrt{\dfrac{1}{n_1} + \dfrac{1}{n_2}}} \sim t_{n_1+n_2-2}$

where $\bar{x} = \dfrac{\sum x}{n_1},\ \bar{y} = \dfrac{\sum y}{n_2}$,

$$S^2 = \frac{1}{n_1 + n_2 - 2}\left[\sum_i \left(x_i - \bar{x}\right)^2 + \sum_j \left(y_j - \bar{y}\right)^2\right]$$

or $S^2 = \dfrac{1}{n_1 + n_2 - 2}\left[n_1 {s_1}^2 + n_2 {s_2}^2\right]$, where ${s_1}^2 = \dfrac{1}{n_1}\sum_i \left(x_i - \bar{x}\right)^2,\quad {s_2}^2 = \dfrac{1}{n_2}\sum_j \left(y_j - \bar{y}\right)^2$

3.Write the test statistic for testing of hypothesis about the difference between means of two dependent samples. (paired t-test)

The test statistic is

$t = \dfrac{\bar{d}}{S/\sqrt{n}}$ where $\bar{d} = \dfrac{1}{n}\sum_{i=1}^{n} d_i$ and $d_i = x_i - y_i,\ S^2 = \dfrac{1}{n-1}\sum\left(d_i - \bar{d}\right)^2$

t follows t – distribution with n-1 d.f.

4.Define level of significance.

The probability alpha of making type I error (probability that a random value of the test statistic belongs to the critical region) is called the level of significance.

KUMARAGURU COLLEGE OF TECHNOLOGY

LABORATORY MANUAL

Experiment Number: 6

Lab Code	**: U18MAI4201**
Lab	**: Probability and Statistics**
Course / Branch	**: B.Tech / Information Technology**
Title of the Experiment/experiment	**:Applications of F test**

STEP 1: INTRODUCTION

OBJECTIVES OF THE EXPERIMENT

To apply F-test to compare the variances of two samples from normal populations.

STEP 2: ACQUISITION

The null hypothesis is that the ratio of the variances of the populations from which x and y were drawn, or in the data to which the linear models x and y were fitted, is equal to ratio.

Procedure for doing the Experiment:

	R-Code for F-test: var.test(x, y, ratio = 1,alternative = c("two.sided", "less", "greater"),conf.level = 0.95, ...)

Note:

x, y	-	numeric vectors of data values, or fitted linear model objects (inheriting from class "lm").
Ratio	-	the hypothesized ratio of the population variances of x and y.
Alternative	-	a character string specifying the alternative hypothesis, must be one of "two.sided" (default), "greater" or "less". You can specify just the initial letter.
conf.level	-	confidence level for the returned confidence interval.

In the test statistic, the greater of the two variances $S_1{}^2$ and $S_2{}^2$ is to be taken in the numerator and v_1 corresponds to the greater variance.

Example:

Two samples of 6 and 7 items respectively have the following values for a variable

Sample 1	**39**	**41**	**42**	**42**	**44**	**40**	
Sample 2	**40**	**42**	**39**	**45**	**38**	**39**	**40**

Do the sample variances differ significantly?

Null Hypothesis: There is no significant difference in sample variances.

Alternative Hypothesis: There is a significant difference in sample variances.

Code:

```
x=c(40,42,39,45,38,39,40)
y=c(39,41,42,42,44,40)
var.test(x, y, ratio = 1,
alternative = c("two.sided"),
conf.level = 0.95)
```

Output:

```
F test to compare two variances
data:  x and y
F = 1.8323, numdf = 6, denomdf = 5, p-value = 0.523
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
  0.2625934 10.9710044
sample estimates:
ratio of variances
          1.832298
```

Critical value of F for (6, 5) d.f. is $F_{0.05} = 4.95$

Conclusion:Since $F < F_{0.05}$, weaccept the null hypothesis and we may conclude th at
there is no significant difference in the sample variances.

Task 1:

Two random samples drawn from two normal populations are

Sample 1: 20	**16**	**26**	**27**	**23**	**22**	**18**	**24**	**25**	**19**	
Sample 2: 27	**33**	**42**	**35**	**32**	**34**	**38**	**28**	**41**	**43**	**30**	**37**

Test whether the populations have the same variances.

Null Hypothesis: The populations have the same variances.

Alternative Hypothesis: The populations do not have the same variances.

R Code:

```
x=c(20,16,26,27,23,22,18,24,25,19)
y=c(27,33,42,35,32,34,38,28,41,43,30,37)
var.test(x, y, ratio = 1,alternative = c("two.sided"),conf.level = 0.95)
1/0.4670913
```

Output:

```
        F test to compare two variances
data:  x and y
F = 0.46709, num df = 9, denom df = 11,
p-value = 0.2629
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.1301852 1.8272959
sample estimates:
ratio of variances
          0.4670913
1/0.4670913
[1] 2.140909
```

Critical value of F for (11, 9) d.f. is $F_{0.05} = 3.10$

Conclusion: Since $F < F_{0.05}$, we accept the null hypothesis and we may conclude that the population has same variance

Task 2:

The nicotine content in 2 random samples of tobacco are given below:

Sample 1: 21 24 25 26 27

Sample 2: 22 27 28 30 31 36

Test whether the populations have the same variances.

Null Hypothesis: The populations have the same variances.

Alternative Hypothesis: The populations does not have the same variances.

R Code:

```
x=c(21,24,25,26,27)
y=c(22,27,28,30,31,36)
var.test(x, y, ratio = 1,alternative = c("two.sided"),conf.level = 0.95)
1/0.2453704
```

Output:

```
        F test to compare two variances
data:  x and y
F = 0.24537, num df = 4, denom df = 5,
p-value = 0.1981
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.03321253 2.29776367
sample estimates:
ratio of variances
          0.2453704
 1/0.2453704
[1] 4.075471
```

Critical value of F for (5, 4) d.f. is $F_{0.05} = 6.26$

Conclusion: Since $F < F_{0.05}$, we accept the null hypothesis and we may conclude that the population has same variance

Task 3:

2 independent samples of 8 and 7 items have the following values.

Sample 1: 9 11 13 11 15 9 12 14

Sample 2: 10 12 10 14 9 8 10

Can we conclude that the two samples have drawn from the same normal population.

To test whether the samples come from the same normal population, we have to test for

a. Equality of population means
b. Equality of population variances.

Equality of means is tested using t-test and equality of variances is tested using F-test.

Since t-test assumes $\sigma_1^2 = \sigma_2^2$, we first apply *F*-test and then t-test.

***F*-test:**

Null Hypothesis: There is no significant difference between two samples

Alternative Hypothesis: There is significant difference between two samples

R Code:

```
x=c(9,11,13,11,15,9,12,14)

y=c(10,12,10,14,9,8,10)

var.test(x, y, ratio = 1,alternative = c("two.sided"), conf.level = 0.95)
```

Output:

```
F test to compare two variances

data:  x and y

F = 1.2108, num df = 7, denom df = 6,

p-value = 0.8315

alternative hypothesis: true ratio of variances is not equal to 1

95 percent confidence interval:

 0.2125976 6.1978188

sample estimates:

ratio of variances

                1.210843
```

Critical value of F for (7,6) d.f. is $F_{0.05} = 4.21$

Conclusion: Since $F < F_{0.05}$, we accept the null hypothesis and we may conclude that the there is no significant difference between two samples.

***t*-test:**

Null Hypothesis: There is no significant difference between two samples.

Alternative Hypothesis: There is significant difference between two samples.

R Code:

```
x=c(9,11,13,11,15,9,12,14)
y=c(10,12,10,14,9,8,10)
t.test(x,y,alternative = "two.sided",var.equal=TRUE)
```

Output:

```
Two Sample t-test

data:  x and y

t = 1.2171, df = 13, p-value = 0.2452

alternative hypothesis: true difference in means is not equal to 0

95 percent confidence interval:

 -1.024204  3.667061

sample estimates:

mean of x mean of y

 11.75000  10.42857
```

Conclusion:t -value = 1.2171 < 2.160.

Hence we may conclude that the there is no significant difference between two samples.

Final conclusion:

Hence we may conclude that the there is no significant difference between two samples.

Task 4:

Two horses A and B were tested according to the time(in seconds) to run a particular track with the following results:

Horse A: 28 30 32 33 33 29 34

Horse B: 29 30 30 24 27 29

Test whether the two horses have the same running capacity.

Null Hypothesis: The two horses have the same running capacity.

Alternative Hypothesis: The two horses does not have the same running capacity.

R Code:

```
x=c(28,30,32,33,33,29,34)
y=c(29,30,30,24,27,29)
var.test(x, y, ratio = 1,alternative = c("two.sided"),conf.level = 0.95)
1/0.9760426
```

Output:

```
        F test to compare two variances
data:  x and y
F = 0.97604, num df = 6, denom df = 5,
p-value = 0.9573
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.1398802 5.8441186
sample estimates:
ratio of variances
          0.9760426


 1/0.9760426
[1] 1.024545
```

Critical value of F for (5,6) d.f. is $F_{0.05} = 4.39$

Conclusion: Since $F < F_{0.05}$, we accept the null hypothesis and we may conclude that the two horses have the same running capacity.

Task 5:

Two samples are drawn from two normal populations. From the following data test whether the two samples have the same variance at 5% level:

Sample 1:	**60**	**65**	**71**	**74**	**76**	**82**	**85**	**87**	
Sample 2:	**61**	**66**	**67**	**85**	**78**	**63**	**85**	**86**	**88**	**91.**

Null Hypothesis: The two samples have the same variance

Alternative Hypothesis: The two samples do not have the same variance

R Code:

```
x=c(60,65,71,74,76,82,85,87)
y=c(61,66,67,85,78,63,85,86,88,91)
var.test(x, y, ratio = 1,alternative = c("two.sided"),conf.level = 0.95)
1/0.6814286
```

Output:

```
        F test to compare two variances
data:  x and y
F = 0.68143, num df = 7, denom df = 9,
p-value = 0.6271
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.1623591 3.2866779
sample estimates:
ratio of variances
          0.6814286
1/0.6814286
[1] 1.467505
```

Critical value of F for (9,7) d.f. is $F_{0.05} = 3.68$

Conclusion: Since $F < F_{0.05}$, we accept the null hypothesis and we may conclude that the two samples have the same variance.

STEP 3: PRACTICE/TESTING

1. What is the use of *F*-distribution?

Uses of F-distribution

F-distribution is used to test the equality of the variances of two normal populations from which two small samples have been drawn.

2.State the important properties of *F*-distribution.

Properties of F-distribution

1. F-distribution is positively skewed

2. The value of F lies between 0 and ∞.

3.What is the difference between *F*-test and *t*-test?

BASIS FOR COMPARISON	**T-TEST**	**F-TEST**
Meaning	T-test is a univariate hypothesis test, that is applied when standard deviation is not known and the sample size is small.	F-test is statistical test, that determines the equality of the variances of the two normal populations.
Test statistic	T-statistic follows Student t-distribution, under null hypothesis.	F-statistic follows Snedecor f-distribution, under null hypothesis.
Application	Comparing the means of two populations.	Comparing two population variances.

KUMARAGURU COLLEGE OF TECHNOLOGY

LABORATORY MANUAL

Experiment Number: 7

Lab Code	**: U18MAI4201**
Lab	**: Probability and Statistics**
Course / Branch	**: B.Tech / Information Technology**
Title of the Experiment	**: Application of Chi square test**

STEP 1: INTRODUCTION

OBJECTIVES OF THE EXPERIMENT

1. To apply chi square test for goodness of fit
2. To apply chi square test for independence of attributes

STEP 2: ACQUISITION

Conditions for the validity of χ^2 -test

1. The sample observations must be independent of one another.
2. The sample size must be reasonably large, say $\geq$ 50.
3. No individual frequency should be less than 5. If any frequency is less than 5, then it is pooled with the preceding or succeeding frequency so that the pooled frequency is more than 5. Finally adjust for the d.f lost in pooling.
4. The number of classes k must be neither too small nor too large, ie $4 \leq k \leq 16$

χ^2 -test of goodness of fit

Tests ofgoodness of fit are used when we want to determine whether an actual sample distribution matches a known theoretical distribution. It enables us to find if the deviation of the experiment from theory is just by chance or it is due to the inadequacy of the theory to fit the data.

Null Hypothesis: H_0: The difference between the observed and expected frequencies is not significant. ie, the theory fits well into the given data.

Regular method: Let $O_i (i = 1,2,....n)$ be a set of observed frequencies and $E_i (i = 1,2,....n)$ be the corresponding set of expected frequencies. Then $\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$ follows Chi- Square Distribution with n – 1 d.f.

(One degree of freedom is subtracted for the constraint $\sum_i O_i = \sum_i E_i$)

Compare the calculated χ^2 -value with the tabulated χ^2 -value (with n – 1 d.f) and form the conclustion.

χ^2 - test of Independence of Attributes

χ^2 - test isused for testing the null hypothesis that two criteria of classification are independent. Let the two attributes be A and B, where A has r categories and B has s categories. Thus the members of the population and hence, those of the sample are divided into rs classes. Let the total number of observations be N. The observations are arranged in the form of a matrix, called contingency table .

H_0:The attributes A and B are independent.

Regular method:

The expected frequencies E_{ij} for various cells are calculated using the formula:

$$E_{ij} = \frac{R_i C_j}{N} \quad , \quad i = 1,2,....r, \quad j = 1,2.....s$$

$$= \frac{\text{Total of observed frequencies in the i}^{\text{th}} \text{ row} \times \text{Total of observed frequencies in the j}^{\text{th}} \text{column}}{\text{Total frequency}}$$

Test statistic is $\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{s} \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$ which follows χ^2 - distribution with n=(r-1)(s-1) d.f.

Note: For a 2x2 contingency table with cell frequencies a,b,c,d, the χ^2 - value is given by

$$\chi^2 = \frac{N(ad - bc)^2}{(a+c)(b+d)(a+b)(c+d)}; \qquad N = a + b + c + d \ ,$$

Degree of freedom =1

Procedure for doing the Experiment:

1.	**R-code for testing goodness of fit:** f=vector of observed frequencies p= vector of expected ratios (probabilities) a=chisq.test(f,p=c(p_1 ,p_2 , ….)) a
2.	**R-code for testing independence of attributes:** a = vector of elements in first row of contingency table b = vector of elements in second row of contingency table c = ……. contingency = as.data.frame(rbind(a,b,c,….)) # to create the table contingency chisq.test(contingency,simulate.p.value=T)

Example: (χ^2 -test of goodness of fit)

The following table gives the number of aircraft accidents that occur during the various days of a week. Find whether the accidents are uniformly distributed over the week.

Days	**Sun**	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**	**Sat**
No. of accidents:	**14**	**16**	**8**	**12**	**11**	**9**	**14**

Null Hypothesis: The accidents are uniformly distributed over the week

Alternative Hypothesis: The accidents are not uniformly distributed over the week

Level of significance: 5% (say)

R-code:

```
accident=c(14,16,8,12,11,9,14)
p=c(1/7,1/7,1/7,1/7,1/7,1/7,1/7)
a=chisq.test(accident,p=c(1/7,1/7,1/7,1/7,1/7,1/7,1/7))
a
```

Output:

Chi-squared test for given probabilities

data: accident

X-squared = 4.1667, df = 6, p-value = 0.6541

Table value of $\chi^2_{0.05}$ for 6 d.f = 12.59

Conclusion: $\chi^2 < \chi^2_{0.05}$,so we accept H_0 and conclude that the accidents are uniformly distributed over the week.

(Or)

Here *p* value ≥ α value,so we accept H_0 and conclude that the accidents are uniformly distributed over the week.

Task 1

The following figures show the distribution of digits in numbers chosen at random from a telephone directory

Digits	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**
Frequency	**1026**	**1107**	**997**	**966**	**1075**	**933**	**1107**	**972**	**964**	**853**	**10000**

Test whether the digits may be taken to occur equally frequently in the directory.

Null Hypothesis: The digits occur equally frequently in the directory.

Alternative Hypothesis: The digits do not occur equally frequently in the directory.

Level of significance: 5%

R-code:

```
a=c(1026,1107,997,966,1075,933,1107,972,964,853)
p=c(1/10,1/10,1/10,1/10,1/10,1/10,1/10,1/10,1/10,1/10)
r=chisq.test(a,p=c(1/10,1/10,1/10,1/10,1/10,1/10,1/10,1/10,1/10,1/10))
r
```

Output:

Chi-squared test for given probabilities

data: a

X-squared = 58.542, df = 9, p-value =

2.558e-09

Table value of $\chi^2_{0.05}$ for 9 d.f = 16.919

Conclusion:

$\chi^2 > \chi^2_{0.05}$,so we reject and conclude that the digits do not occur equally frequently in the directory.

Task 2

The following is the distribution of the hourly number of trucks arriving at a company's warehouse:

Trucks arriving hour	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Frequency	**52**	**151**	**130**	**102**	**45**	**12**	**5**	**1**	**2**	**500**

Test for goodness of fit at the 0.05 level of significance.

Null Hypothesis: The number of trucks arrived are uniformly distributed over the hour

Alternative Hypothesis: The number of trucks do not arrive uniformly distributed over the hour

Level Of Significance: 5%

R-Program:

```
a=c(52,151,130,102,45,12,5,1,2)

p=c(1/9,1/9,1/9,1/9,1/9,1/9,1/9,1/9,1/9)

r=chisq.test(a,p=c(1/9,1/9,1/9,1/9,1/9,1/9,1/9,1/9,1/9))

r
```

Output:

```
Chi-squared test for given probabilities

data:  a

X-squared = 490.14, df = 8, p-value <

2.2e-16
```

Table value of $\chi^2_{0.05}$ for 8 d.f = 15.507

Conclusion:

$\chi^2 > \chi^2_{0.05}$,so we reject and conclude the number of trucks arrived are not uniformly distributed over the hour.

Example (χ^2 - test of Independence of Attributes)

A survey of 920 people that ask for their preference of one of three ice cream flavours (chocolate, vanilla, strawberry) gives the following results:

	Flavour				
Gender		**Chocolate**	**Vanilla**	**Strawberry**	**Total**
	Men	**100**	**120**	**60**	**280**
	Women	**350**	**200**	**90**	**640**
	Total	**450**	**320**	**150**	**920**

Using χ^2 test, determine whether or not there is an association between gender and preference for ice cream flavour.

R-code

```
men = c(100, 120, 60)

women = c(350, 200, 90)

icecream = as.data.frame(rbind(men, women))

chisq.test(icecream,simulate.p.value=T)
```

Output:

```
V1   V2  V3

men          100  120  60

women  350  200  90

>chisq.test(icecream,  simulate.p.value=T)

Pearson's Chi-squared test with simulated p-value (based on 2000 replicates)

data:   icecream

X-squared = 28.362, df = NA, p-value = 0.0004998
```

Table value of χ^2 =5.991

Conclusion: $\chi^2 > \chi_\alpha{}^2$, hence we conclude that there is association between gender and preference for ice cream flavour.

Note:

The R-code

men = c(100, 120, 60)

women = c(350, 200, 90)

ice.cream.survey = as.data.frame(rbind(men, women))

ice.cream.survey

generates the table

V1 V2 V3

men 100 120 60

women 350 200 90

Task 3

Two sample polls of votes for two candidates A and B for a public office are taken, one from among the residents of rural areas and one from the residents of urban areas. The results are given in the table. Examine whether the nature of the area is related to voting preference in the election

Votes for area	**A**	**B**	**Total**
Rural	**620**	**380**	**1000**
Urban	**550**	**450**	**1000**
Total	**1170**	**830**	**2000**

Null Hypothesis: H_0: The nature of the area is related to voting preference in the election

Alternative Hypothesis: H_1: The nature of the area is not related to voting preference in the election

Level of significance: α = 5%

R-code:

rural = c(620,380)

urban = c(550,450)

vote = as.data.frame(rbind(rural, urban))

chisq.test(vote,simulate.p.value=T)

Output:

Pearson's Chi-squared test withn simulated p-value (based on 2000 replicates)

data: vote

X-squared = 10.092, df = NA, p-value =

0.003498

Table value: $\chi^2 = 3.841$

Conclusion: $\chi^2 > \chi_\alpha^2$, hence we reject H0 and conclude that the nature of the area is related to voting preference in the election.

Task 4

A sample of 200 persons with a particular disease was selected. Out of these, 100 were given a drug and the others were not given any drug. The results are as follows:

No. of persons	Drug	No drug
Cured	65	55
Not cured	35	45

Test whether the drug is effective or not (Use α = 0.05)

Null Hypothesis: H_0: The drug is not effective

Alternative Hypothesis: H_1: The drug is effective

Level of significance: α = 5%

R-code:

rural = c(620,380)

urban = c(550,450)

vote = as.data.frame(rbind(rural, urban))

chisq.test(vote,simulate.p.value=T)

Output:

Pearson's Chi-squared test with simulated p-value (based on 2000 replicates)

data: drug

X-squared = 2.0833, df = NA, p-value =0.2069

Table value: $\chi^2 = 3.841$

Conclusion: $\chi^2 < \chi_\alpha^2$, hence we accept H_0 and conclude that the drug is not effective.

Task 5

The following data are collected on two characters.

	Smokers	**Non – Smokers**
Literates	**83**	**57**
Illiterates	**45**	**68**

Based on this, can you say that there is no relation between smoking and literacy?

Null Hypothesis: H_0: There is no relation between smoking and literacy

Alternative Hypothesis: H_1: There is relation between smoking and literacy

Level of significance: α **= 5%**

R-code:

```
smoker = c(83,57)

nosmoker = c(45,68)

literacy = as.data.frame(rbind(smoker,nosmoker))

chisq.test(literacy,simulate.p.value=T)
```

Output:

```
Pearson's Chi-squared test with simulated p-value (based on 2000 replicates)

data:  literacy

X-squared = 9.4757, df = NA, p-value =

0.001999
```

Table value: $\chi^2 = 3.841$

Conclusion: $\chi^2 < \chi_\alpha^2$, hence we reject H_0 and conclude that there is relation between smoking and literacy

Task 6

From the following data, test whether there is any association between intelligence and economic conditions?

Intelligence

Economic condition	Excellent	Good	Medium	Dull	Total
Good	**48**	**200**	**150**	**80**	**478**
Not good	**52**	**180**	**190**	**100**	**522**
Total	**100**	**380**	**340**	**180**	**1000**

Null Hypothesis: H_0: There is no association between intelligence and economic conditions

Alternative Hypothesis: H_1: There is association between intelligence and economic conditions

Level of significance: α = 5%

R-code:

```
smoker = c(83,57)

nosmoker = c(45,68)

literacy = as.data.frame(rbind(smoker,nosmoker))

chisq.test(literacy,simulate.p.value=T)
```

Output:

Pearson's Chi-squared test with simulated p-value (based on 2000 replicates)

data: condition

X-squared = 6.2168, df = NA, p-value =0.1024

Table value:Table value: χ^2 = 7.815

Conclusion: $\chi^2 < \chi_\alpha^2$ hence we accept H_0 and conclude that there is no association between intelligence and economic conditions

STEP 3: PRACTICE/TESTING

1.When is chi-square test used?

1. To test for single population variance.
2. To test goodness of fit
3. To test independence of attributes.

2.State the conditions for the validity of χ^2 -test

The sample observations must be independent of one another.The sample size must be reasonably large, say 50.No individual frequency should be less than 5. If any frequency is less than 5, then it is pooled with the preceding or succeeding frequency so that the pooled frequency is more than 5. Finally adjust for the d.f lost in pooling.The number of classes k must be neither too small nor too large.

3.When do we use χ^2 -test of goodness of fit ?

Tests of goodness of fit are used when we want to determine whether an actual sample distribution matches a known theoretical distribution. It enables us to find if the deviation of the experiment from theory is just by chance or it is due to the inadequacy of the theory to fit the data.

4.When do we use χ^2 - test of Independence of Attributes?

χ^2 - test is used for testing the null hypothesis that two criteria of classification are independent.Let the two attributes be A and B, where A has r categories and B has s categories.Thus the members of the population and hence, those of the sample are divided into rs classes.Let the total number of observations be N. The observations are arranged in the form of a matrix, called contingency table .

KUMARAGURU COLLEGE OF TECHNOLOGY

LABORATORY MANUAL

Experiment Number: 8

Lab Code	**: U18MAI4201**
Lab	**: Probability and Statistics**
Course / Branch	**: B.Tech / Information Technology**
Title of the Experiment	**: ANOVA – one way classification**

STEP 1: INTRODUCTION

OBJECTIVES OF THE EXPERIMENT

To perform analysis of variance for a completely randomized design

STEP 2: ACQUISITION

Analysis of variance refers to the separation of variance ascribable to one group of causes from the variance ascribable to the other group. It is used to test the homogeneity of several means.

Three types of variation present in a data

1. Treatments
2. Environmental
3. Residual or Error

Assumptions for ANOVA test

1. The observations are independent.
2. The parent population is normal
3. Various treatment and environmental effects are additive in nature.
4. The samples have been randomly selected from the population

Null Hypothesis: All the population means are equal

Alternative Hypothesis: Some of the means are not equal.

Three important designs of experiments:

1. Completely Randomised Design (CRD) – One-way classification
2. Randomised Block Design (RBD) – Two-way classification
3. Latin Square Design (LSD) – Three-way classification

Procedure for doing the Experiment:

1.	aov(response~factor,data=data_name)

Example

A drug company tested three formulations of a pain relief medicine for migraine headachesufferers. For the experiment 27 volunteers were selected and 9 were randomly assigned to one of three drug formulations. The subjects were instruct ed to take the drug during theirnext migraine headache episode and to report th eir pain on a scale of 1 to 10 (10 beingmaximum pain)

Drug A	**4**	**5**	**4**	**3**	**2**	**4**	**3**	**4**	**4**
Drug B	**6**	**8**	**4**	**5**	**4**	**6**	**5**	**8**	**6**
Drug C	**6**	**7**	**6**	**6**	**7**	**5**	**6**	**5**	**5**

R-code:

```
pain=c(4,5,4,3,2,4,3,4,4,6,8,4,5,4,6,5,8,6,6,7,6,6,7,5,6,5,5)

drug=c(rep("A",9),rep("B",9),rep("C",9))

data=data.frame(pain,drug)

data

results=aov(pain~drug,data=data)
summary(results)
```

Output:

```
pain  drug

1       4       A
2       5       A
3       4       A
4       3       A
5       2       A
6       4       A
7       3       A
8       4       A
9       4       A
10      6       B
```

11	8	B
12	4	B
13	5	B
14	4	B
15	6	B
16	5	B
17	8	B
18	6	B
19	6	C
20	7	C
21	6	C
22	6	C
23	7	C
24	5	C
25	6	C
26	5	C
27	5	C

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
drug	2	28.22	14.111	11.91	0.000256	***
Residuals	24	28.44	1.185			

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$F_\alpha = 3.40, F > F_\alpha$, so we reject the null hypothesis and conclude that that the means of the
three drug groups are different.

Task 1

Three machines A, B & C gave the production of pieces in 4 days as below is there a significant difference between machines?

A	**17**	**16**	**14**	**13**
B	**15**	**12**	**19**	**18**
C	**20**	**8**	**11**	**17**

Null Hypothesis : There is no significant difference between machines

Alternate Hypothesis : There is significant difference between machines

PROGRAM:

```
production=c(17,16,14,13,15,12,19,18,20,8,11,17)

machine=c(rep("A",4),rep("B",4),rep("C",4))

data=data.frame(production,machine)

data

results=aov(production~machine,data=data)

summary(results)
```

```
1/0.277
```

OUTPUT:

```
   production machine
1            17         A
2            16         A
3            14         A
4            13         A
5            15         B
6            12         B
7            19         B
8            18         B
9            20         C
10            8         C
11           11         C
12           17         C
> results=aov(production~machine,data=data)
> summary(results)
                Df Sum Sq Mean Sq F value Pr(>F)
machine          2      8    4.00   0.277  0.764
Residuals        9    130   14.44
> 1/0.277
[1] 3.610108
```

CONCLUSION:

Fα=19.38 , F<Fα , so we accept the null hypothesis and conclude that there is no significant difference between the machines

Task 2

Four machines A,B,C,D are used to produce a certain kind of cotton fabric. Samples of size 4 with each unit as 100 square meters are selected from the outputs of the machines

at random and the number of flaws in each 100 square meters is counted with the following result.

A	B	C	D
8	6	14	20
9	8	12	22
11	10	18	25
12	4	9	23

Do you think that there is significant difference in the performance of the four machines?

Null Hypothesis : There is no significant difference in the performance of the four machines

Alternate Hypothesis : There is significant difference in the performance of the four machines

PROGRAM:

```
production=c(8,9,11,12,6,8,10,4,14,12,18,9,20,22,25,23)

machine=c(rep("A",4),rep("B",4),rep("C",4),rep("D",4))

data=data.frame(production,machine)

data

results=aov(production~machine,data=data)

summary(results)
```

OUTPUT:

```
  production machine
1          8       A
2          9       A
3         11       A
4         12       A
5          6       B
6          8       B
7         10       B
8          4       B
9         14       C
10        12       C
11        18       C
```

12 9 C

13 20 D

14 22 D

15 25 D

16 23 D

```
> results=aov(production~machine,data=data)
> summary(results)
            Df Sum Sq Mean Sq F value     Pr(>F)
machine      3  540.7  180.23   25.22 1.81e-05 ***
Residuals   12   85.7    7.15
---
Signif. codes:
0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

CONCLUSION:

Fα= 3.49 , F>Fα, so we reject the null hypothesis and conclude that there is a significant difference in the performance of machines.

Task 3

Ten varieties of wheat are grown in 3 plots each and the following yields in quintals per acre, obtained.

		Variety									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Plots	**I**	**7**	**7**	**14**	**11**	**9**	**6**	**9**	**8**	**12**	**9**
	II	**8**	**9**	**13**	**10**	**9**	**7**	**13**	**13**	**11**	**11**
	III	**7**	**6**	**16**	**11**	**12**	**6**	**12**	**11**	**11**	**11**

Test the significance of the differences between variety yields

Null Hypothesis : There is no significant difference between variety yields

Alternate Hypothesis : There is significant difference between variety yields

PROGRAM:

```
plot=c(7,8,7,7,9,6,14,13,16,11,10,11,9,9,12,6,7,6,9,13,12,8,13,11,12,11,11,9,11,11)

variety=c(rep("1",3),rep("2",3),rep("3",3),rep("4",3),rep("5",3),rep("6",3),rep("7",3),rep("8",3),rep("9
",3),rep("10",3))

data=data.frame(plot,variety)

data

results=aov(plot~variety,data=data)

summary(results)
```

OUTPUT:

	plot	variety
1	7	1
2	8	1
3	7	1
4	7	2
5	9	2
6	6	2
7	14	3
8	13	3
9	16	3
10	11	4
11	10	4
12	11	4
13	9	5
14	9	5
15	12	5
16	6	6
17	7	6
18	6	6
19	9	7

20 13 7

21 12 7

22 8 8

23 13 8

24 11 8

25 12 9

26 11 9

27 11 9

28 9 10

29 11 10

30 11 10

> results=aov(plot~variety,data=data)

> summary(results)

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
variety	9	153	17.0	8.093	5.5e-05 ***
Residuals	20	42	2.1		

Signif. codes:

0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

CONCLUSION:

Fα= 2.40 , F>Fα , so we reject the null hypothesis and conclude that there is a significant difference between the variety yields.

Task 4

An experiment was conducted to study effect of four different dyes A, B, C, D on the strength of the fabric and following results of fabric strength are obtained.

Dye

A 8.67 8.68 8.66 8.65

B	**7.68**	**7.58**	**8.67**	**8.65**	**8.62**
C	**8.69**	**8.67**	**8.92**	**7.7**	
D	**7.7**	**7.90**	**8.65**	**8.20**	**8.60**

Null Hypothesis:There is no significant difference between effect of four different dyes

Alternate Hypothesis : There is significant difference between effect of four different dyes

PROGRAM:

```
strength=c(8.67,8.68,8.66,8.65,7.68,7.58,8.67,8.65,8.62,8.69,8.67,8.92,7.7,7.7,7.90,8.65,8.20,8.60)
dye=c(rep("A",4),rep("B",5),rep("C",4),rep("D",5))
data=data.frame(strength,dye)
data
results=aov(strength~dye,data=data)
summary(results)
```

OUTPUT:

	strength	dye
1	8.67	A
2	8.68	A
3	8.66	A
4	8.65	A
5	7.68	B
6	7.58	B
7	8.67	B
8	8.65	B
9	8.62	B
10	8.69	C
11	8.67	C
12	8.92	C

13 7.70 C

14 7.70 D

15 7.90 D

16 8.65 D

17 8.20 D

18 8.60 D

```
> results=aov(strength~dye,data=data)
> summary(results)
            Df Sum Sq Mean Sq F value Pr(>F)
dye          3 0.6202  0.2067   1.023  0.412
Residuals   14 2.8304  0.2022
```

CONCLUSION:

Fα= 3.34, F<Fα, so we accept the null hypothesis and conclude that there is no significant difference between effect of four different dye.

STEP 3: PRACTICE/TESTING

1.What are the basic principles of Experimental Design?

Basic principles of Experimental Design

1. Replication –Repetition of treatments under investigation

2. Randomization–Assigning treatments randomly to the experimental units

3.Local control –Making the experimental units homogeneous and reducing the experimental error

2.Mention the important designs of experiments:

Three important designs of experiments:

1.Completely Randomised Design (CRD) – One-way classification
2.Randomised Block Design (RBD) – Two-way classification
3.Latin Square Design (LSD) – Three-way classification

3.Explain a completely randomized design.

A completely randomized design (CRD) is one where the treatments are assigned completely at random so that each experimental unit has the same chance of receiving any one treatment. For the CRD, any difference among experimental units receiving the same treatment is considered as experimental error.

The different treatments to be applied is completely random, so that any material to which the treatments might be applied is considered to be approximately homogeneous. Such a design is called a completely randomized design.

4.What is the purpose of analysis of variance?

Analysis of variance

– Separation of variance ascribable to one group of causes from the variance ascribable to the other group

– used to test the homogeneity of several means.

KUMARAGURU COLLEGE OF TECHNOLOGY

LABORATORY MANUAL

Experiment Number: 9

Lab Code	**: U18MAI4201**
Lab	**: Probability and Statistics**
Course / Branch	**: B.Tech / Information Technology**
Title of the Experiment	**: ANOVA – two way classification**

STEP 1: INTRODUCTION

OBJECTIVES OF THE EXPERIMENT

To perform analysis of variance for a Randomised Block Design.

STEP 2: ACQUISITION

The data collected from experiments with randomised block design form a two-way classification, classified according to two factors – blocks and treatments. The two-way table has k rows and r columns – ie, N=kr entries.

Consider an agricultural experiment in which we wish to test the effect of k fertilising treatments on the yield of a crop. We divide the plots into r blocks, according to soil fertility, each block containing k plots. The plots in each block will be of homogeneous fertility. I each block, the k treatments are given to the k plots in a random manner in such a way that each treatment occurs only once in each block. The same k treatments are repeated from block to block.

H_{01} : There is no difference in the yield of crop due to treatments

H_{02} : There is no difference in the yield of crop due to blocks

Procedure for doing the Experiment:

Consider a two way table with k rows and r columns

1.	a=c(a_1 , a_2 ,……) (entries entered columnwise) f=c("row1","row2","row3","row4","row5") k=5

	r=4 A=gl(k,1,r*k,factor(f)) A B=gl(r,k,k*r) B av = aov(a ~ A+B) summary(av)

Example

The following data represents the number of units of loom crank bushes produced per day turned out by different workers using four different types of machines.

		Machine Type			
		A	**B**	**C**	**D**
	1	**44**	**38**	**47**	**36**
Workers	**2**	**46**	**40**	**52**	**43**
	3	**34**	**36**	**44**	**32**
	4	**43**	**38**	**46**	**33**
	5	**38**	**42**	**49**	**39**

Test whether the 5 men differ with respect to mean productivity and test whether the mean Productivity is the same for the four different machine types.

R-code:

```
a=c(44,46,34,43,38,38,40,36,38,42,47,52,44,46,49,36,43,32,33,39)

f=c("w1","w2","w3","w4","w5")

k=5

r=4

worker=gl(k,1,r*k,factor(f))

worker

machine=gl(r,k,k*r)

machine

av = aov(a ~ worker+machine)

summary(av)
```

Output:

```
a=c(44,46,34,43,38,38,40,36,38,42,47,52,44,46,49,36,43,32,33,39)

 f=c("w1","w2","w3","w4","w5")
```

```
 k=5
 r=4
worker=gl(k,1,r*k,factor(f))
worker
 [1] w1 w2 w3 w4 w5 w1 w2 w3 w4 w5 w1 w2 w3 w4 w5 w1 w2 w3 w4 w5
Levels: w1 w2 w3 w4 w5
machine=gl(r,k,k*r)
machine
 [1] 1 1 1 1 1 2 2 2 2 2 3 3 3 3 3 4 4 4 4 4
Levels: 1 2 3 4
>av = aov(a ~ worker+machine)
>summary(av)
Df Sum Sq Mean Sq F value Pr(>F)
worker 4 161.5 40.37 6.574 0.00485 **
machine 3 338.8 112.93 18.388 8.78e-05 ***
Residuals 12 73.7 6.14
---
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Conclusion:

From F-table, $F_{0.05}(4,12) = 3.26$

$F_{0.05}(3,12) = 3.49$

$F_1 = 6.54 > F_{0.05}(4,12) = 3.26$, hence we reject H_{01} and conclude that the 5 workers differ with respect to mean productivity.

$F_2 = 18.388 > F_{0.05}(3,12) = 3.49$, hence we reject H_{02} and conclude that the 4 machines differ with respect to mean productivity.

Task 1

A company appoints 4 salesmen A,B,C,D and observes their sales in 3 seasons: summer, winter and monsoon. The figures (in lakhs of Rs.) are given in the following table:

	Salesmen			
Season	**A**	**B**	**C**	**D**
Summer	**45**	**40**	**38**	**37**
Winter	**43**	**41**	**45**	**38**
Monsoon	**39**	**39**	**41**	**41**

Carry out an analysis of variance.

Null Hypothesis

H_{01} : There is no significant difference between the sales in three seasons

H_{02} : There is no significant difference between the sales of 4 salesman

Alternate Hypothesis :

H_{11} : There is significant difference between the sales in three seasons

H_{12} : There is significant difference between the sales of 4 salesman

PROGRAM:

```
a=c(45,43,39,40,41,39,38,45,41,37,38,41)

f=c("summer","winter","monsoon")

k=3

r=4

season=gl(k,1,r*k,factor(f))

season

salesmen=gl(r,k,k*r)

salesmen

av = aov(a ~ season+salesmen)

summary(av)
```

OUTPUT:

```
[1] summer  winter  monsoon summer  winter
```

```
 [6] monsoon summer    winter    monsoon summer

[11] winter    monsoon

Levels: summer winter monsoon

> salesmen=gl(r,k,k*r)

> salesmen

 [1] 1 1 1 2 2 2 3 3 3 4 4 4

Levels: 1 2 3 4

> av = aov(a ~ season+salesmen)

> summary(av)

                Df Sum Sq Mean Sq F value Pr(>F)

season           2   8.17   4.083   0.535  0.611

salesmen         3  22.92   7.639   1.000  0.455

Residuals        6  45.83   7.639
```

Conclusion:

From F-table, $F_{0.05}(6,2) = 19.33$, $F_{0.05}(3,6) = 4.76$

$F_1 = 1.869 < F_{0.05}(6,2) = 19.33$, hence we accept H_{01} and conclude that there is no significant difference between the sales in three seasons

$F_2 = 1.000 < F_{0.05}(3,6) = 4.76$, hence we accept H_{01} and conclude that there is no significant difference between the sales of 4 salesman

Task 2

Four different, though supposedly equivalent, forms of a standardized reading achievementtest were given to each of 5 students and the following are the scores which they obtained:

	Student 1	Student 2	Student 3	Student 4	Student 5
Form A	**75**	**73**	**59**	**69**	**84**
Form B	**83**	**72**	**56**	**70**	**92**
Form C	**86**	**61**	**53**	**72**	**88**
Form D	**73**	**67**	**62**	**79**	**95**

Perform a two-way analysis of variance to test at the level of significance 0.01 whether it is reasonable to treat the forms as equivalent.

Null Hypothesis

H_{01} : It is reasonable to treat the forms as equivalent

H_{02} : There is no significant difference between the marks of 5 students

Alternate Hypothesis :

H_{11} : It is not reasonable to treat the forms as equivalent

H_{12} : There is significant difference between the marks of 5 students

PROGRAM:

```
a=c(45,43,39,40,41,39,38,45,41,37,38,41)
f=c("summer","winter","monsoon")
k=3
r=4
season=gl(k,1,r*k,factor(f))
season
salesmen=gl(r,k,k*r)
salesmen
av = aov(a ~ season+salesmen)
summary(av)
```

OUTPUT:

```
 [1] A B C D A B C D A B C D A B C D A B C D
Levels: A B C D
> student=gl(r,k,k*r)
> student
 [1] 1 1 1 1 2 2 2 2 3 3 3 3 4 4 4 4 5 5 5 5
Levels: 1 2 3 4 5
> av = aov(a ~ forms+student)
> summary(av)
```

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
forms	3	43.0	14.3	0.506	0.685	
student	4	2326.7	581.7	20.572	2.65e-05	***
Residuals	12	339.3	28.3			

Signif. codes:

0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '1

Conclusion :

From F-table $F_{0.01}(12,3) = 27.05, F_{0.01}(4,12) = 5.41$

$F_1 = 1.976285 < F_{0.01}(12,3) = 27.05$, hence we accept H_{01} and conclude that it is reasonable to treat the forms as equivalent.

$F_2 = 20.572 > F_{0.01}(4,12) = 5.41$, hence we reject H_{11} and conclude that there is a significant difference between the marks of 5 students

Task 3

An experiment was designed to study the performance of different detergents for cleaning fuel injectors. The following 'cleanness' readings were obtained with specially designed equipment's for 12 tanks of gas distributed over 3 different models of engines:

	Engine 1	Engine 2	Engine 3	Total
Detergent A	**45**	**43**	**51**	**139**
Detergent B	**47**	**46**	**52**	**145**
Detergent C	**48**	**50**	**55**	**153**
Detergent D	**42**	**37**	**49**	**128**
Total	**182**	**176**	**207**	**565**

Test at the 0.01 level of significance whether there are differences in the detergents or in the engines.

Null Hypothesis

H_{01} : There is no significant difference in the performance of detergents

H_{02} : There is no significant difference in the performance of engines.

Alternate Hypothesis :

H_{11} : There is significant difference in the performance of detergents

H_{12} : There is significant difference in the performance of engines.

PROGRAM:

```
a=c(45,47,48,42,43,46,50,37,51,52,55,49)
f=c("A","B","C","D")
k=4
r=3
detergent=gl(k,1,r*k,factor(f))
detergent
engine=gl(r,k,k*r)
engine
av = aov(a ~ detergent+engine)
summary(av)
```

OUTPUT:

```
[1] A B C D A B C D A B C D
Levels: A B C D
> engine=gl(r,k,k*r)
> engine
 [1] 1 1 1 1 2 2 2 2 3 3 3 3
Levels: 1 2 3
> av = aov(a ~ detergent+engine)
> summary(av)
             Df Sum Sq Mean Sq F value    Pr(>F)
detergent     3 110.92   36.97   11.78 0.00631 **
engine        2 135.17   67.58   21.53 0.00183 **
Residuals     6  18.83    3.14
---
Signif. codes:
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Conclusion :

From F-table, $F_{0.01}(3,6) = 9.78, F_{0.01}(2,6) = 10.92$

$F_1 = 11.78 > F_{0.01}(3,6) = 9.78$, hence we reject H_{01} and conclude that there is a difference between the detergents

$F_2 = 21.53 > F_{0.01}(2,6) = 10.92$, hence we reject H_{02} and conclude that there is a significant difference between the engine

Task 4:

Four experiments determine the moisture content of samples of a powder each observer taking a sample from each of six consignments. The assessments are given below

Observer	Consignment					
	1	2	3	4	5	6
1	9	10	9	10	11	11
2	12	11	9	11	10	10
3	11	10	10	12	11	10
4	12	13	11	14	12	10

Perform an analysis of variance on these data and discuss whether there is any significant difference between consignments or between observers.

Null Hypothesis

H_{01} : There is no significant difference between the Observers

H_{02} : There is no significant difference between the consignments

Alternate Hypothesis :

H_{11} : There is significant difference between the Observers

H_{12} : There is significant difference between the consignments.

PROGRAM:

```
a=c(9,12,11,12,10,11,10,13,9,9,10,11,10,11,12,14,11,10,11,12,11,10,10,10)

f=c("1","2","3","4")

k=4

r=6
```

```
observer=gl(k,1,r*k,factor(f))

observer

consignment=gl(r,k,k*r)

consignment

av = aov(a ~ observer+consignment)

summary(av)
```

OUTPUT:

```
[1] 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3

[24] 4

Levels: 1 2 3 4

> consignment=gl(r,k,k*r)

> consignment

 [1] 1 1 1 1 2 2 2 2 3 3 3 3 4 4 4 4 5 5 5 5 6 6 6

[24] 6

Levels: 1 2 3 4 5 6

> av = aov(a ~ observer+consignment)

> summary(av)

                Df Sum Sq Mean Sq F value Pr(>F)

observer         3 13.125   4.375   5.000 0.0134 *

consignment    5   9.708    1.942    2.219 0.1064

Residuals      15 13.125    0.875

---

Signif. codes:

0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Conclusion :

From F-table,$F_{0.05}(3,15) = 3.29, F_{0.05}(5,15) = 2.90$

$F_1 = 5.000 > F_{0.05}(3,15) = 3.29$, hence we reject H_{01} and conclude that there is a significant difference between the Observers

$F_2 = 2.219 < F_{0.05}(5,15) = 2.90$, hence we accept H_{02} and conclude that there is no significant difference between the consignments

STEP 3: PRACTICE/TESTING

1.What is meant by a randomized block design?

A randomized block design is an experimental design where the experimental units are in groups called blocks. The treatments are randomly allocated to the experimental units inside each block. When all treatments appear at least once in each block, we have a completely randomized block design. Otherwise, we have an incomplete randomized block design.

2.Write the differences between CRD and RBD.

1. RBD is more efficient/accurate than CRD for most types of experimental work.

2. In CRD, grouping of the experimental size so as to allocate the treatments at random to the experimental units is not done. But in RBD, treatments are allocated at random within the units of each stratum.

3. RBD is more flexible than CRD since no restrictions are placed on the number of treatments or the number of replications.

3.Bring out any two advantages of RBD over CRD.

1. This design is more efficient/accurate than CRD, i.e., it has less experimental error.

2. This design is more flexible. ie. no restrictions are placed on the number of treatments or the number of replications

3. The statistical analysis for this design is simple and rapid.

4. It is easily adaptable. In an agricultural experiment it can be accommodated well in a rectangular or square field.

4.When do you apply the analysis of variance technique?

It is similar in application to techniques such as t-test and z-test, in that it is used to compare means and the relative variance between them. However, analysis of variance (ANOVA) is best applied where more than 2 populations or samples are meant to be compared.

KUMARAGURU COLLEGE OF TECHNOLOGY

LABORATORY MANUAL

Experiment Number: 10

Lab Code	**: U18MAI4201**
Lab	**: Probability and Statistics**
Course / Branch	**: B.Tech / Information Technology**
Title of the Experiment	**: Control charts for variables (mean and range chart)**

STEP 1: INTRODUCTION

OBJECTIVES OF THE EXPERIMENT

To plot $\overline{X}$ - chart and R-chart and comment on the state of control of the process.

STEP 2: ACQUISITION

Statistical Quality Control is a statistical method for finding whether the variation in the quality of the product is due to random causes or assignable causes

Control chart is a graphical device used in statistical quality control for the study and control of the manufacturing process.

There are two types of control charts:

1. Control charts of variables (Mean ($\overline{X}$)and range (R)charts)
2. Control charts of attributes (p-chart, np-chart, c-chart)

The Lower control limit and Upper control limit for mean and range charts

1. $\overline{X}$ chart LCL: $\overline{\overline{X}} - A_2 \overline{R}$ UCL: $\overline{\overline{X}} + A_2 \overline{R}$
2. R-Chart LCL: $D_3 \overline{R}$ UCL: $D_4 \overline{R}$

Procedure to plot $\overline{X}$ and R charts using RStudio

To install qcc package in RStudio go to the "Tools" menu, select "Install Packages…" and type "qcc" into the packages field being sure to also select "Install Dependencies" and click "Install."

Load the data from a.csv file with one subgroup per row :

my.data = read.csv("my-data.csv",header=FALSE)
OR,
Load the data for each subgroup manually:
a1 = c( )
a2 = c( )
a3 = c( ) etc.
If there is more than one subgroup, create a dataframe: my.data = rbind(a1,a2,a3)

Procedure for doing the Experiment:

Suppose the given values are x, y, z, …….

1.	**R code to create dataframe** S1=c(a_1 , a_2 ,……) S2=c(b_1 , b_2 ,……) A= as.data.frame(rbind(S1,S2,……..)) A

2.	**For $\overline{X}$ chart:**
	
	Xbarchart= qcc(data = A,
	type = "xbar",
	sizes = n, # n=number of items in each sample
	title = "X-bar Chart ",
	plot = TRUE)

3.	**For R chart:**
	
	rchart = qcc(data = A,
	type = "R",
	sizes = n, # n=number of items in each sample
	title = "R Chart",
	plot = TRUE)

Example

The measurements are given below with 5 samples each containing 5 items at equal intervals of time. Construct $\overline{X}$ and R charts and comment on the state of control.

Sample no	Measurements				
1	46	45	44	43	42
2	41	41	44	42	40
3	40	40	42	40	42
4	42	43	43	42	45
5	43	44	47	47	45

#R code to create dataframe

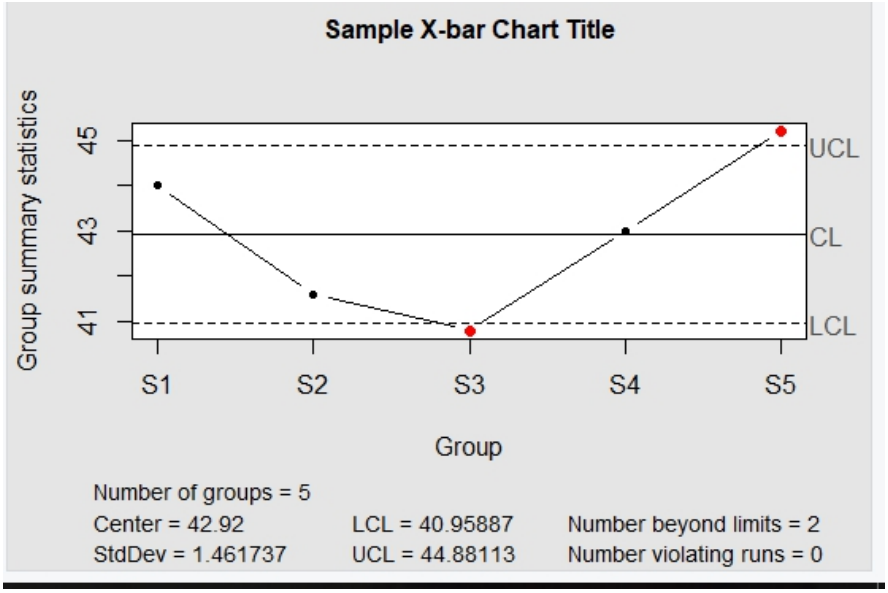
```
S1=c(46,45,44,43,42)

S2=c(41,41,44,42,40)

S3=c(40,40,42,40,42)

S4=c(42,43,43,42,45)

S5=c(43,44,47,47,45)

A= as.data.frame(rbind(S1,S2,S3,S4,S5))

A
```

#**For $\overline{X}$ chart:**

```
Xbarchart= qcc(data = A,

type = "xbar",

sizes = 5,

title = "X-bar Chart ",

plot = TRUE)
```

Output:

```
    V1  V2  V3  V4  V5

S1  46  45  44  43  42

S2  41  41  44  42  40

S3  40  40  42  40  42

S4  42  43  43  42  45

S5  43  44  47  47  45
```

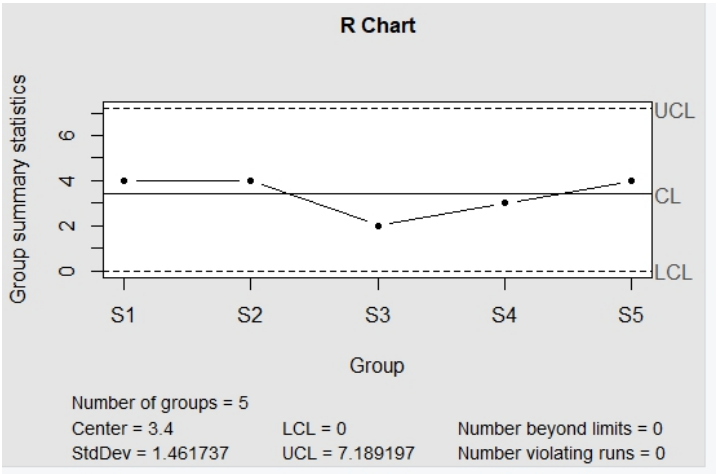


For R chart:

R-code:

```
rchart = qcc(data = A,
type = "R",
sizes = 5,
title = "R Chart",
plot = TRUE)
```

Output:



Conclusion:

In $\overline{X}$ chart, two points are beyond the control limits, so as far as sample mean is concerned, the system is out of control.

In R chart, all points are within the control limits, so as far as variability is concerned, the system is under control.

On the whole, the system is out of control.

Task 1

Samples of five ring bobbins each selected from a ring frame for eight shifts have shown following results of count of yarn.

Sample no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Count of yarn	**27.5**		**27.4**	**25.4**	**28.5**	**28.5**	**28.9**	**28.0**	**28.4**
	28.5	**26.9**	**26.9**	**28.0**	**29.0**	**29.5**	**28.5**	**28.5**	
	28	**26.0**	**28.0**	**29.2**	**28.5**	**30.0**	**27.8**	**28.4**	
	26.9	**28.7**	**26.7**	**29.0**	**28.5**	**29.4**	**28.0**	**28.0**	
	28.6	**29.0**	**28.2**	**28.7**	**28.0**	**28.9**	**28.1**	**28.7**	

Draw $\overline{X}$ and R chart for the above data and write conclusion about the state of the process.

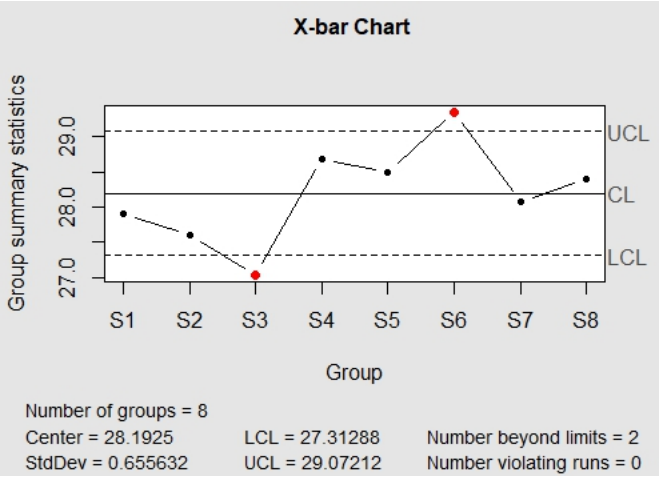
PROGRAM:

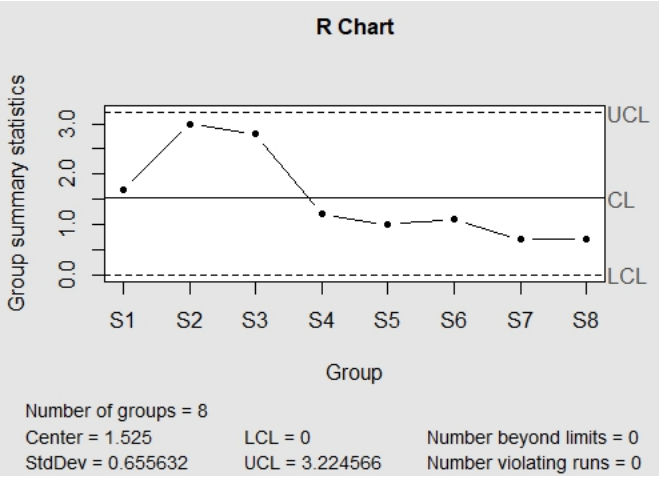
```
S1=c(27.5,28.5,28,26.9,28.6)

S2=c(27.4,26.9,26.0,28.7,29.0)

S3=c(25.4,26.9,28.0,26.7,28.2)

S4=c(28.5,28.0,29.2,29.0,28.7)

S5=c(28.5,29.0,28.5,28.5,28.0)

S6=c(28.9,29.5,30.0,29.4,28.9)

S7=c(28.0,28.5,27.8,28.0,28.1)

S8=c(28.4,28.5,28.4,28.0,28.7)

A= as.data.frame(rbind(S1,S2,S3,S4,S5,S6,S7,S8))

A


Xbarchart= qcc(data = A,type = "xbar",sizes = 5,title = "X-bar Chart ",plot = TRUE)
```

rchart = qcc(data = A,type = "R",sizes = 5,title = "R Chart",plot = TRUE)

OUTPUT:

	V1	V2	V3	V4	V5
S1	27.5	28.5	28.0	26.9	28.6
S2	27.4	26.9	26.0	28.7	29.0
S3	25.4	26.9	28.0	26.7	28.2
S4	28.5	28.0	29.2	29.0	28.7
S5	28.5	29.0	28.5	28.5	28.0
S6	28.9	29.5	30.0	29.4	28.9
S7	28.0	28.5	27.8	28.0	28.1
S8	28.4	28.5	28.4	28.0	28.7





Conclusion:

In $\overline{X}$ chart, two points are beyond the control limits, so as far as sample mean is concerned, the system is out of control.

In R chart, all points are within the control limits, so as far as variability is concerned, the system is under control. On the whole, the system is out of control

Task 2:

The following data gives the measurements of 10 samples each of size 5, in a production process taken at intervals of 2 hours. Draw the control charts for the mean and range and comment on the state of control:

Sample No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Measurements	**47**	**52**	**48**	**49**	**50**	**55**	**50**	**54**	**49**	**53**
	49	**55**	**53**	**49**	**53**	**55**	**51**	**54**	**55**	**50**
	50	**47**	**51**	**49**	**48**	**50**	**53**	**52**	**54**	**54**
	44	**56**	**50**	**53**	**52**	**53**	**46**	**54**	**49**	**47**
	45	**50**	**53**	**45**	**47**	**57**	**50**	**56**	**53**	**51**

PROGRAM:

```
S1=c(47,49,50,44,45)

S2=c(52,55,47,56,50)

S3=c(48,53,51,50,53)

S4=c(49,49,49,53,45)

S5=c(50,53,48,52,47)

S6=c(55,55,50,53,57)

S7=c(50,51,53,46,50)

S8=c(54,54,52,54,56)

S9=c(49,55,54,49,53)

S10=c(53,50,54,47,51)

A= as.data.frame(rbind(S1,S2,S3,S4,S5,S6,S7,S8,S9,S10))
```

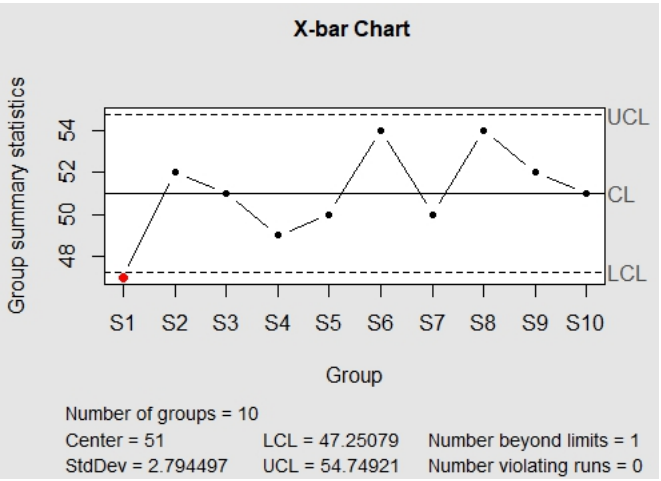
A

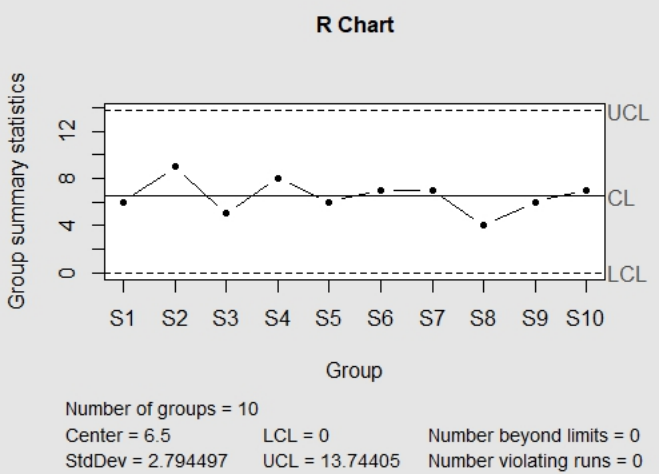
Xbarchart= qcc(data = A,type = "xbar",sizes = 5,title = "X-bar Chart ",plot = TRUE)

rchart = qcc(data = A,type = "R",sizes = 5,title = "R Chart",plot = TRUE)

OUTPUT:

	V1	V2	V3	V4	V5
S1	47	49	50	44	45
S2	52	55	47	56	50
S3	48	53	51	50	53
S4	49	49	49	53	45
S5	50	53	48	52	47
S6	55	55	50	53	57
S7	50	51	53	46	50
S8	54	54	52	54	56
S9	49	55	54	49	53
S10	53	50	54	47	51





CONCLUSION:

In $\overline{X}$ chart, one points are beyond the control limits, so as far as sample mean is concerned, the system is out of control.

In R chart, all points are within the control limits, so as far as variability is concerned, the system is under control. On the whole, the system is out of control

Task 3:

Plot the mean and range charts for the following data

Rotation Time (msec)

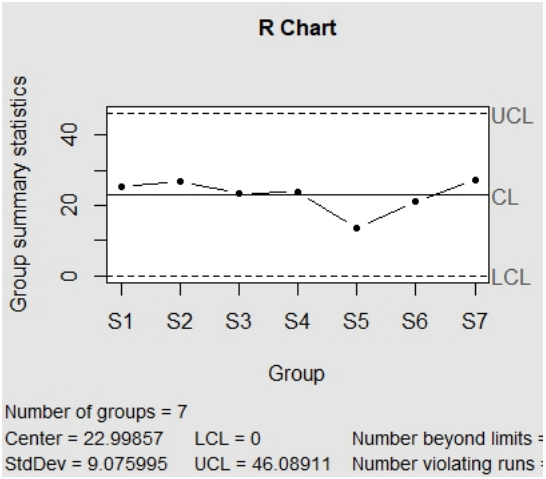
Sample Number	**1**	**2**	**3**	**4**	**5**	**6**
1	**469.92**	**468.67**	**479.76**	**454.38**	**469.58**	**454.46**
2	**457.34**	**454.37**	**475.28**	**453.46**	**480.03**	**480.40**
3	**473.96**	**459.26**	**460.42**	**462.04**	**450.60**	**451.52**
4	**480.06**	**469.86**	**456.42**	**460.63**	**465.66**	**466.99**
5	**467.46**	**476.56**	**474.01**	**465.34**	**475.27**	**462.97**
6	**473.06**	**475.86**	**472.97**	**454.93**	**470.73**	**466.24**
	456.27	**476.37**	**479.50**	**459.86**	**470.73**	**452.3**

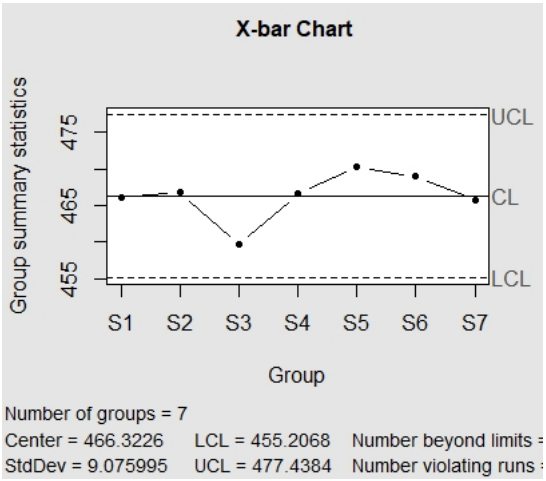
PROGRAM:

```
S1=c(469.92,468.67,479.76,454.38,469.58,454.46)

S2=c(457.34,454.37,475.28,453.46,480.03,480.40)

S3=c(473.96,459.26,460.42,462.04,450.60,451.52)

S4=c(480.06,469.86,456.42,460.63,465.66,466.99)

S5=c(467.46,476.56,474.01,465.34,475.27,462.97)

S6=c(473.06,475.86,472.97,454.93,470.73,466.24)

S7=c(456.27,476.37,479.50,459.86,470.73,452.35)

A= as.data.frame(rbind(S1,S2,S3,S4,S5,S6,S7))

A


Xbarchart= qcc(data = A,type = "xbar",sizes = 6,title = "X-bar Chart ",plot = TRUE)


rchart = qcc(data = A,type = "R",sizes = 6,title = "R Chart",plot = TRUE)
```

OUTPUT:

	V1	V2	V3	V4	V5	V6
S1	469.92	468.67	479.76	454.38	469.58	454.46
S2	457.34	454.37	475.28	453.46	480.03	480.40
S3	473.96	459.26	460.42	462.04	450.60	451.52
S4	480.06	469.86	456.42	460.63	465.66	466.99
S5	467.46	476.56	474.01	465.34	475.27	462.97
S6	473.06	475.86	472.97	454.93	470.73	466.24
S7	456.27	476.37	479.50	459.86	470.73	452.35





CONCLUSION:

In $\overline{X}$ chart, all points are within the control limits, so as far as sample mean is concerned, the system is under control.

In R chart, all points are within the control limits, so as far as variability is concerned, the system is under control. On the whole, the system is under control.

STEP 3: PRACTICE/TESTING

1.Define Statistical Quality Control.

Statistical quality control is defined as the technique of applying statistical methods based on sampling to establish quality standards and to maintain it in the most economical manner.

2.What are control charts? What are the types of control charts?

Control chart is a graphical device used in statistical quality control for the study and control of the manufacturing process.

There are two types of control charts:

1. Control charts of variables (Mean ( )and range (R)charts)
2. Control charts of attributes (p-chart, np-chart, c-chart)

3. Write the Lower control limit and Upper control limit for mean and range charts.

The Lower control limit and Upper control limit for mean and range charts

1.	$\overline{X}$ chart	LCL: $\overline{\overline{X}} - A_2\overline{R}$	UCL: $\overline{\overline{X}} + A_2\overline{R}$
2.	R-Chart	LCL: $D_3\overline{R}$	UCL: $D_4\overline{R}$