1) Aim: Write a python program to find the best fit straight line and draw the scatter plot.

Source Code:

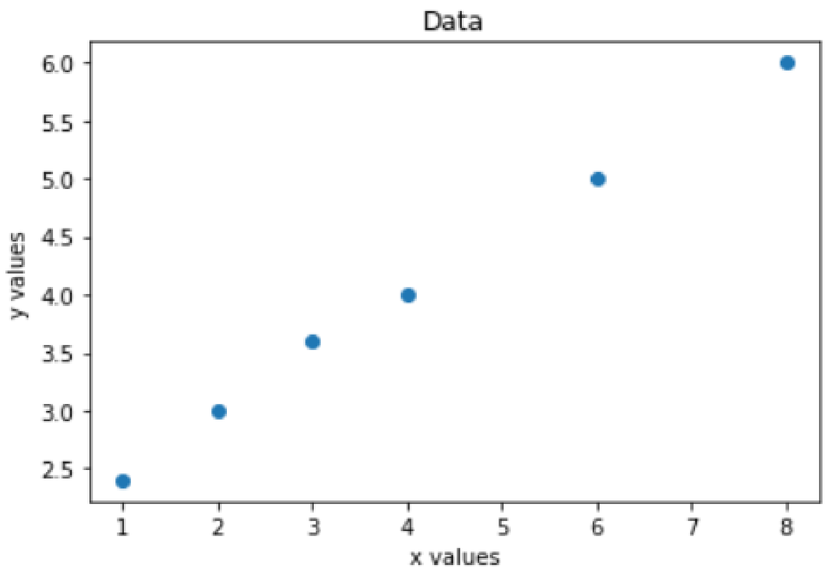
```
#Import libraries
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from statistics import mean

#Reading data
data=pd.read_csv('csdata.csv')

print(data)

x=data['x']
y=data['y']

def linear_regression(x,y):
  sumx=0
  for i in range(len(x)):
    sumx=sumx+x[i]
  sumy=0
  for i in range(len(y)):
    sumy=sumy+y[i]
  meanx=sumx/len(x)
  meany=sumy/len(y)
  print("mean of x :",meanx)
  print("mean of y :",meany)
  n=sum((x-meanx)*(y-meany))
  d=sum((x-meanx)**2)
  b1=n/d
  b0=meany-b1*meanx
  return b0,b1

b0,b1=linear_regression(x,y)
print("B0 :",round(b0,5),", B1 :",round(b1,5))

print("Equation :")
print("y =",round(b0,5),"+ x *",round(b1,5))

y_hat=b0+x*b1
print("y_hat\n",y_hat)

def plot1(x,y,y_hat):
```

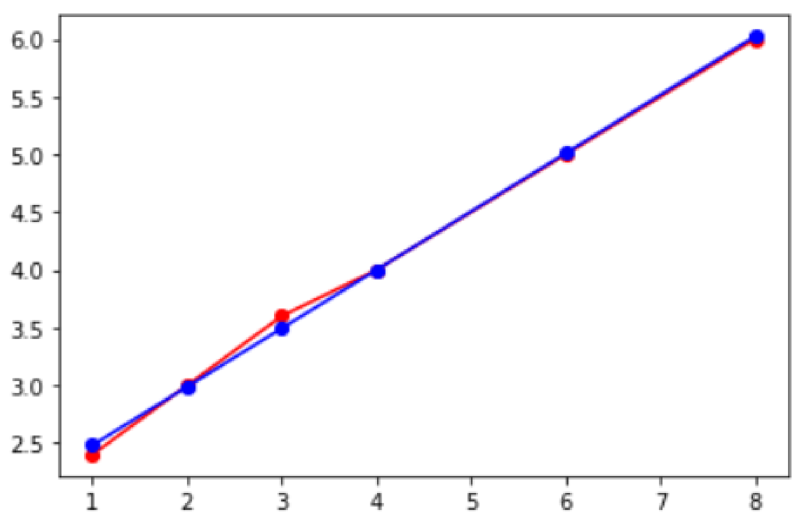
```
  plt.scatter(x,y)
  plt.xlabel("x values")
  plt.ylabel("y values")
  plt.title("Data")
  plt.show()
  plt.plot(x,y,'ro-')
  plt.plot(x,y_hat,'bo-')
  plt.show()

#plot the graph

plot1(x,y,y_hat)

def cost_function(y,y_hat):
  ybar=mean(y)
  sst=sum((y-ybar)**2)
  ssr=sum((y_hat-ybar)**2)
  r2=ssr/sst
  return r2

r2=cost_function(y,y_hat)
print("Cost function is",round(r2,5))
if r2<0.9:
  print("Not best fit")
else:
  print("Best fit")
```

Output 1

```
   x    y
0  1  2.4
1  2  3.0
2  3  3.6
3  4  4.0
4  6  5.0
5  8  6.0

mean of x : 4.0
mean of y : 4.0
B0 : 1.97647 , B1 : 0.50588

Equation :
y = 1.97647 + x * 0.50588
```

y_hat :
0   2.482353
1   2.988235
2   3.494118
3   4.000000
4   5.011765
5   6.023529
Name: x, dtype: float64





Cost function is 0.99784
Best fit

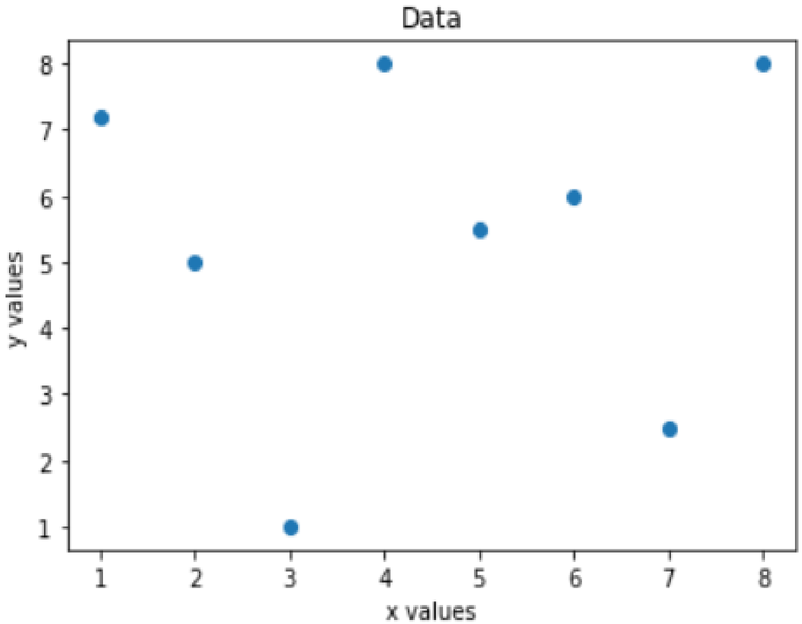
Output 2

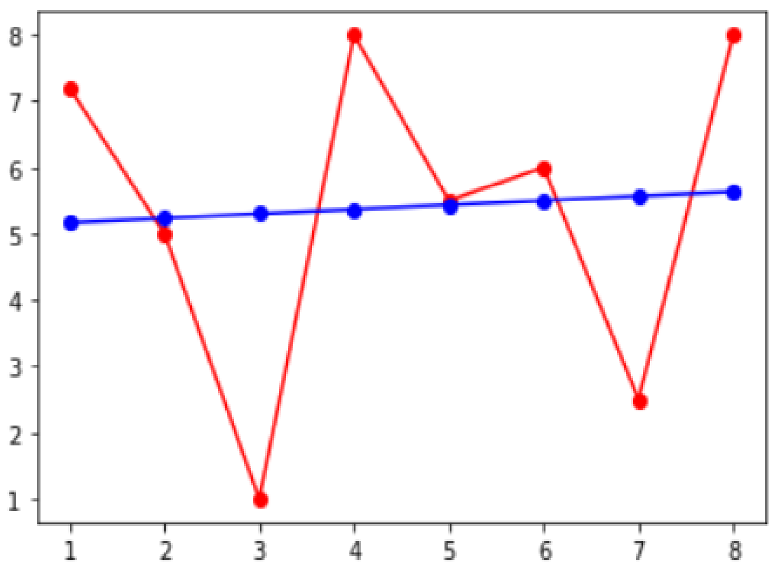
```
   x    y
0  1  7.2
1  2  5.0
2  3  1.0
3  4  8.0
4  5  5.5
5  6  6.0
6  7  2.5
7  8  8.0
```

mean of x : 4.5
mean of y : 5.4
B0 : 5.1 , B1 : 0.06667

Equation :
y = 5.1 + x * 0.06667

```
y_hat :
0    5.166667
1    5.233333
2    5.300000
3    5.366667
4    5.433333
5    5.500000
6    5.566667
7    5.633333
Name: x, dtype: float64
```





Cost function is 0.00414
Not best fit

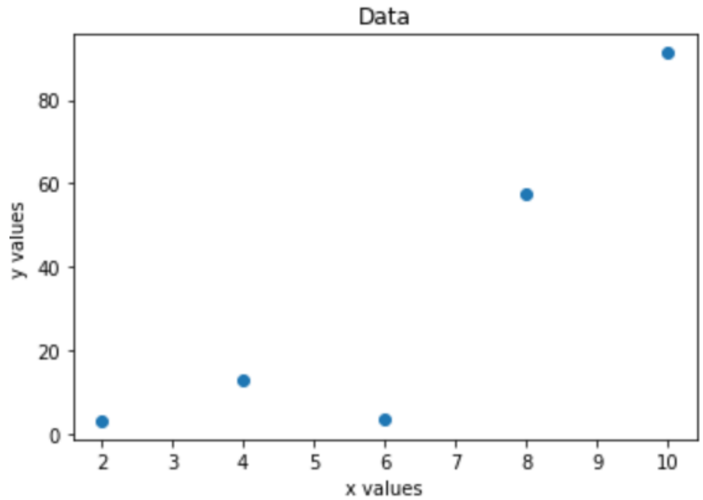
2) Aim: Write a python program to fit a second degree parabola of the form y=a+bx+cx^2 and draw the scatter plot.

Source Code:

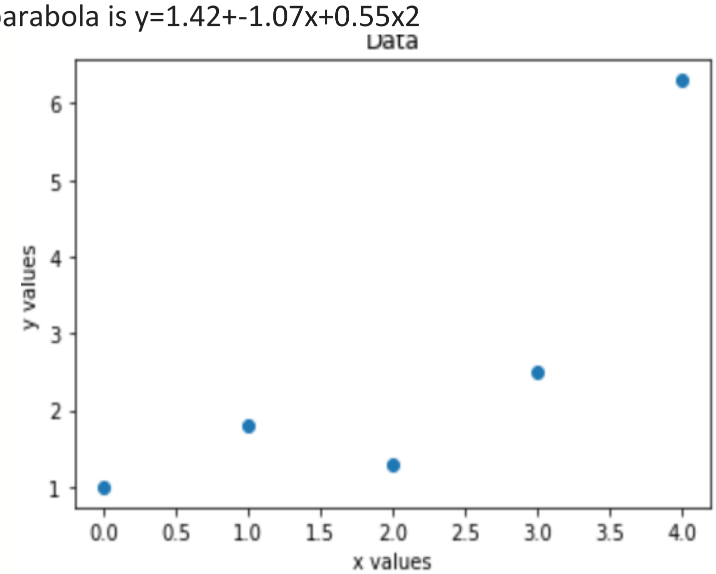
```
#importing libraries
import numpy as np
x=np.array([float(x) for x in input().split(" ")])
y=np.array([float(x) for x in input().split(" ")])
n=len(x)

sumx=np.sum(x)
sumy=np.sum(y)
sumxy=np.sum(x*y)
sumx2=np.sum(x*x)
sumx3=np.sum(x*x*x)
sumx4=np.sum(x*x*x*x)
sumx2y=np.sum(x*x*y)

#calculating determinant
def getMinor(m,i,j):
  return [row[:j] + row[j+1:] for row in (m[:i]+m[i+1:])]
def getDeternminant(m):
  if len(m) == 2:
    return m[0][0]*m[1][1]-m[0][1]*m[1][0]
  determinant = 0
  for c in range(len(m)):
    determinant += ((-1)**c)*m[0][c]*getDeternminant(getMinor(m,0,c))
  return determinant

#by using cramer's rule (without built-in)
p=getDeternminant([[n,sumx,sumx2],[sumx,sumx2,sumx3],[sumx2,sumx3,sumx4]])
q=getDeternminant([[sumy,sumxy,sumx2y],[sumx,sumx2,sumx3],[sumx2,sumx3,sumx4]])
r=getDeternminant([[n,sumx,sumx2],[sumy,sumxy,sumx2y],[sumx2,sumx3,sumx4]])
s=getDeternminant([[n,sumx,sumx2],[sumx,sumx2,sumx3],[sumy,sumxy,sumx2y]])
a=round(q/p,3)
b=round(r/p,3)
c=round(s/p,3)

print("The equation of parabola is y={}+{}x+{}x2".format(a,b,c))
import matplotlib.pyplot as plt
plt.scatter(x,y)
plt.xlabel("x values")
plt.ylabel("y values")
```

```
plt.title("Data")
plt.show()
```

Input 1:
2 4 6 8 10
3.07 12.85 3.47 57.38 91.29
Output 1:
The equation of parabola is y=23.096+-12.855x+1.992x2



Input 2:
0 1 2 3 4
1 1.8 1.3 2.5 6.3
Output 2:
The equation of parabola is y=1.42+-1.07x+0.55x2



3) Aim: Write a python program to find karl Pearson's correlation coefficient between x and y variables.

Source Code:

```
from math import sqrt
import numpy as np
print("Enter x :")
x=[int(x) for x in input().split()]
print("Enter y :")
y=[int(x) for x in input().split()]
x=np.array(x)
y=np.array(y)
xy=x*y
x2=x**2
y2=y**2
n=len(x)
num=n*sum(xy)-(sum(x)*sum(y))
den=sqrt((n*sum(x2)-sum(x)**2)*(n*sum(y2)-sum(y)**2))
r=num/den
print("Corelation coefficient is :",round(r,4))
```

Output 1

```
Enter x :
3 7 4 2 0 4 1 2
Enter y :
11 18 9 4 7 6 3 8

Corelation coefficient is : 0.7867
```

Output 2

```
Enter x :
65 66 67 67 68 69 70 72
Enter y :
67 68 65 68 72 72 69 71

Corelation coefficient is : 0.603
```

4) Aim: Write a python program to find the Spearman's correlation coefficient between x and y variables.

Source Code:

```
import pandas as pd
s=input()
a=[float(i) for i in s.split(" ")]
s1=input()
b=[float(i) for i in s1.split(" ")]
n=len(a)
data=pd.DataFrame({'A':a,'B':b})

def rank(a):
  s=sorted(a)
  n=len(a)
  s=s[::-1]
  i=0
  d=[]
  count=[]
  while i<n:
    k=s.count(s[i])
    if k==1:
      d.append(i+1)
      i=i+1
    else:
      m=0
      for j in range(i+1,i+k+1):
        m=m+j
      m=m/k
      for j in range(k):
        d.append(m)
      i=i+k
      count.append(k)
  r=[]
  for i in range(n):
    j=s.index(a[i])
    r.append(d[j])
  return r,count

r_x,c_x=rank(a)
r_y,c_y=rank(b)
data['Rank of x']=r_x
data['Rank of y']=r_y
```

```
di=[]
di2=[]
for i in range(len(a)):
  k=r_x[i]-r_y[i]
  di.append(k)
  di2.append(k**2)
data['di']=di
data['di2']=di2
print(data)

def correction_factor(c):
  if len(c)!=0:
    m=c[0]
    cf=(m*(m**2-1))/12
    return cf
  else:
    return 0
cf_x=correction_factor(c_x)
cf_y=correction_factor(c_y)
sum_di2=sum(di2)+cf_x+cf_y
print("Correction factor of a",cf_x)
print("Correction factor of b",cf_y)
print("di2 after correction factor is added",sum_di2)
r=1-((6*sum_di2)/(n*(n**2-1)))
print("Rank Corelation coefficint : ",round(r,4))
```

Input 1

```
68 64 75 50 64 80 75 40 55 64
62 58 68 45 81 60 68 48 50 70
```

Output 1:

```
      A     B  Rank of x  Rank of y   di   di2
0  68.0  62.0        4.0        5.0 -1.0   1.0
1  64.0  58.0        6.0        7.0 -1.0   1.0
2  75.0  68.0        2.5        3.5 -1.0   1.0
3  50.0  45.0        9.0       10.0 -1.0   1.0
4  64.0  81.0        6.0        1.0  5.0  25.0
5  80.0  60.0        1.0        6.0 -5.0  25.0
6  75.0  68.0        2.5        3.5 -1.0   1.0
7  40.0  48.0       10.0        9.0  1.0   1.0
8  55.0  50.0        8.0        8.0  0.0   0.0
9  64.0  70.0        6.0        2.0  4.0  16.0
```

Correction factor of a 0.5
Correction factor of b 0.5
di2 after correction factor is added 73.0

Rank Corelation coefficint : 0.5576

Input 2:

115 109 112 87 98 120 98 100 98 118
75 73 85 70 76 82 65 73 68 80

Output 2:

	A	B	Rank of x	Rank of y	di	di2
0	115.0	75.0	3.0	5.0	-2.0	4.00
1	109.0	73.0	5.0	6.5	-1.5	2.25
2	112.0	85.0	4.0	1.0	3.0	9.00
3	87.0	70.0	10.0	8.0	2.0	4.00
4	98.0	76.0	8.0	4.0	4.0	16.00
5	120.0	82.0	1.0	2.0	-1.0	1.00
6	98.0	65.0	8.0	10.0	-2.0	4.00
7	100.0	73.0	6.0	6.5	-0.5	0.25
8	98.0	68.0	8.0	9.0	-1.0	1.00
9	118.0	80.0	2.0	3.0	-1.0	1.00

Correction factor of a 2.0
Correction factor of b 0.5
di2 after correction factor is added 45.0

Rank Corelation coefficint : 0.7273

5) Aim: Write a python program to classify the data based on one way Anova.

Source Code:

```
import numpy as np
import scipy.stats as stats
print("Enter treatment 1:")
a=[int(x) for x in input().split()]
print("Enter treatment 2:")
b=[int(x) for x in input().split()]
print("Enter treatment 3:")
c=[int(x) for x in input().split()]

#read level of significance
print("Level of significance :")
alpha=float(input())

fa=np.array(a)
fb=np.array(b)
fc=np.array(c)

print("Treatment 1 :",fa)
print("Treatment 2 :",fb)
print("Treatment 3 :",fc)

#calculate rss,cf,sst,sstr,sse
N=np.size(fa)+np.size(fb)+np.size(fc)
rss=np.sum(fa**2)+np.sum(fb**2)+np.sum(fc**2)
cf=(np.sum(fa)+np.sum(fb)+np.sum(fc))**2/(N)
sst=rss-cf
sstr=(np.sum(fa)**2/np.size(fa)+np.sum(fb)**2/np.size(fb)+np.sum(fc)**2/np.size(fc))-cf
sse=sst-sstr
print("rss=",rss)
print("cf=",cf)
print("sst=",sst)
print("sstr=",sstr)
print("sse=",sse)

#degree of freedom
k=3
d1=k-1
d2=N-k
print("Degree of freedom of treatments =",d1)
print("Degree of freedom of error =",d2)
```

```
#calculate f
msstr=sstr/d1
msse=sse/d2
F=msstr/msse
if F<1:
  F=msse/msstr
print("Calculated value :",F)

#table value
tablevalue=stats.f.ppf(1-alpha,d1,d2)
print("Table value :",round(tablevalue,4))

 #testing
if tablevalue>F:
  print("H0 is accepted.")
else:
  print("H0 is rejected.")
```

Input 1:

```
Enter treatment 1:
13 10 8 11 8
Enter treatment 2:
13 11 14 14
Enter treatment 3:
4 1 3 4 2 4

Level of significance :
0.05
```

Output 1:

```
Treatment 1 : [13 10  8 11  8]
Treatment 2 : [13 11 14 14]
Treatment 3 : [4 1 3 4 2 4]

rss= 1262
cf= 960.0
sst= 302.0
sstr= 270.0
sse= 32.0

Degree of freedom of treatments = 2
Degree of freedom of error = 12

Calculated value : 50.625
```

Table value : 3.8853

H0 is rejected.

Input 2:

Enter treatment 1:
90 82 79 98 83 91
Enter treatment 2:
105 89 93 104 89 95 86
Enter treatment 3:
83 89 80 94

Level of significance :
0.05

Output 2:

Treatment 1 : [90 82 79 98 83 91]
Treatment 2 : [105 89 93 104 89 95 86]
Treatment 3 : [83 89 80 94]

rss= 138638
cf= 137700.0
sst= 938.0
sstr= 234.4523809523671
sse= 703.5476190476329

Degree of freedom of treatments = 2
Degree of freedom of error = 14

Calculated value : 2.3327016142676427

Table value : 3.7389

H0 is accepted.

6) Aim: Write a python program to classify the data based on two way Anova

Source Code:

```
import scipy.stats as stats
import pandas as pd

def input_data(k):

 l=[]

 for i in range(k):
   print("Enter treatment ",i+1)
   s=[int(x) for x in input().split()]
   l.append(s)
 return l
print("Enter number of treatments :")
k=int(input())
print("Enter number of blocks :")
h=int(input( ))
l=input_data(k)

def dataframe(l):
 df=pd.DataFrame(l)
 col=[]
 for i in range(h):
   col.append("B"+str(i+1))
 df.columns=col
 index=[]
 for i in range(k):
   index.append("T"+str(i+1))
 df.index=index
 print("Given data :")
 print(df)
dataframe(l)

def calculations(l):
 G=0
 flag_ftr=0
 flag_fb=0
 Ti2=0
 for i in range(k):
   G=G+sum(l[i])
   Ti2=Ti2+sum(l[i])**2
 bj2=0
```

```
  rss=0
  for j in range(h):
    bj=0
    for i in range(k):
      bj=bj+l[i][j]
      rss=rss+l[i][j]**2
    bj2=bj2+bj**2
  cf=(G**2)/(k*h)
  st2=rss-cf
  str2=Ti2*(1/h)-cf
  sb2=bj2*(1/k)-cf
  se2=st2-str2-sb2
  print("Row sum of squares =",rss)
  print("Correction factor =",cf)
  print("Sum of squares due to total =",st2)
  print("Sum of squares due to treatments =",str2)
  print("Sum of squares due to blocks =",sb2)
  print("Sum of squares due to error =",se2)
  mstr=str2/(k-1)
  msb=sb2/(h-1)
  mse=se2/((k-1)*(h-1))
  ftr=mstr/mse
  fb=msb/mse
  if ftr<1:
    ftr=mse/mstr
    flag_ftr=1
  if fb<1:
    fb=mse/msb
    flag_fb=1
  return ftr,fb,flag_ftr,flag_fb
ftr,fb,flag_ftr,flag_fb=calculations(l)
print("Caluclated values")
print("Treatments :",round(ftr,4))
print("Blocks :",round(fb,4))
if flag_ftr==1:
  ft_tr=stats.f.ppf(0.95,(k-1)*(h-1),(k-1))
else:
  ft_tr=stats.f.ppf(0.95,(k-1),(k-1)*(h-1))
if flag_fb==1:
  ft_b=stats.f.ppf(0.95,(k-1)*(h-1),(h-1))
else:
  ft_b=stats.f.ppf(0.95,(h-1),(k-1)*(h-1))
print("Table values")
```

```
print("Treatments :",round(ft_tr,4))
print("Blocks :",round(ft_b,4))

if ftr>ft_tr:
  print("H0(tr) is rejected.")
else:
  print("H0(tr) is accepeted.")
if fb>ft_b:
  print("H0(b) is rejected.")
else:
  print("H0(b) is accepeted.")
```

Input 1:

```
Enter number of treatments :
3
Enter number of blocks :
4
13 7 9 3
6 6 3 1
11 5 15 5
```

Output 1:

```
Given data :
   B1  B2  B3  B4
T1  13   7   9   3
T2   6   6   3   1
T3  11   5  15   5

Row sum of squares = 786
Correction factor = 588.0
Sum of squares due to total = 198.0
Sum of squares due to treatments = 56.0
Sum of squares due to blocks = 90.0
Sum of squares due to error = 52.0

Caluclated values

Treatments : 3.2308

Blocks : 3.4615

Table values

Treatments : 5.1433
```

Blocks : 4.7571

H0(tr) is accepeted.
H0(b) is accepeted.

Input 2:

Enter number of treatments :
4
Enter number of blocks :
5
Enter treatment 1
75 73 59 69 84
Enter treatment 2
83 72 56 70 92
Enter treatment 3
86 61 53 72 88
Enter treatment 4
73 67 62 79 95

Output 2:

Given data :

	B1	B2	B3	B4	B5
T1	75	73	59	69	84
T2	83	72	56	70	92
T3	86	61	53	72	88
T4	73	67	62	79	95

Row sum of squares = 110607
Correction factor = 107898.05
Sum of squares due to total = 2708.949999999997
Sum of squares due to treatments = 42.94999999999709
Sum of squares due to blocks = 2326.699999999997
Sum of squares due to error = 339.3000000000029

Caluclated values
Treatments : 1.975
Blocks : 20.5721

Table values
Treatments : 8.7446
Blocks : 3.2592

H0(tr) is accepeted.
H0(b) is rejected.

7. Aim: Write a python program to fit a multiple regression model for any given data.

Source Code:

```
#transpose
def transpose(arr):
  t=[]
  for i in range(len(arr[0])):
    T=[]
    for j in range(len(arr)):
      T.append(arr[j][i])
    t.append(T)
  return t
#multipliction
def mul(a,b):
  c=[]
  n=len(a)
  m=len(a[0])
  q=len(b[0])
  for i in range(n):
    C=[]
    for j in range(q):
      multi=0
      for k in range(m):
        multi=multi+a[i][k]*b[k][j]
      C.append(round(multi,4))
    c.append(C)
  return c
```

```
#inverse
def inverse(a):
    n=len(a)
    m=len(a[0])
    cofactor=[]
    det=0
    if n==2 and m==2:
        cofactor.append([a[1][1],-1*a[0][1]])
        cofactor.append(-1*[a[1][0],a[0][0]])
        det=cofactor[0][0]*cofactor[1][1]-cofactor[0][1]*cofactor[1][0]
    else:
        for i in range(n):
            co=[]
            for j in range(m):
                c=[]
                for k in range(n):
                    for o in range(m):
                        if i!=k and j!=o:
                            c.append(a[k][o])
                if (i+j)%2!=0:
                    q=-1*(c[0]*c[3]-c[1]*c[2])
                else:
                    q=(c[0]*c[3]-c[1]*c[2])
                co.append(q)
                if i==0:
```

```
            det=det+a[i][j]*q
        cofactor.append(co)
      inv=transpose(cofactor)
    ine=inv/det
    return ine
import numpy as np
import pandas as pd
import scipy.stats as s
df=pd.read_csv('mutliple.csv')
print(df)
#beta_hat=(x'x)-1(x'y)
df['x0']=[1]*len(df)
x=df[['x0','x1','x2']].to_numpy()
y=df[['y']].to_numpy()
#calculate x'x and x'y and (x'x)(x'y)
x1=transpose(x)
x1x=mul(x1,x)
inv=inverse(x1x)
x1y=mul(x1,y)
beta_hat=mul(inv,x1y)
print("y =",beta_hat[0][0],"+ x1",beta_hat[1][0],"+ x2",beta_hat[2][0])
#test of goodness of fit using coefficient of determination
y_hat=[]
error=[]
for i in range(len(x)):
    s=beta_hat[0][0]+x[i][1]*beta_hat[1][0]+x[i][2]*beta_hat[2][0]
```

```
    y_hat.append(round(s,4))
    error.append(round(y[i][0]-s,4))
d=pd.DataFrame({'y_hat':y_hat,'error':error})
print(d)
#calculations
sse=sum(np.array(error)**2)
y_bar=sum(y)/len(y)
sst=sum((y-y_bar)**2)
ssr=sst-sse
R2=ssr/sst
print(R2)
if R2<0.9:
    print("The Regression model is not good fit")
else:
    print("The Regression model is good fit")
#degree of freedom
n1=len(x[0])-1
n2=len(x)-len(x[0])
#to test goodness of fit using anova
msr=ssr/n1
mse=sse/n2
f=msr/mse
f=f[0]
if f<1:
    f=mse/msr
print("Calculated value",round(f,4))
```

```
#table value
f_tab=s.f.ppf(0.95,n1,n2)
print("Table value",round(f_tab,4))
if f<f_tab:
   print("H0 is Accepted")
   print("Hence we conclude that there is no regression parameter that influence in the model.")
else:
   print("H0 is Rejected")
   print("Hence we conclude that there is atleast one regression parameter that influence in the model.")
#test of individual variables
cij=[inv[0][0],inv[1][1],inv[2][2]]
t_cal=[]
print("Calculated value :")
for i in range(len(cij)):
   se=sqrt(mse*cij[i])
   t=beta_hat[i][0]
   t_cal.append(round(t/se,4))
   print("beta",i,"=",t_cal[i])
#table value
t_tab=stats.t.ppf(1-0.05/2,n2)
print("Table value",round(t_tab,4))
weak_variable=-1
for i in range(len(t_cal)):
   if t_tab>t_cal[i]:
      print("H0 is accepted.\nHence the parameter beta",i,"is not influencing the model")
```

```
        weak_variable=i
    else:
        print("H0 is rejected.\nHence the parameter beta",i,"is influencing the model")
print("Therefore,The weak variable is beta",weak_variable)
```

Output 1:

```
   x1  x2   y
0  -5   5  11
1  -4   4  11
2  -1   1   8
3   2  -3   2
4   2  -2   5
5   3  -2   5
6   3  -3   4
```

y = 6.5714 + 1.0 x1 + 2.0 x2

```
     y_hat   error
0  11.5714 -0.5714
1  10.5714  0.4286
2   7.5714  0.4286
3   2.5714 -0.5714
4   4.5714  0.4286
5   5.5714 -0.5714
6   3.5714  0.4286
```

#R2

R2= 0.97674419
The Regression model is good fit
#anova
Calculated value 84.0
Table value 6.9443
H0 is Rejected
Hence we conclude that there is atleast one regression parameter that influence in the model.
#testing weak variables
Calculated value :
beta 0 = 26.558

beta 1 = 2.1523
beta 2 = 4.3046

Table value 2.7764

H0 is rejected.
Hence the parameter beta 0 is influencing the model
H0 is accepted.
Hence the parameter beta 1 is not influencing the model
H0 is rejected.
Hence the parameter beta 2 is influencing the model

Therefore, The weak variable is beta 1

Output 2:

	month	y	x1	x2
0	1	100	9	62
1	2	110	8	58
2	3	105	7	64
3	4	94	14	60
4	5	95	12	63
5	6	99	10	57
6	7	104	7	55
7	8	108	4	56
8	9	105	6	59
9	10	98	5	61
10	11	105	7	57
11	12	110	6	60

y = 133.4605 + -1.2485 x1 + -0.351 x2

	y_hat	error
0	100.4620	-0.4620
1	103.1145	6.8855
2	102.2570	2.7430
3	94.9215	-0.9215
4	96.3655	-1.3655
5	100.9685	-1.9685
6	105.4160	-1.4160
7	108.8105	-0.8105
8	105.2605	-0.2605
9	105.8070	-7.8070

10 104.7140 0.2860
11 104.9095 5.0905

[0.5415279]
The Regression model is not good fit
Calculated value 5.3152
Table value 4.2565
H0 is Rejected
Hence we conclude that there is atleast one regression parameter that influence in the model.

Calculated value :
beta 0 = 5.0882
beta 1 = -2.8079
beta 2 = -0.7711
Table value 2.2622

H0 is rejected.
Hence the parameter beta 0 is influencing the model
H0 is accepted.
Hence the parameter beta 1 is not influencing the model
H0 is accepted.
Hence the parameter beta 2 is not influencing the model
Therefore,The weak variable is beta 2

8) Aim: Write a python program to fit a multivariate regression model for the given data.

Source Code:

```
import numpy as np

import pandas as pd

import scipy.stats as stats

df=pd.read_csv('multivariate.csv')

print(df)

#beta ground=(x'x)-1*(x'y)

df['x0']=[1]*len(df)

x=df[['x0','x1','x2','x3']].to_numpy()

y=df[['y1','y2']].to_numpy()

x1x=mul(transpose(x),x)

x1y=mul(transpose(x),y)

inv=np.linalg.inv(x1x)

beta=np.array(mul(inv,x1y))

print("y1 =",beta[0][0],"+",beta[1][0],"x1 +",beta[2][0],"x2 +",beta[3][0],"x3")

print("y2 =",beta[0][1],"+",beta[1][1],"x1 +",beta[2][1],"x2 +",beta[3][1],"x3")

#test of goodness of fit using coefficient of determination

y_hat=x@beta

error=y-y_hat

sse=np.sum(error**2,axis=0)

mean=np.sum(y,axis=0)/len(y)

sst=np.sum((y-mean)**2,axis=0)

ssr=sst-sse

R2=ssr/sst

def test(r2):
```

```
    if r2<0.9:
        print("The Regression model is not good fit")
    else:
        print("The Regression model is good fit")
print("For y1 R2 is:",round(R2[0],4))
test(R2[0])
print("For y2 R2 is:",round(R2[1],4))
test(R2[1])
#to test goodness of fit using anova
def cal_value(f_cal):
    if f_cal<1:
        f_cal=mse/msr
    print("Calculated value",round(f_cal,4))
#degree of freedom
n1=len(x[0])-1
n2=len(x)-len(x[0])
msr=ssr/n1
mse=sse/n2
f=msr/mse
cal_value(f[0])
cal_value(f[1])
#table value
f_tab=stats.f.ppf(0.95,n1,n2)
print("Table value",round(f_tab,4))
def test(f_cal):
    if f_cal<f_tab:
```

```
        print("H0 is Accepted")
        print("Hence we conclude that there is no regression parameter that influence in the model.")
    else:
        print("H0 is Rejected")
        print("Hence we conclude that there is atleast one regression parameter that influence in the model.")
print("For y1 :")
test(f[0])
print("For y2 :")
test(f[1])
#testing individual parameters
t=[]
for i in range(len(inv)):
    se1=sqrt(mse[0]*inv[i][i])
    se2=sqrt(mse[1]*inv[i][i])
    t1=round(beta[i][0]/se1,4)
    t2=round(beta[i][1]/se2,4)
    t.append([t1,t2])
for i in range(len(t[0])):
    print("t calculated value for y"+str(i+1))
    for j in range(len(t)):
        print("beta"+str(j)+":",t[j][i])
t_tab=round(stats.t.ppf(1-0.05/2,n2),4)
print("Table Value :",t_tab)
#testing the weak parameters
for i in range(len(t[0])):
```

```
    print("For y"+str(i+1)+" :")
    weak_variable=[]
    for j in range(len(t)):
        if t_tab>t[j][i]:
            print("H0 is accepted.\nHence the parameter beta",i,"is not influencing the model")
            weak_variable.append(j)
        else:
            print("H0 is rejected.\nHence the parameter beta",i,"is influencing the model")
    print("\nTherefore,The weak variable is beta",weak_variable)
```

Output 1:

```
#output
   month  y1   y2  x1  x2   x3
0      1  10  100   9  62  1.0
1      2  12  110   8  58  1.3
2      3  11  105   7  64  1.2
3      4   9   94  14  60  0.8
4      5   9   95  12  63  0.8
5      6  10   99  10  57  0.9
6      7  11  104   7  55  1.0
7      8  12  108   4  56  1.2
8      9  11  105   6  59  1.1
9     10  10   98   5  61  1.0
10    11  11  103   7  57  1.2
11    12  12  110   6  60  1.2
```

y1 = 10.897 + -0.0449 x1 + -0.0877 x2 + 5.0355 x3

y2 = 91.0972 + -0.064 x1 + -0.2944 x2 + 27.8353 x3

For y1 R2 is: 0.9238

The Regression model is good fit

For y2 R2 is: 0.8655

The Regression model is not good fit

Calculated value 32.3272

Calculated value 17.1613

Table value 4.0662

For y1 :

H0 is Rejected

Hence we conclude that there is atleast one regression parameter that influence in the model.

For y2 :

H0 is Rejected

Hence we conclude that there is atleast one regression parameter that influence in the model.

t calculated value for y1

beta0: 4.2373

beta1: -0.8276

beta2: -2.2751

beta3: 5.4618

t calculated value for y2

beta0: 5.2648

beta1: -0.1753

beta2: -1.1351

beta3: 4.4872

Table Value : 2.306

For y1 :

H0 is rejected.

Hence the parameter beta 0 is influencing the model

H0 is accepted.

Hence the parameter beta 0 is not influencing the model

H0 is accepted.

Hence the parameter beta 0 is not influencing the model

H0 is rejected.

Hence the parameter beta 0 is influencing the model

Therefore,The weak variable is beta [1, 2]

For y2 :

H0 is rejected.

Hence the parameter beta 1 is influencing the model

H0 is accepted.

Hence the parameter beta 1 is not influencing the model

H0 is accepted.

Hence the parameter beta 1 is not influencing the model

H0 is rejected.

Hence the parameter beta 1 is influencing the model

Therefore, The weak variable is beta [1, 2]

Output 2:

```
    y1   y2  x1  x2   x3
0    9  150   3  62  1.5
1    2   98   8  58  0.7
2    5   75   3  64  3.6
3    2   24  14  60  1.8
4    4   95  15  63  1.8
5   13   39  18  57  6.9
6   10   14  23  55  1.1
7   16   88   4  56  1.0
8    6   15   6  59  1.0
9    2   48  12  61  1.6
10   1   73   9  57  1.3
11  12   91  10  60  1.2
```

y1 = 59.8734 + -0.2111 x1 + -0.8916 x2 + 1.0523 x3
y2 = -84.0353 + -3.0545 x1 + 3.1483 x2 + -1.7594 x3

For y1 R2 is: 0.2755
The Regression model is not good fit
For y2 R2 is: 0.3696
The Regression model is not good fit

Calculated value 1.014
Calculated value 1.5632

Table value 4.0662

For y1 :
H0 is Accepted
Hence we conclude that there is no regression parameter that influence in the model.
For y2 :
H0 is Accepted
Hence we conclude that there is no regression parameter that influence in the model.

t calculated value for y1
beta0: 1.6625
beta1: -0.7635
beta2: -1.5111
beta3: 1.1341

t calculated value for y2
beta0: -0.3096
beta1: -1.4659
beta2: 0.708
beta3: -0.2516

Table Value : 2.306
For y1 :
H0 is accepted.
Hence the parameter beta 0 is not influencing the model
H0 is accepted.
Hence the parameter beta 0 is not influencing the model
H0 is accepted.
Hence the parameter beta 0 is not influencing the model
H0 is accepted.
Hence the parameter beta 0 is not influencing the model

Therefore,The weak variable is beta [0, 1, 2, 3]
For y2 :
H0 is accepted.
Hence the parameter beta 1 is not influencing the model
H0 is accepted.
Hence the parameter beta 1 is not influencing the model
H0 is accepted.
Hence the parameter beta 1 is not influencing the model
H0 is accepted.
Hence the parameter beta 1 is not influencing the model

Therefore, The weak variable is beta [0, 1, 2, 3]

9) Aim: Write a python program to classify the treatments based on MANOVA Test.

Source Code:

```
import numpy as np
import scipy.stats as stats
from math import sqrt
m=int(input('Enter number of treatments : '))
t=[]
for i in range(m):
  print("Enter Treatment",(i+1))
  y1=[int(x) for x in input().split()]
  y2=[int(x) for x in input().split()]
  t.append([y1,y2])
for i in range(m):
  print("Treatment",i+1)
  print(t[i][0])
  print(t[i][1])
t_mean=[]
total=[0,0]
t_size=0
for i in range(m):
  y1=np.array(t[i][0])
  y2=np.array(t[i][1])
  t_mean.append([sum(y1)/len(y1),sum(y2)/len(y2)])
  total[0]+=sum(y1)
  total[1]+=sum(y2)
  t_size+=len(y1)
```

```
total[0]=total[0]/t_size
total[1]=total[1]/t_size
print("Yi mean")
for i in range(m):
 print(t_mean[i])
print("Y mean")
print(total)
def calculations(t,t_mean,total,y):
 sse=0
 sst=0
 for i in range(m):
  for j in range(len(t[i][0])):
   if y==-1:
    sse+=t[i][0][j]*t[i][1][j]-t_mean[i][0]*t_mean[i][1]
    sst+=t[i][0][j]*t[i][1][j]-total[0]*total[1]
   else:
    sse+=(t[i][y][j]-t_mean[i][y])**2
    sst+=(t[i][y][j]-total[y])**2
 return sse,sst
sse_y1,sst_y1=calculations(t,t_mean,total,0)
ssr_y1=sst_y1-sse_y1
sse_y2,sst_y2=calculations(t,t_mean,total,1)
ssr_y2=sst_y2-sse_y2
sse_y,sst_y=calculations(t,t_mean,total,-1)
ssr_y=sst_y-sse_y
print("For y1 :")
```

```
print("sse =",sse_y1,end=" , ")
print("sst =",sst_y1,end=" , ")
print("ssr =",ssr_y1)
print("For y2 :")
print("sse =",sse_y2,end=" , ")
print("sst =",sst_y2,end=" , ")
print("ssr =",ssr_y2)
print("Cross product values of y1 and y2 :")
print("sse =",sse_y,end=" , ")
print("sst =",sst_y,end=" , ")
print("ssr =",ssr_y)
#sum of squares
B=np.array([ssr_y1,ssr_y,ssr_y,ssr_y2]).reshape(2,2)
W=np.array([sse_y1,sse_y,sse_y,sse_y2]).reshape(2,2)
T=np.array([sst_y1,sst_y,sst_y,sst_y2]).reshape(2,2)
print("Regression :\n",B)
print("Error :\n",W)
print("Total :\n",T)
#Degree of Freedom
d1=m-1
n=0
for i in range(m):
  n=n+len(t[i][0])
d2=n-m
print("Degree of Freedom :",d1,",",d2)
def det(A):
```

```
  return A[0][0]*A[1][1]-A[0][1]*A[1][0]
wilks=det(W)/det(T)
print("Wilk's Value :",round(wilks,4))
f=((n-m-1)/(m-1))*(1-sqrt(wilks))/sqrt(wilks)
print("Calculate value :",round(f,4))
tab=stats.f.ppf(0.95,2*(m-1),2*(n-m-1))
print("Table Value :",round(tab,4))
if f>tab:
  print("H0 is Rejected.Hence we conclude that there is no homogenity among regression model")
else:
  print("H0 is Accepted.Hence we conclude that there is homogenity among regression model")
```

Input 1:

Enter number of treatments : 3

Enter Treatment 1

2 3 5 2

3 4 4 5

Enter Treatment 2

4 5 6

8 6 7

Enter Treatment 3

7 8 10 9 7

6 7 8 5 6

Output 1:

Treatment 1

[2, 3, 5, 2]

[3, 4, 4, 5]

Treatment 2

[4, 5, 6]

[8, 6, 7]

Treatment 3

[7, 8, 10, 9, 7]

[6, 7, 8, 5, 6]

Yi mean

[3.0, 4.0]

[5.0, 7.0]

[8.2, 6.4]

Y mean

[5.666666666666667, 5.75]

For y1 :

sse = 14.799999999999997 , sst = 76.66666666666667 , ssr = 61.866666666666674

For y2 :

sse = 9.2 , sst = 28.25 , ssr = 19.05

Cross product values of y1 and y2 :

sse = 1.6000000000000156 , sst = 25.999999999999943 , ssr = 24.399999999999928

Regression :

```
 [[61.86666667 24.4       ]
 [24.4       19.05      ]]
```

Error :

```
 [[14.8  1.6]
 [ 1.6  9.2]]
```

Total :

[[76.66666667 26.   ]
 [26.   28.25   ]]

Degree of Freedom : 2 , 9

Wilk's Value : 0.0897

Calculate value : 9.3575

Table Value : 3.0069

H0 is Rejected.Hence we conclude that there is no homogenity among regression model

Input 2:

Enter number of treatments : 3

Enter Treatment 1

9 6 9

3 2 7

Enter Treatment 2

0 2

4 0

Enter Treatment 3

3 1 2

8 9 7

Output 2:

Treatment 1

[9, 6, 9]

[3, 2, 7]

Treatment 2

[0, 2]

[4, 0]

Treatment 3

[3, 1, 2]

[8, 9, 7]

Yi mean

[8.0, 4.0]

[1.0, 2.0]

[2.0, 8.0]

Y mean

[4.0, 5.0]

For y1 :

sse = 10.0 , sst = 88.0 , ssr = 78.0

For y2 :

sse = 24.0 , sst = 72.0 , ssr = 48.0

Cross product values of y1 and y2 :

sse = 1.0 , sst = -11.0 , ssr = -12.0

```
Regression :
 [[ 78. -12.]
 [-12.  48.]]
Error :
 [[10.  1.]
 [ 1. 24.]]
Total :
 [[ 88. -11.]
 [-11.  72.]]
Degree of Freedom : 2 , 5
Wilk's Value : 0.0385
Calculate value : 8.1989
Table Value : 3.8379
H0 is Rejected.Hence we conclude that there is no homogenity among regression model
```

10) Aim: Write a python program to classify the given observation using Linear Discriminant Analysis.

Source Code:

```
import pandas as pd

import numpy as np

sat=int(input('Enter incoming student SAT : '))

gpa=float(input('Enter incoming student GPA : '))

df=pd.read_csv('discriminant.csv')

print(df)

df['x0']=[1]*len(df)

x=df[['x0','x1','x2']]

x=np.array(x,dtype=float)

y=df[['y']].replace('yes',1)

y=df[['y']].replace('no',0)

y=np.array(y)

#beta hat

x1x=mul(transpose(x),x)

inv=np.linalg.inv(x1x)

x1y=mul(transpose(x),y)

beta_hat=mul(inv,x1y)

print("y = ",beta_hat[0][0],"+",beta_hat[1][0],"x1 +",beta_hat[2][0],"x2")

new_y=beta_hat[0][0]+beta_hat[1][0]*sat+beta_hat[2][0]*gpa

print("new_y =",new_y)

if round(new_y)==0:

   print("The value is nearer to zero.Therefore, the candidate will not graduated.")

else:
```

```
    print("The value is nearer to one.Therefore, the candidate will graduated.")
```

Input 1:

Enter incoming student SAT : 1000

Enter incoming student GPA : 2.9

Output 1:

```
     x1   x2   y
0  1300  2.7  yes
1  1260  3.7  yes
2  1220  2.9  yes
3  1180  2.5  yes
4  1060  3.9  yes
5  1140  2.1   no
6  1100  3.5   no
7  1020  3.3   no
8   980  2.3   no
9   940  3.1   no
y =  -3.8392 + 0.0032 x1 + 0.2395 x2
new_y = 0.05535000000000023
The value is nearer to zero.Therefore, the candidate will not graduated.
```

Output 2:

Enter incoming student SAT : 1500

Enter incoming student GPA : 1.3

```
     x1   x2   y
0  1150  2.7  yes
1  1060  3.7  yes
2  1220  2.9  yes
```

3 1980 2.5 yes

4 1980 3.9   no

5 1840 2.1   no

y = 2.264495 + -0.00080765 x1 + -0.11979125 x2
new_y = 0.89727898

The value is nearer to one.Therefore, the candidate will graduated.

#Fishers' Linear Discrminant

```
import pandas as pd

import numpy as np

from math import log

print("Enter new matrix")

l=[float(x) for x in input().split()]

df=pd.read_csv('fishers.csv')

print(df)

x_1=[]

x_2=[]

for i in range(len(df)):

   if df['y'][i]==1:

      x_1.extend([df['x1'][i],df['x2'][i]])

   else:

      x_2.extend([df['x1'][i],df['x2'][i]])

x=df[['x1','x2']].to_numpy()

x_1=np.array(x_1).reshape(len(x_1)//2,2)

x_2=np.array(x_2).reshape(len(x_2)//2,2)

print("x :\n",x)
```

```
print("\nx1 :\n",x_1)
print("\nx2 :\n",x_2)
mean=np.mean(x,axis=0)
mean_1=np.mean(x_1,axis=0)
mean_2=np.mean(x_2,axis=0)
print("mean for x :",mean)
print("mean for x_1 :",mean_1)
print("mean for x_2 :",mean_2)
xm=x-mean
c=mul(transpose(xm),xm)
c=np.array(c)/len(x)
c_inv=np.linalg.inv(c)
print("Pooled covariance matrix :\n",c)
def fisherEquation(mean,c_inv,x,p):
    m_c=mul([mean],c_inv)
    f=mul(m_c,x)[0][0]-0.5*mul(m_c,transpose([mean]))[0][0]+log(p)
    return f
f1=fisherEquation(mean_1,c_inv,transpose([l]),len(x_1)/len(x))
f2=fisherEquation(mean_2,c_inv,transpose([l]),len(x_2)/len(x))
print("f1 =",f1)
print("f2 =",f2)
if f1>f2:
    print("The new observation",l,"is classified into group 1")
else:
    print("The new observation",l,"is classified into group 2")
```

Input 1:

Enter new matrix

5.1 3.2

Output 1:

```
   x1  x2  y
0   1   2  1
1   2   3  1
2   3   3  1
3   4   5  1
4   5   5  1
5   4   2  0
6   5   0  0
7   5   2  0
8   3   2  0
9   5   3  0
10   6   3  0
```

x :

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

```
 [3 2]
 [5 3]
 [6 3]]
x1 :
 [[1 2]
 [2 3]
 [3 3]
 [4 5]
 [5 5]]
x2 :
 [[4 2]
 [5 0]
 [5 2]
 [3 2]
 [5 3]
 [6 3]]
mean for x : [3.90909091  2.72727273]
mean for x_1 : [3.  3.6]
mean for x_2 : [4.66666667  2. ]
Pooled covariance matrix :
 [[2.08264545 0.15702727]
 [0.15702727 1.83470909]]
f1 = 6.48594263963573
f2 = 7.393764196429685
The new observation [5.1, 3.2] is classified into group 2
```

Input 2:

Enter new matrix

5 6

Output 2:

```
    x1  x2  y
0   4   2  1
1   2   4  1
2   2   3  1
3   3   6  1
4   4   4  1
5   9   10  0
6   6   8  0
7   9   5  0
8   8   7  0
9   10   8  0
x :
 [[4 2]
 [2 4]
 [2 3]
 [3 6]
 [4 4]
 [9 10]
 [6 8]
 [9 5]
 [8 7]
 [10 8]]
```

```
x1 :
[[4 2]
 [2 4]
 [2 3]
 [3 6]
 [4 4]]
x2 :
[[9 10]
 [6 8]
 [9 5]
 [8 7]
 [10 8]]
mean for x : [5.7  5.7]
mean for x_1 : [3.  3.8]
mean for x_2 : [8.4  7.6 ]
Pooled covariance matrix :
 [[86.1  50.1]
 [50.1 58.1]]
f1 = 1.9839
f2 = 1.7051
The new observation [5, 6] is classified into group 1
```

11) Aim: Write a python program to find Principal Components for the given variables.

Source Code:

```
import numpy as np
import pandas as pd
n=int(input('Enter number of components :'))
l=[]
for i in range(n):
  k=[float(x) for x in input().split()]
  l.extend(k)
  m=len(k)
x=np.array(l).reshape(n,m)
x=transpose(x)
print("x\n",x)
mean=np.sum(x,axis=0)/m
print("Mean\n",mean)
x_mean=x-mean
c=mul(transpose(x_mean),x_mean)/m
print("c\n",c)
e_values,e_vectors=np.linalg.eig(c)
e1=np.argsort(e_values)[::-1]
e_values=e_values[e1]
e_vectors=e_vectors[:,e1]
print('Eigen values:\n',e_values)
print('Eigen vectors:\n',e_vectors)
z=[]
z_name=[]
```

```
sum=0
t_sum=np.sum(e_values)
for i in range(len(e_values)):
  sum=sum+e_values[i]
  z_name.append('z'+str(i+1))
  z.append(round(sum*100/t_sum,2))
print("Principal Components :",z)
threshold=int(input('Enter Threshold value :'))
c=0
for x in z:
  if x<=threshold+2:
    c=c+1
d={'principle components':z_name,'variance explained':e_values,'cummulative proportion of total variance':z}
df=pd.DataFrame(d)
print(df)
print("Principal Components are:")
for i in range(c):
  print("z"+str(i+1)+" =",end='')
  for y in range(n):
    if y==n-1:
      print(round(e_vectors[y][i],4),"x"+str(y+1))
    else:
      print(round(e_vectors[y][i],4),"x"+str(y+1)+" + ",end='')
p=mul(x,transpose(e_vectors[:c]))
p=transpose(p)
d={}
```

```
for i in range(c):
d.update({'z'+str(i+1):p[i]})
df=pd.DataFrame(d)
df
```

Input 1:

Enter number of components :2

2 1 0 -1

4 3 1 0.5

Output 1:

```
x
 [[ 2.   4. ]
 [ 1.   3. ]
 [ 0.   1. ]
 [-1.   0.5]]
Mean
 [0.5   2.125]
c
 [[1.25     1.5625  ]
 [1.5625   2.046875]]
Eigen values:
 [3.26093826 0.03593674]
Eigen vectors:
 [[-0.6135581  -0.78964958]
 [-0.78964958  0.6135581 ]]
Principal Components : [98.91, 100.0]
Enter Threshold value :99
```

	principle components	variance explained	cummulative proportion of total variance
0	z1	3.260938	98.91
1	z2	0.035937	100.00

Principal Components are:

z1 =-0.6136 x1 + -0.7896 x2
z2 =-0.7896 x1 + 0.6136 x2

	z1	z2
0	-4.385715	0.874933
1	-2.982507	1.051025
2	-0.789650	0.613558
3	0.218733	1.096429

Input 2:

Enter number of components :3

7 4 6 8 8 7 5 9 7 8

4 1 3 6 5 2 3 5 4 2

3 8 5 1 7 9 3 8 5 2

Output 2:

x

[[7. 4. 3.]

[4. 1. 8.]

[6. 3. 5.]

[8. 6. 1.]

```
 [8. 5. 7.]
 [7. 2. 9.]
 [5. 3. 3.]
 [9. 5. 8.]
 [7. 4. 5.]
 [8. 2. 2.]]
Mean
 [6.9 3.5 5.1]
c
 [[ 2.09  1.45 -0.39]
 [ 1.45  2.25 -1.15]
 [-0.39 -1.15  7.09]]
Eigen values:
 [7.44654832 3.30851634 0.67493534]
Eigen vectors:
 [[-0.1375708   0.69903712 -0.70172743]
 [-0.25045969  0.66088917  0.70745703]
 [ 0.95830278  0.27307986  0.08416157]]
Principal Components : [65.15, 94.1, 100.0]
Enter Threshold value :93

 Principle components  variance explained  \
0                z1           7.446548
1                z2           3.308516
2                z3           0.674935

   cumulative proportion of total variance
0                               65.15
1                               94.10
2                              100.00
```

Principal Components are:

z1 =-0.1376 x1 + -0.2505 x2 + 0.9583 x3
z2 =0.699 x1 + 0.6609 x2 + 0.2731 x3

	z1	z2
0	-0.272029	3.012710
1	-5.465065	5.318707
2	-2.236951	4.017195
3	2.391929	2.669115
4	-2.517473	6.252968
5	-5.880468	5.935674
6	-0.695925	2.852740
7	-3.356771	6.709965
8	-1.675484	4.427624
9	-1.105947	0.733015

12) Aim: Write a python program to group the given variables using Factor Analysis.

Source Code:

```
import numpy as np
import pandas as pd
from math import floor
from math import sqrt
n=int(input('Enter number of components :'))
l=[]

for i in range(n):
  k=[float(x) for x in input().split()]
  l.extend(k)
  m=len(k)
x=np.array(l).reshape(n,m)
x=transpose(x)
print("x\n",x)
mean=np.sum(x,axis=0)/m
x_mean=x-mean
s_d=[]
s_d=np.sum((x_mean)**2,axis=0)/(m-1)
for i in range(n):
  s_d[i]=sqrt(s_d[i])
x=x_mean/s_d
c=mul(transpose(x),x)/m

e_values,e_vectors=np.linalg.eig(c)
e1=np.argsort(e_values)[::-1]
e_values=e_values[e1]
e_vectors=e_vectors[:,e1]
print('Eigen values:\n',e_values)
print('Eigen vectors:\n',e_vectors)

z=[]
z_name=[]
sum=0
t_sum=np.sum(e_values)
for i in range(len(e_values)):
```

```
  sum=sum+e_values[i]
  z_name.append('z'+str(i+1))
  z.append(round(sum*100/t_sum,2))

print("Principal Components :",z)
threshold=int(input('Enter Threshold value :'))
c=0
for x in z:
  if floor(x)<=threshold+2:
    c=c+1
print("Principal Components are:")
for i in range(c):
  print("z"+str(i+1)+" =",end='')
  for y in range(n):
    if y==n-1:
      print(round(e_vectors[y][i],4),"x"+str(y+1))
    else:
      print(round(e_vectors[y][i],4),"x"+str(y+1)+" + ",end='')

f=[]
for i in range(c):
  f1=[]
  for j in range(n):
    f1.append(sqrt(e_values[i])*e_vectors[j][i])
  f.append(f1)

f1=f
f=transpose(np.array(f))
h2=np.sum(f**2,axis=1)
s=np.sum(f,axis=0)
t_s=np.sum(h2)
f1[0].extend([s[0],s[0]*100/t_s])
f1[1].extend([s[1],s[1]*100/t_s])
h2=list(h2)
h2.extend([t_s,s[0]+s[1]])
df=pd.DataFrame({'variables':['Finance','Marketing','Business Policy','variance explained','%of v
ariance explained'],'F1':f1[0],'F2':f1[1],'h^2':h2})
df
```

Input 1:

Enter number of components :3
3 7 10 3 10
6 3 9 9 6
5 3 8 7 5

Output 1:

```
x
 [[ 3.  6.  5.]
 [ 7.  3.  3.]
 [10.  9.  8.]
 [ 3.  9.  7.]
 [10.  6.  5.]]

Eigen values:
 [1.5851705  0.80664506 0.00818443]

Eigen vectors:
 [[ 0.0212208  -0.99538347 -0.09360247]
 [ 0.70623585  0.08119286 -0.70330551]
 [ 0.70765853 -0.05118071  0.70469847]]

Principal Components : [66.05, 99.66, 100.0]
Enter Threshold value :97
Principal Components are:
z1 =0.0212 x1 + 0.7062 x2 + 0.7077 x3
z2 =-0.9954 x1 + 0.0812 x2 + -0.0512 x3
```

	variables	F1	F2	h^2
0	Finance	0.026718	-0.893988	0.799928
1	Marketing	0.889176	0.072922	0.795952
2	Business Policy	0.890967	-0.045967	0.795936
3	variance explained	1.806861	-0.867033	2.391816
4	%of variance explained	75.543493	-36.249995	0.939828

Input 2:

Enter number of components :3
2 4 1 5
2 8 4 0
8 3 1 2

Output 2:

```
x
 [[2. 2. 8.]
 [4. 8. 3.]
 [1. 4. 1.]
 [5. 0. 2.]]

Eigen values:
 [0.89208647 0.82928548 0.52862805]
Eigen vectors:
 [[-0.5267742   0.63311916  0.56715876]
 [-0.34594212 -0.76916788  0.53731259]
 [ 0.7764232   0.08683831  0.62420039]]

Principal Components : [39.65, 76.51, 100.0]
Enter Threshold value :75
Principal Components are:
z1 =-0.5268 x1 + -0.3459 x2 + 0.7764 x3
z2 =0.6331 x1 + -0.7692 x2 + 0.0868 x3
```

	variables	F1	F2	h^2
0	Finance	-0.497540	0.576551	0.579957
1	Marketing	-0.326743	-0.700444	0.597383
2	Business Policy	0.733334	0.079079	0.544033
3	variance explained	-0.090949	-0.044814	1.721372
4	%of variance explained	-5.283528	-2.603361	-0.135763