Practical Set 1

Preet Paul

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Problem 1

Loading the dataset

```
Concrete <- read.csv("C:\\Users\\PREET PAUL\\Desktop\\Presidency University M.Sc. Notes\\3rd Sem
ester\\Concrete.csv")

View(Concrete)
head(Concrete,5)
```

```
##   Cement..component.1..kg.in.a.m.3.mixture.
## 1                                     540.0
## 2                                     540.0
## 3                                     332.5
## 4                                     332.5
## 5                                     198.6
##   Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture.
## 1                                                   0.0
## 2                                                   0.0
## 3                                                 142.5
## 4                                                 142.5
## 5                                                 132.4
##   Fly.Ash..component.3..kg.in.a.m.3.mixture.
## 1                                          0
## 2                                          0
## 3                                          0
## 4                                          0
## 5                                          0
##   Water...component.4..kg.in.a.m.3.mixture.
## 1                                       162
## 2                                       162
## 3                                       228
## 4                                       228
## 5                                       192
##   Superplasticizer..component.5..kg.in.a.m.3.mixture.
## 1                                                 2.5
## 2                                                 2.5
## 3                                                 0.0
## 4                                                 0.0
## 5                                                 0.0
##   Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.
## 1                                               1040.0
## 2                                               1055.0
## 3                                                932.0
## 4                                                932.0
## 5                                                978.4
##   Fine.Aggregate..component.7..kg.in.a.m.3.mixture. Age..day.
## 1                                             676.0        28
## 2                                             676.0        28
## 3                                             594.0       270
## 4                                             594.0       365
## 5                                             825.5       360
##   Concrete.compressive.strength.MPa..megapascals..
## 1                                            79.99
## 2                                            61.89
## 3                                            40.27
## 4                                            41.05
## 5                                            44.30
```

Checking for any missing value present in the dataset

```
which(is.na(Concrete))
```

```
## integer(0)
```

Using the covariance matrix S

Principal Component Analysis

```
S <- cov(Concrete)
S
```

```
##                                                        Cement..component.1..kg.in.a.m.3.mixtur
e.
## Cement..component.1..kg.in.a.m.3.mixture.                                             10921.58
02
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture.                                 -2481.55
04
## Fly.Ash..component.3..kg.in.a.m.3.mixture.                                            -2658.29
90
## Water...component.4..kg.in.a.m.3.mixture.                                              -182.07
32
## Superplasticizer..component.5..kg.in.a.m.3.mixture.                                      57.67
71
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.                                   -888.54
62
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.                                     -1866.13
06
## Age..day.                                                                               540.97
96
## Concrete.compressive.strength.MPa..megapascals..                                        869.14
30
##                                                        Blast.Furnace.Slag..component.2..kg.in.
a.m.3.mixture.
## Cement..component.1..kg.in.a.m.3.mixture.
-2481.5504
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture.
7444.1248
## Fly.Ash..component.3..kg.in.a.m.3.mixture.
-1786.6851
## Water...component.4..kg.in.a.m.3.mixture.
197.6041
## Superplasticizer..component.5..kg.in.a.m.3.mixture.
22.3024
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.
-1905.2217
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.
-1947.9951
## Age..day.
-241.1522
## Concrete.compressive.strength.MPa..megapascals..
194.3376
##                                                        Fly.Ash..component.3..kg.in.a.m.3.mixtu
re.
## Cement..component.1..kg.in.a.m.3.mixture.                                             -2658.29
903
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture.                                 -1786.68
505
## Fly.Ash..component.3..kg.in.a.m.3.mixture.                                             4095.61
654
## Water...component.4..kg.in.a.m.3.mixture.                                              -351.19
591
## Superplasticizer..component.5..kg.in.a.m.3.mixture.                                     144.32
245
```

```
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.                    -49.56
528
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.                       405.90
745
## Age..day.                                                              -624.07
138
## Concrete.compressive.strength.MPa..megapascals..                       -113.06
443
##                                              Water...component.4..kg.in.a.m.3.mixtur
e.
## Cement..component.1..kg.in.a.m.3.mixture.                             -182.073
21
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture.                  197.604
13
## Fly.Ash..component.3..kg.in.a.m.3.mixture.                            -351.195
91
## Water...component.4..kg.in.a.m.3.mixture.                              456.002
65
## Superplasticizer..component.5..kg.in.a.m.3.mixture.                    -83.879
31
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.                  -302.675
73
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.                     -771.574
92
## Age..day.                                                              374.491
46
## Concrete.compressive.strength.MPa..megapascals..                      -103.323
25
##                                              Superplasticizer..component.5..kg.in.a.
m.3.mixture.
## Cement..component.1..kg.in.a.m.3.mixture.
57.67710
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture.
22.30240
## Fly.Ash..component.3..kg.in.a.m.3.mixture.
144.32245
## Water...component.4..kg.in.a.m.3.mixture.
-83.87931
## Superplasticizer..component.5..kg.in.a.m.3.mixture.
35.68678
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.
-123.55389
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.
106.65988
## Age..day.
-72.71864
## Concrete.compressive.strength.MPa..megapascals..
36.53373
##                                              Coarse.Aggregate...component.6..kg.in.
a.m.3.mixture.
## Cement..component.1..kg.in.a.m.3.mixture.
-888.54620
```

```
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture.
-1905.22172
## Fly.Ash..component.3..kg.in.a.m.3.mixture.
-49.56528
## Water...component.4..kg.in.a.m.3.mixture.
-302.67573
## Superplasticizer..component.5..kg.in.a.m.3.mixture.
-123.55389
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.
6045.67736
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.
-1112.65019
## Age..day.
-14.81313
## Concrete.compressive.strength.MPa..megapascals..
-214.23975
##                                                         Fine.Aggregate..component.7..kg.in.a.m.
3.mixture.
## Cement..component.1..kg.in.a.m.3.mixture.
-1866.1306
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture.
-1947.9951
## Fly.Ash..component.3..kg.in.a.m.3.mixture.
405.9074
## Water...component.4..kg.in.a.m.3.mixture.
-771.5749
## Superplasticizer..component.5..kg.in.a.m.3.mixture.
106.6599
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.
-1112.6502
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.
6428.1878
## Age..day.
-790.5743
## Concrete.compressive.strength.MPa..megapascals..
-224.0028
##                                                          Age..day.
## Cement..component.1..kg.in.a.m.3.mixture.              540.97961
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture. -241.15224
## Fly.Ash..component.3..kg.in.a.m.3.mixture.            -624.07138
## Water...component.4..kg.in.a.m.3.mixture.              374.49146
## Superplasticizer..component.5..kg.in.a.m.3.mixture.    -72.71864
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.   -14.81313
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.     -790.57434
## Age..day.                                             3990.43773
## Concrete.compressive.strength.MPa..megapascals..       347.05976
##                                                         Concrete.compressive.strength.MPa..mega
pascals..
## Cement..component.1..kg.in.a.m.3.mixture.
869.14302
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture.
194.33756
```

```
## Fly.Ash..component.3..kg.in.a.m.3.mixture.                                    -
113.06443
## Water...component.4..kg.in.a.m.3.mixture.                                     -
103.32325
## Superplasticizer..component.5..kg.in.a.m.3.mixture.
36.53373
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.                          -
214.23975
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.                             -
224.00280
## Age..day.
347.05976
## Concrete.compressive.strength.MPa..megapascals..
279.08181
```

```
model <- prcomp(S)  # prcomp stands for principal component analysis
```

Summary of the model

```
summary1 <- summary(model)
summary1
```

```
## Importance of components:
##                              PC1       PC2       PC3       PC4       PC5
## Standard deviation     4528.0068 3473.7291 2575.3060 1.499e+03 1.370e+03
## Proportion of Variance    0.4719    0.2777    0.1527 5.173e-02 4.322e-02
## Cumulative Proportion     0.4719    0.7497    0.9023 9.540e-01 9.972e-01
##                              PC6      PC7   PC8       PC9
## Standard deviation     343.36928 36.07932 14.58 5.705e-14
## Proportion of Variance   0.00271  0.00003  0.00 0.000e+00
## Cumulative Proportion    0.99997  1.00000  1.00 1.000e+00
```

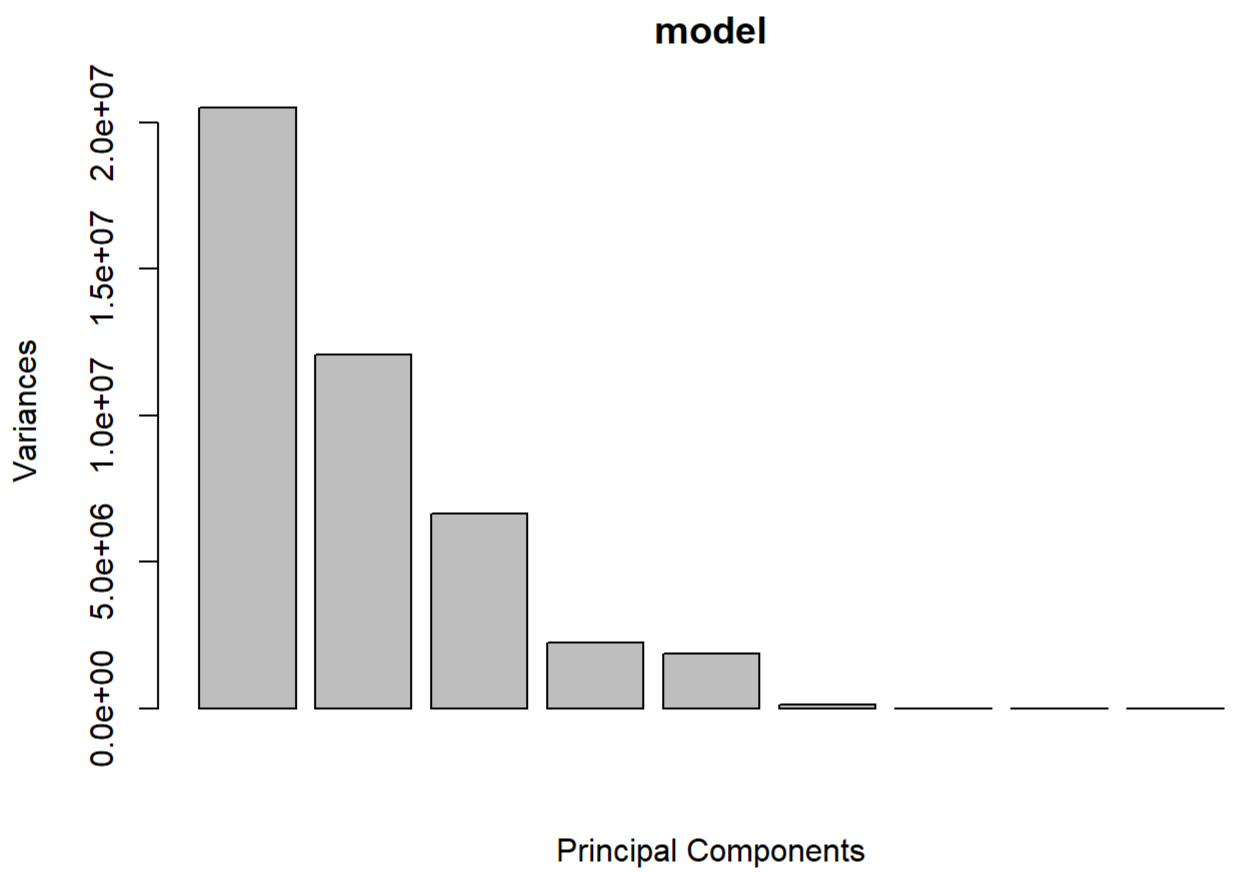
Display the Loadings of the variables on the principal components

```
model$rotation
```

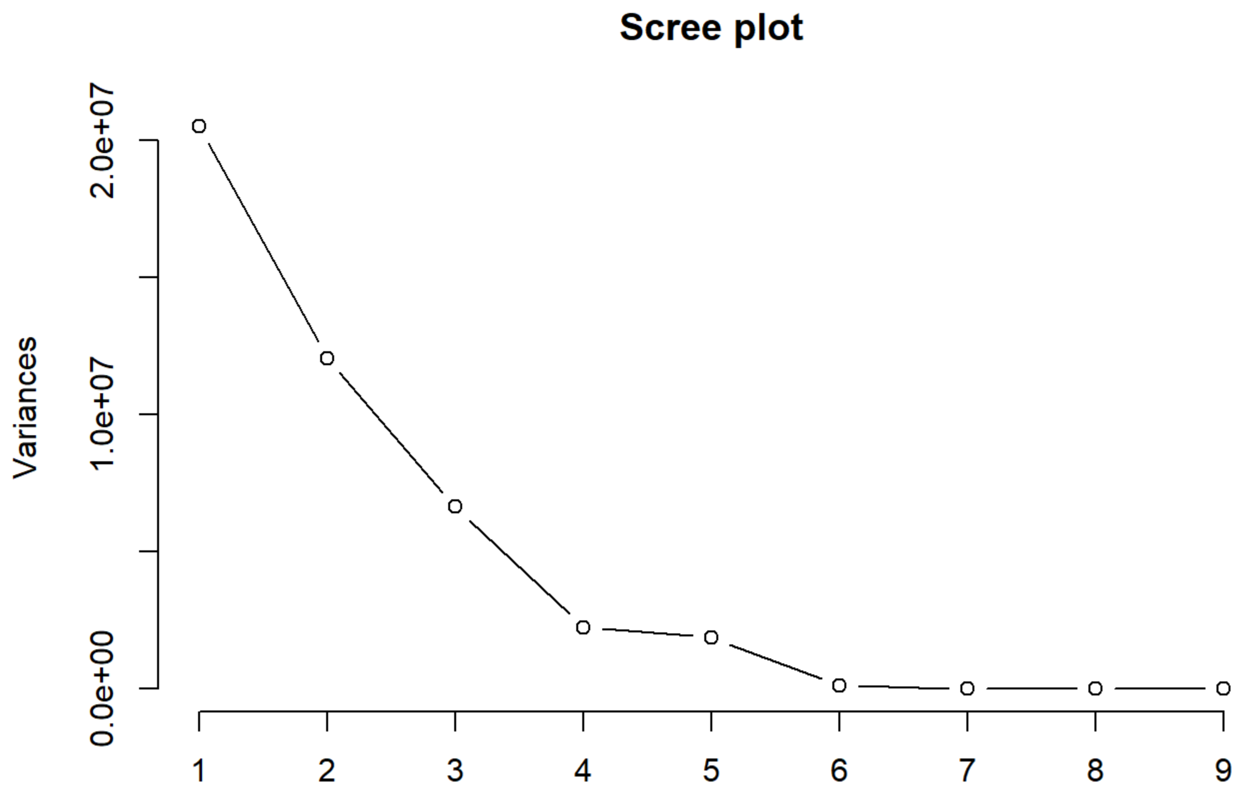
```
##                                                             PC1          PC2
## Cement..component.1..kg.in.a.m.3.mixture.             -0.904202461 -0.021128813
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture.  0.255657650 -0.789631169
## Fly.Ash..component.3..kg.in.a.m.3.mixture.             0.239915255  0.298589904
## Water...component.4..kg.in.a.m.3.mixture.             -0.007891226 -0.075231310
## Superplasticizer..component.5..kg.in.a.m.3.mixture.    0.001478481  0.004838927
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.   0.018614557  0.275366732
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.      0.216268634  0.445770683
## Age..day.                                             -0.090032037 -0.071011795
## Concrete.compressive.strength.MPa..megapascals..      -0.064876014 -0.040200485
##                                                               PC3         PC4
## Cement..component.1..kg.in.a.m.3.mixture.             -0.14959875  0.02669282
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture. -0.07378223  0.20399994
## Fly.Ash..component.3..kg.in.a.m.3.mixture.             0.04895220 -0.67111260
## Water...component.4..kg.in.a.m.3.mixture.              0.04303737 -0.07992731
## Superplasticizer..component.5..kg.in.a.m.3.mixture.   -0.02433294 -0.01914388
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.   0.75848460  0.48044903
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.     -0.61555905  0.46103188
## Age..day.                                              0.11259384 -0.23592280
## Concrete.compressive.strength.MPa..megapascals..      -0.02113203 -0.03851357
##                                                               PC5        PC6
## Cement..component.1..kg.in.a.m.3.mixture.              0.15930200 -0.2691816
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture.  0.10979763 -0.4207754
## Fly.Ash..component.3..kg.in.a.m.3.mixture.             0.27944716 -0.4636819
## Water...component.4..kg.in.a.m.3.mixture.             -0.10974676  0.4953251
## Superplasticizer..component.5..kg.in.a.m.3.mixture.    0.02989262 -0.1037349
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.   0.02859789 -0.2746752
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.     -0.17011769 -0.2579428
## Age..day.                                             -0.91710907 -0.2540506
## Concrete.compressive.strength.MPa..megapascals..      -0.02630207 -0.2699219
##                                                               PC7         PC8
## Cement..component.1..kg.in.a.m.3.mixture.              0.18628144  0.15502433
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture.  0.18572002  0.19256171
## Fly.Ash..component.3..kg.in.a.m.3.mixture.             0.19825618  0.25469476
## Water...component.4..kg.in.a.m.3.mixture.              0.08612637  0.73819440
## Superplasticizer..component.5..kg.in.a.m.3.mixture.   -0.05910353 -0.42812471
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.   0.07898835  0.16851517
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.      0.10606843  0.22342862
## Age..day.                                              0.11200622 -0.01832425
## Concrete.compressive.strength.MPa..megapascals..      -0.92225579  0.25911926
##                                                                PC9
## Cement..component.1..kg.in.a.m.3.mixture.             -0.048062672
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture. -0.058160270
## Fly.Ash..component.3..kg.in.a.m.3.mixture.            -0.056830665
## Water...component.4..kg.in.a.m.3.mixture.             -0.419877766
## Superplasticizer..component.5..kg.in.a.m.3.mixture.   -0.894749867
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.  -0.082435935
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.     -0.080047736
## Age..day.                                              0.001636475
## Concrete.compressive.strength.MPa..megapascals..      -0.031574903
```

Applying screeplot in the model

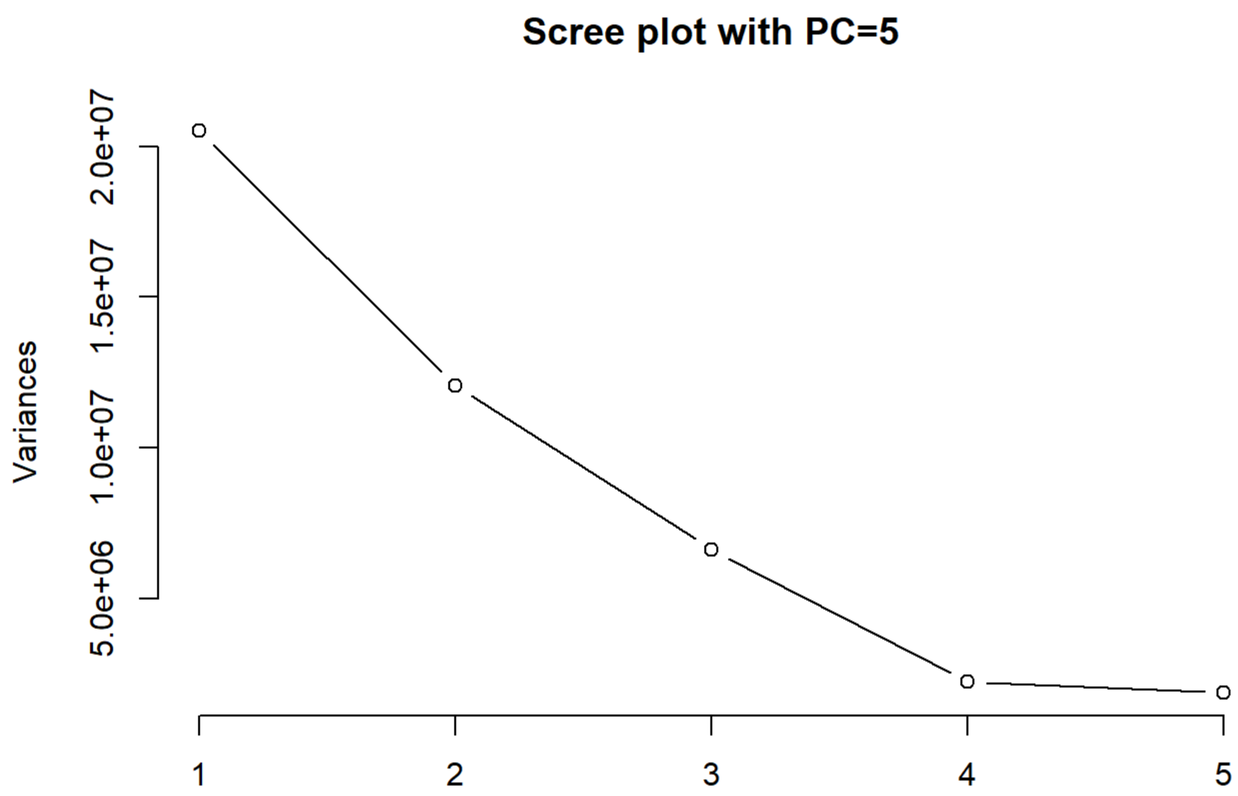
```
library("MASS")
plot(model,xlab="Principal Components")
```




```
screeplot(model, type="l", main="Scree plot")
```




```
# npcs stands for number of principal components
screeplot(model, npcs=5, type="l", main="Scree plot with PC=5")
```



No. of variables which explains 90% of the total variation

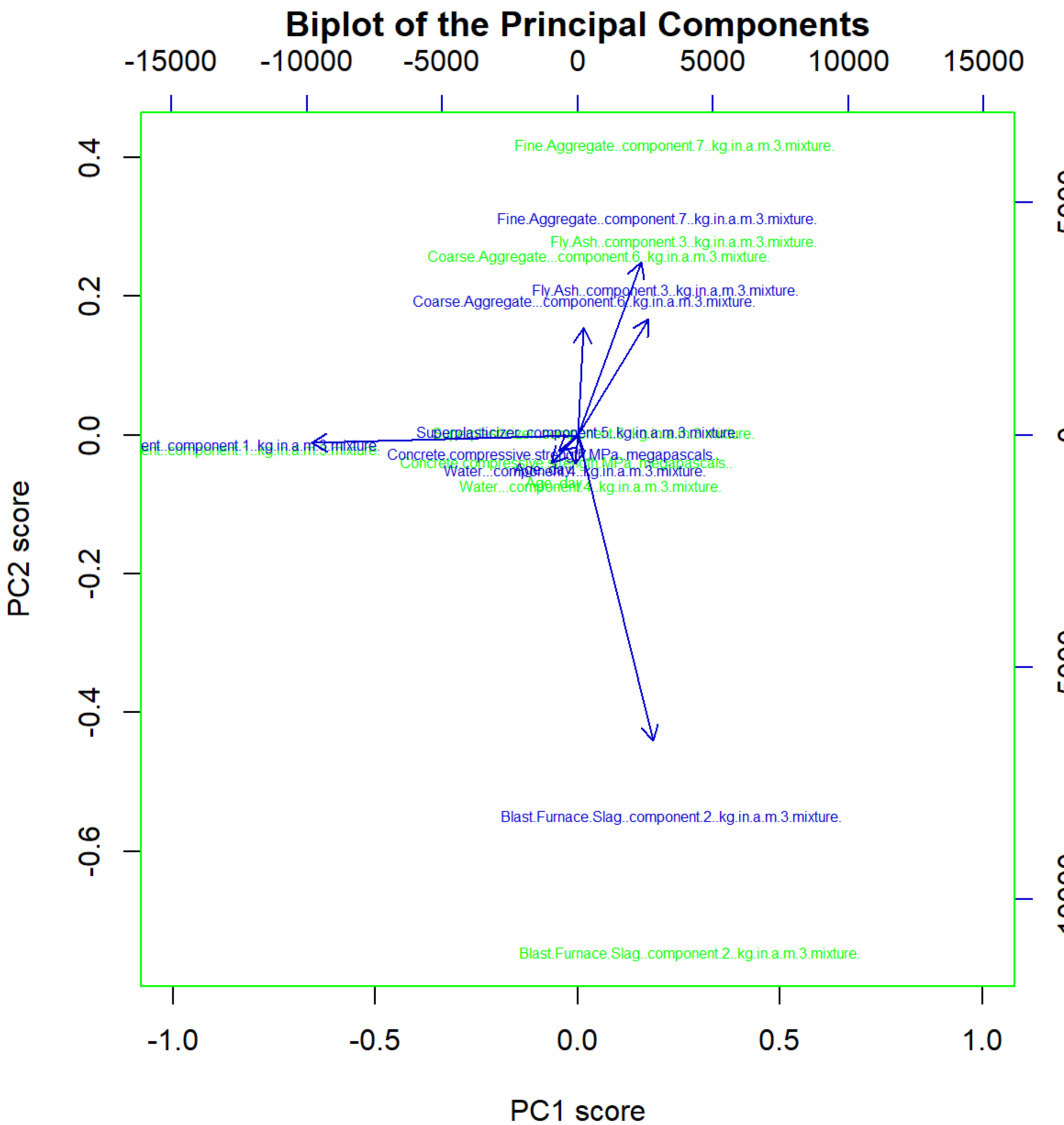
```
var_proportion1 <- summary1$importance["Cumulative Proportion", ]
var_proportion1
```

```
##     PC1     PC2     PC3     PC4     PC5     PC6     PC7     PC8     PC9
## 0.47191 0.74965 0.90230 0.95403 0.99725 0.99997 1.00000 1.00000 1.00000
```

Hence, there are 3 principal components which explains atleast 90% of the variation.

Applying biplot in the model

```
require(graphics)
biplot(prcomp(S), scale = TRUE, col=c("green","blue3"),
       main="Biplot of the Principal Components",xlab="PC1 score", cex=c(0.5,0.5),
       ylab="PC2 score",xlim=c(-1,1))
```



Using the correlation matrix R

Principal Component Analysis

```
R <- cor(Concrete)
R
```

```
##                                                       Cement..component.1..kg.in.a.m.3.mixtur
e.
## Cement..component.1..kg.in.a.m.3.mixture.                                            1.000000
00
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture.                               -0.275215
91
## Fly.Ash..component.3..kg.in.a.m.3.mixture.                                          -0.397467
34
## Water...component.4..kg.in.a.m.3.mixture.                                           -0.081586
75
## Superplasticizer..component.5..kg.in.a.m.3.mixture.                                  0.092386
17
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.                                -0.109348
99
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.                                   -0.222717
85
## Age..day.                                                                            0.081946
02
## Concrete.compressive.strength.MPa..megapascals..                                     0.497831
92
##                                                       Blast.Furnace.Slag..component.2..kg.in.
a.m.3.mixture.
## Cement..component.1..kg.in.a.m.3.mixture.
-0.27521591
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture.
1.00000000
## Fly.Ash..component.3..kg.in.a.m.3.mixture.
-0.32357990
## Water...component.4..kg.in.a.m.3.mixture.
0.10725203
## Superplasticizer..component.5..kg.in.a.m.3.mixture.
0.04327042
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.
-0.28399861
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.
-0.28160267
## Age..day.
-0.04424602
## Concrete.compressive.strength.MPa..megapascals..
0.13482926
##                                                       Fly.Ash..component.3..kg.in.a.m.3.mixtu
re.
## Cement..component.1..kg.in.a.m.3.mixture.                                           -0.397467
341
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture.                               -0.323579
901
## Fly.Ash..component.3..kg.in.a.m.3.mixture.                                           1.000000
000
## Water...component.4..kg.in.a.m.3.mixture.                                           -0.256984
023
## Superplasticizer..component.5..kg.in.a.m.3.mixture.                                  0.377503
146
```

```
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.                                    -0.009960
828
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.                                        0.079108
491
## Age..day.                                                                               -0.154370
516
## Concrete.compressive.strength.MPa..megapascals..                                        -0.105754
916
##                                                         Water...component.4..kg.in.a.m.3.mixtur
e.
## Cement..component.1..kg.in.a.m.3.mixture.                                               -0.081586
75
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture.                                    0.107252
03
## Fly.Ash..component.3..kg.in.a.m.3.mixture.                                              -0.256984
02
## Water...component.4..kg.in.a.m.3.mixture.                                                1.000000
00
## Superplasticizer..component.5..kg.in.a.m.3.mixture.                                     -0.657532
91
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.                                    -0.182293
60
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.                                       -0.450661
17
## Age..day.                                                                                0.277618
22
## Concrete.compressive.strength.MPa..megapascals..                                        -0.289633
38
##                                                         Superplasticizer..component.5..kg.in.a.
m.3.mixture.
## Cement..component.1..kg.in.a.m.3.mixture.
0.09238617
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture.
0.04327042
## Fly.Ash..component.3..kg.in.a.m.3.mixture.
0.37750315
## Water...component.4..kg.in.a.m.3.mixture.
-0.65753291
## Superplasticizer..component.5..kg.in.a.m.3.mixture.
1.00000000
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.
-0.26599915
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.
0.22269123
## Age..day.
-0.19270003
## Concrete.compressive.strength.MPa..megapascals..
0.36607883
##                                                         Coarse.Aggregate...component.6..kg.in.
a.m.3.mixture.
## Cement..component.1..kg.in.a.m.3.mixture.
-0.109348994
```

```
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture.
-0.283998612
## Fly.Ash..component.3..kg.in.a.m.3.mixture.
-0.009960828
## Water...component.4..kg.in.a.m.3.mixture.
-0.182293602
## Superplasticizer..component.5..kg.in.a.m.3.mixture.
-0.265999148
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.
1.000000000
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.
-0.178480957
## Age..day.
-0.003015880
## Concrete.compressive.strength.MPa..megapascals..
-0.164934614
##                                                       Fine.Aggregate..component.7..kg.in.a.m.
3.mixture.
## Cement..component.1..kg.in.a.m.3.mixture.                                                    -
0.22271785
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture.                                        -
0.28160267
## Fly.Ash..component.3..kg.in.a.m.3.mixture.
0.07910849
## Water...component.4..kg.in.a.m.3.mixture.                                                    -
0.45066117
## Superplasticizer..component.5..kg.in.a.m.3.mixture.
0.22269123
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.                                         -
0.17848096
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.
1.00000000
## Age..day.                                                                                    -
0.15609470
## Concrete.compressive.strength.MPa..megapascals..                                             -
0.16724125
##                                                         Age..day.
## Cement..component.1..kg.in.a.m.3.mixture.              0.08194602
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture. -0.04424602
## Fly.Ash..component.3..kg.in.a.m.3.mixture.            -0.15437052
## Water...component.4..kg.in.a.m.3.mixture.              0.27761822
## Superplasticizer..component.5..kg.in.a.m.3.mixture.   -0.19270003
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.  -0.00301588
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.     -0.15609470
## Age..day.                                              1.00000000
## Concrete.compressive.strength.MPa..megapascals..       0.32887300
##                                                       Concrete.compressive.strength.MPa..mega
pascals..
## Cement..component.1..kg.in.a.m.3.mixture.
0.4978319
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture.
0.1348293
```

```
## Fly.Ash..component.3..kg.in.a.m.3.mixture.                                    -
0.1057549
## Water...component.4..kg.in.a.m.3.mixture.                                     -
0.2896334
## Superplasticizer..component.5..kg.in.a.m.3.mixture.
0.3660788
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.                          -
0.1649346
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.                             -
0.1672412
## Age..day.
0.3288730
## Concrete.compressive.strength.MPa..megapascals..
1.0000000
```

```
result <- prcomp(R) # prcomp stands for principal component analysis
```

Summary of the model

```
summary2 <- summary(result)
summary2
```

```
## Importance of components:
##                           PC1    PC2    PC3     PC4     PC5     PC6     PC7
## Standard deviation     0.8058 0.6464 0.4976 0.36161 0.34520 0.28933 0.10133
## Proportion of Variance 0.3908 0.2516 0.1491 0.07872 0.07174 0.05039 0.00618
## Cumulative Proportion  0.3908 0.6424 0.7915 0.87020 0.94194 0.99233 0.99851
##                            PC8       PC9
## Standard deviation     0.04972 2.083e-17
## Proportion of Variance 0.00149 0.000e+00
## Cumulative Proportion  1.00000 1.000e+00
```

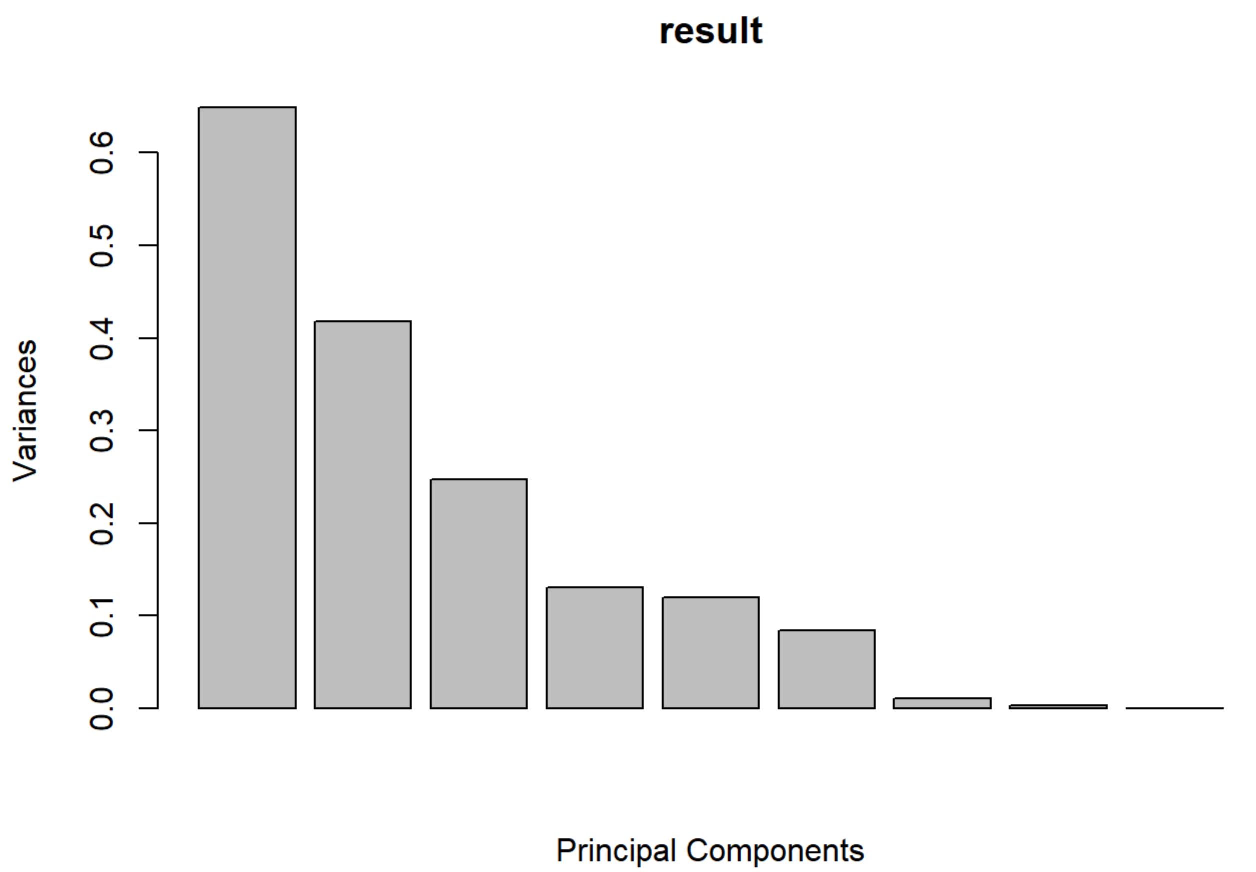
Display the Loadings of the variables on the principal components

```
result$rotation
```

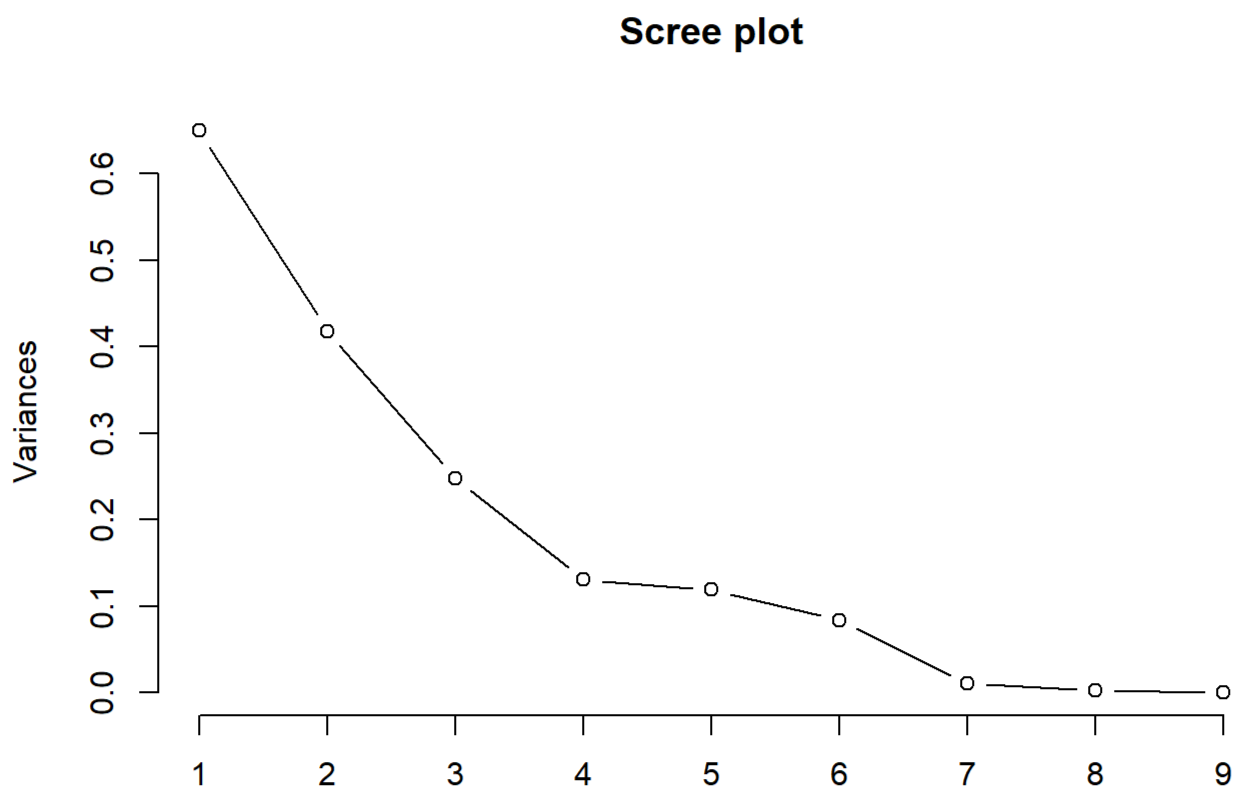
```
##                                                            PC1        PC2
## Cement..component.1..kg.in.a.m.3.mixture.             -0.07758874  0.5619745
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture. -0.17148509  0.1385509
## Fly.Ash..component.3..kg.in.a.m.3.mixture.             0.38281724 -0.2835914
## Water...component.4..kg.in.a.m.3.mixture.             -0.55401115 -0.1663558
## Superplasticizer..component.5..kg.in.a.m.3.mixture.    0.51332402  0.2786785
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.  -0.04654306 -0.2559843
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.      0.39636985 -0.1467328
## Age..day.                                             -0.29237728  0.1550846
## Concrete.compressive.strength.MPa..megapascals..       0.05323651  0.6067278
##                                                             PC3        PC4
## Cement..component.1..kg.in.a.m.3.mixture.             -0.383087574  0.1291354
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture.  0.696464018 -0.3097546
## Fly.Ash..component.3..kg.in.a.m.3.mixture.            -0.002301872 -0.2299285
## Water...component.4..kg.in.a.m.3.mixture.              0.128071019  0.1882120
## Superplasticizer..component.5..kg.in.a.m.3.mixture.    0.182675177 -0.1446875
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.  -0.540442614 -0.5379081
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.     -0.002222302  0.6568599
## Age..day.                                             -0.156538627  0.1838894
## Concrete.compressive.strength.MPa..megapascals..      -0.042621328 -0.1533799
##                                                           PC5         PC6
## Cement..component.1..kg.in.a.m.3.mixture.              0.1235405  0.41173805
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture.  0.2462311 -0.23173525
## Fly.Ash..component.3..kg.in.a.m.3.mixture.            -0.6444596  0.17303729
## Water...component.4..kg.in.a.m.3.mixture.             -0.2634475  0.28287062
## Superplasticizer..component.5..kg.in.a.m.3.mixture.   -0.1321964  0.04198542
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.   0.2834172 -0.30415246
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.      0.2436406 -0.32465092
## Age..day.                                             -0.5009344 -0.64297686
## Concrete.compressive.strength.MPa..megapascals..      -0.1768560 -0.23178417
##                                                             PC7        PC8
## Cement..component.1..kg.in.a.m.3.mixture.             -0.133101955 -0.3292855
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture.  0.004377383 -0.2542246
## Fly.Ash..component.3..kg.in.a.m.3.mixture.             0.245319706 -0.2755380
## Water...component.4..kg.in.a.m.3.mixture.             -0.002735089  0.5597799
## Superplasticizer..component.5..kg.in.a.m.3.mixture.   -0.611203850  0.4521743
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.  -0.056932811  0.2244882
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.      0.177682923  0.1129562
## Age..day.                                             -0.350130085 -0.2089724
## Concrete.compressive.strength.MPa..megapascals..       0.625381227  0.3555012
##                                                            PC9
## Cement..component.1..kg.in.a.m.3.mixture.              0.45143896
## Blast.Furnace.Slag..component.2..kg.in.a.m.3.mixture.  0.43749986
## Fly.Ash..component.3..kg.in.a.m.3.mixture.             0.37253381
## Water...component.4..kg.in.a.m.3.mixture.              0.38831703
## Superplasticizer..component.5..kg.in.a.m.3.mixture.    0.08521520
## Coarse.Aggregate...component.6..kg.in.a.m.3.mixture.   0.35272102
## Fine.Aggregate..component.7..kg.in.a.m.3.mixture.      0.42520733
## Age..day.                                              0.03910999
## Concrete.compressive.strength.MPa..megapascals..      -0.03493668
```

Applying screeplot in the model

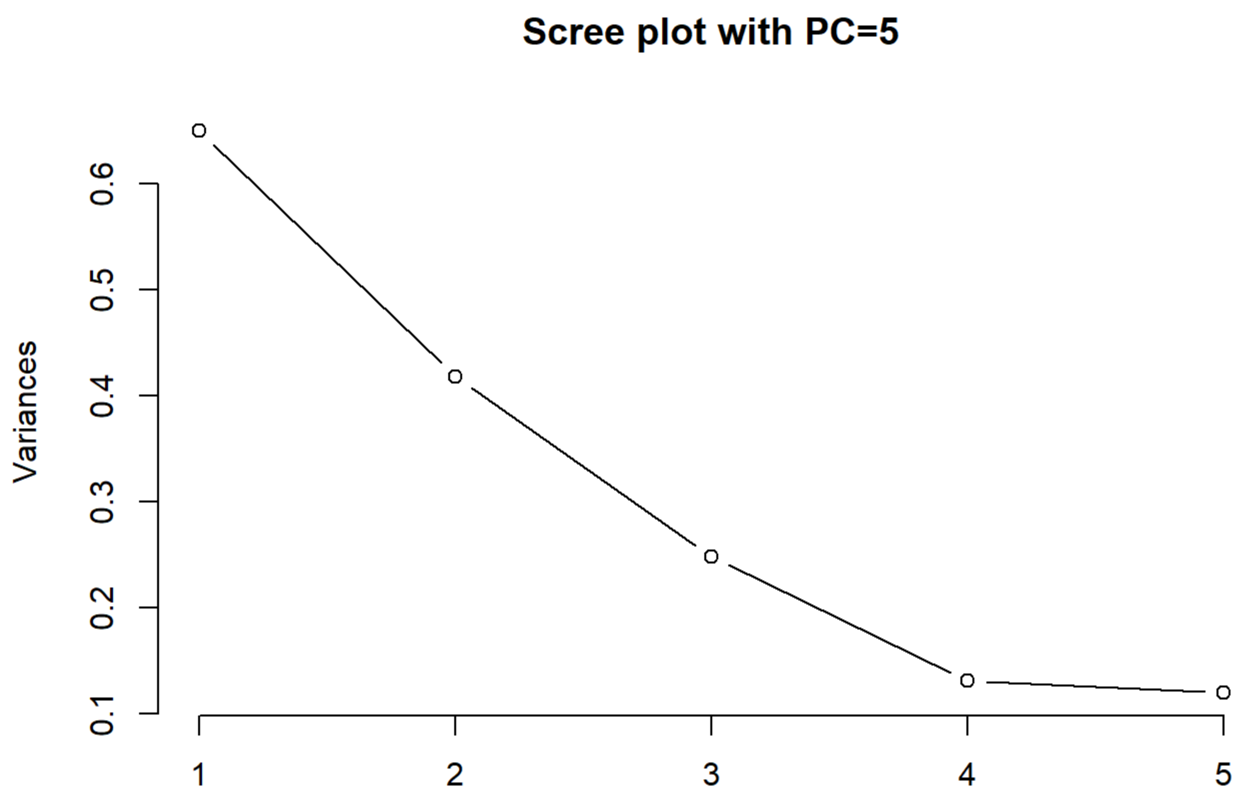
```
library("MASS")
plot(result,xlab="Principal Components")
```




```
screeplot(result, type="l", main="Scree plot")
```




```
# npcs stands for number of principal components
screeplot(result, npcs=5, type="l", main="Scree plot with PC=5")
```



No. of variables which explains 90% of the total variation

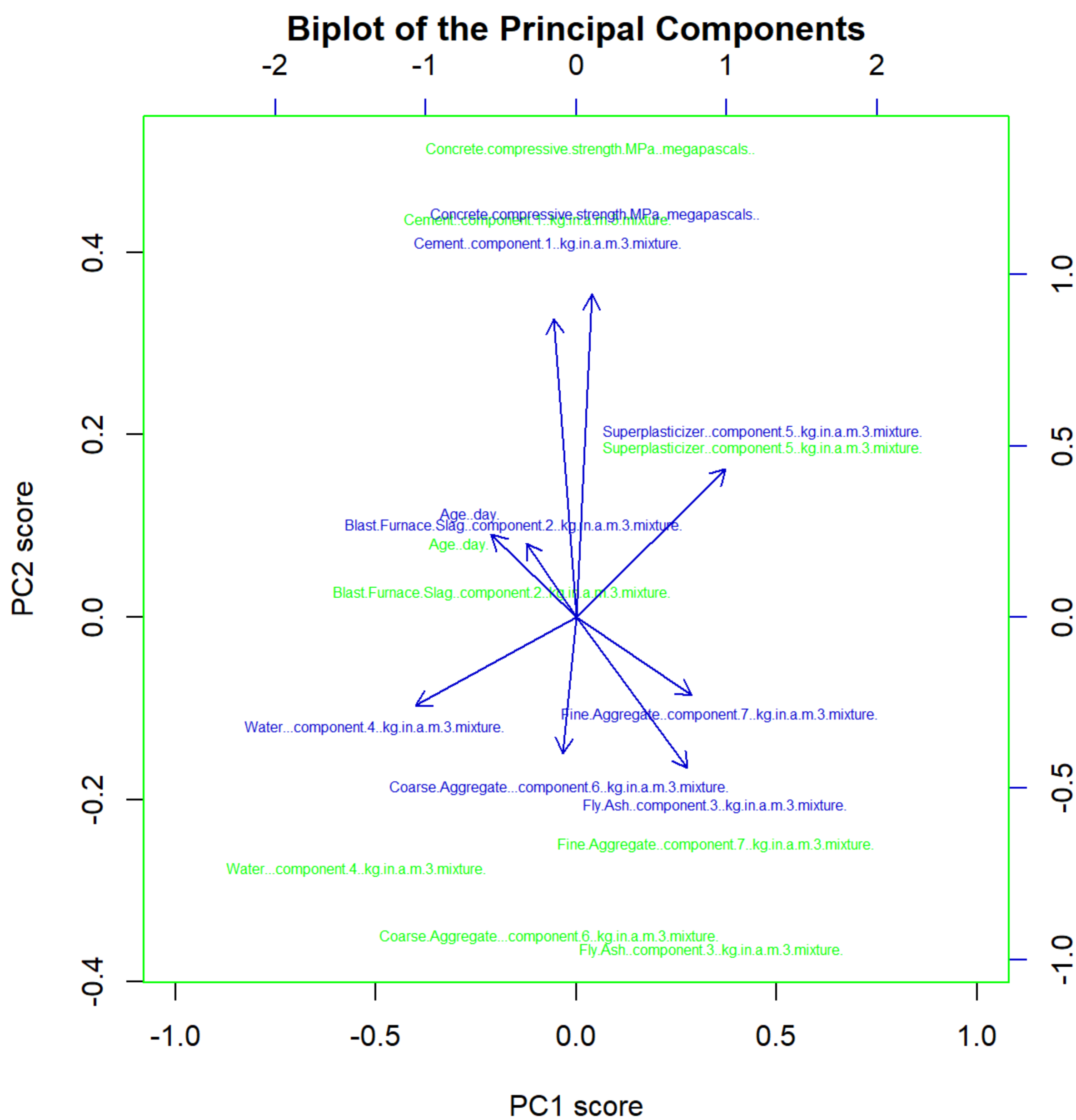
```
var_proportion2 <- summary2$importance["Cumulative Proportion", ]
var_proportion2
```

```
##     PC1     PC2     PC3     PC4     PC5     PC6     PC7     PC8     PC9
## 0.39084 0.64240 0.79148 0.87020 0.94194 0.99233 0.99851 1.00000 1.00000
```

Hence, there are 5 principal components which explains atleast 90% of the variation.

Applying biplot in the model

```
require(graphics)
biplot(prcomp(R), scale = TRUE, col=c("green","blue3"),
       main="Biplot of the Principal Components",xlab="PC1 score",cex=c(0.5,0.5),
       ylab="PC2 score",xlim=c(-1,1))
```



Problem 2

Loading the dataset

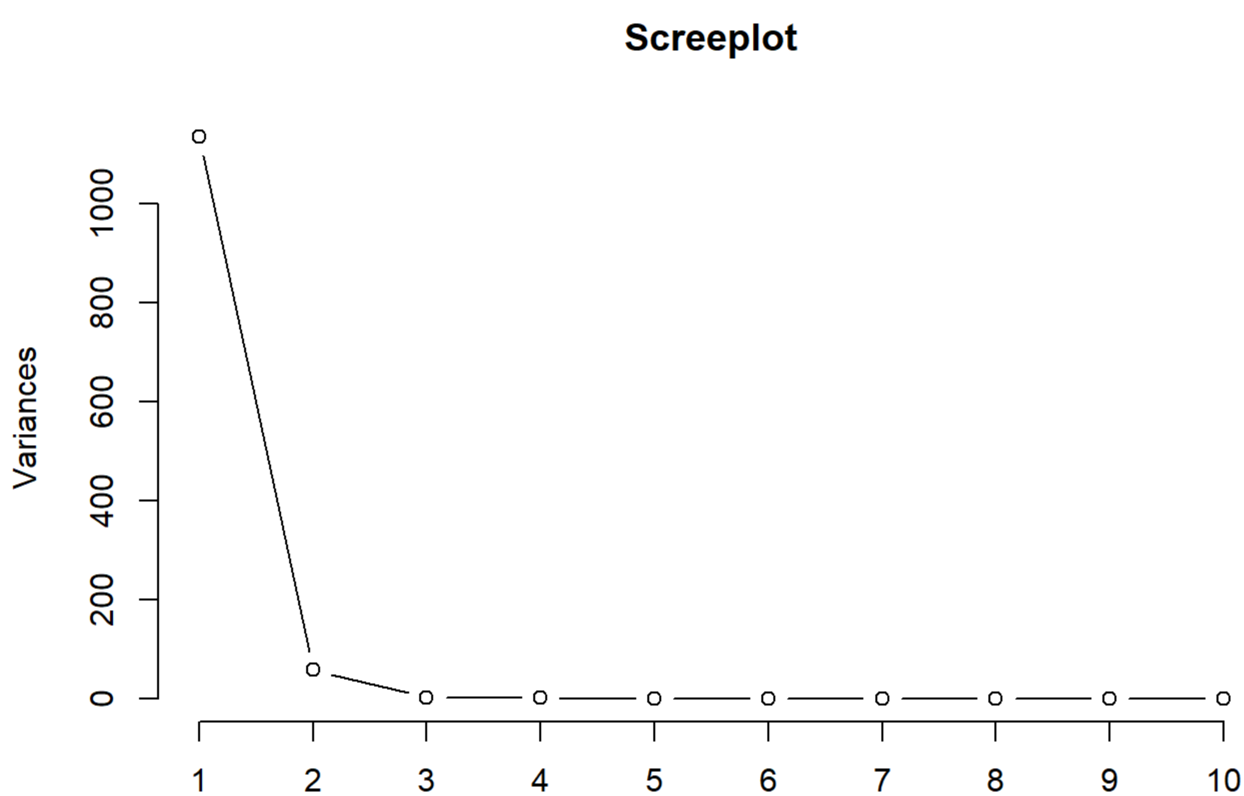
```
wine <- read.csv("C:\\Users\\PREET PAUL\\Desktop\\Presidency University M.Sc. Notes\\3rd Semeste
r\\winequality-red.csv",sep=";")

View(wine)
head(wine,5)
```

```
##   fixed.acidity volatile.acidity citric.acid residual.sugar chlorides
## 1           7.4             0.70        0.00            1.9     0.076
## 2           7.8             0.88        0.00            2.6     0.098
## 3           7.8             0.76        0.04            2.3     0.092
## 4          11.2             0.28        0.56            1.9     0.075
## 5           7.4             0.70        0.00            1.9     0.076
##   free.sulfur.dioxide total.sulfur.dioxide density   pH sulphates alcohol
## 1                  11                   34  0.9978 3.51      0.56     9.4
## 2                  25                   67  0.9968 3.20      0.68     9.8
## 3                  15                   54  0.9970 3.26      0.65     9.8
## 4                  17                   60  0.9980 3.16      0.58     9.8
## 5                  11                   34  0.9978 3.51      0.56     9.4
##   quality
## 1       5
## 2       5
## 3       5
## 4       6
## 5       5
```

Finding the optimal number of factors using prcomp() and screeplot

```
prin <- prcomp(wine)
screeplot(prin, type="l",main="Screeplot")
```



Clearly, we see that the slope is changing after the 3rd component. So, the optimal number of factors is 3.

Performing Factor Analysis

```
result2 <- factanal(x=wine, factors=3, rotation="varimax")
result2
```

```
##
## Call:
## factanal(x = wine, factors = 3, rotation = "varimax")
##
## Uniquenesses:
##        fixed.acidity     volatile.acidity          citric.acid
##                0.164                0.589                0.272
##       residual.sugar            chlorides  free.sulfur.dioxide
##                0.899                0.943                0.540
## total.sulfur.dioxide              density                   pH
##                0.007                0.201                0.526
##            sulphates              alcohol              quality
##                0.875                0.502                0.653
##
## Loadings:
##                      Factor1 Factor2 Factor3
## fixed.acidity         0.779   0.448  -0.172
## volatile.acidity             -0.640
## citric.acid           0.482   0.703
## residual.sugar        0.263           0.177
## chlorides             0.237
## free.sulfur.dioxide                   0.676
## total.sulfur.dioxide  0.108           0.989
## density               0.888
## pH                   -0.557  -0.404
## sulphates             0.140   0.321
## alcohol              -0.477   0.505  -0.126
## quality              -0.192   0.540  -0.133
##
##                Factor1 Factor2 Factor3
## SS loadings      2.361   1.931   1.537
## Proportion Var   0.197   0.161   0.128
## Cumulative Var   0.197   0.358   0.486
##
## Test of the hypothesis that 3 factors are sufficient.
## The chi square statistic is 2579.68 on 33 degrees of freedom.
## The p-value is 0
```

Interpretation to the factors for the best model

```
result2$loadings
```

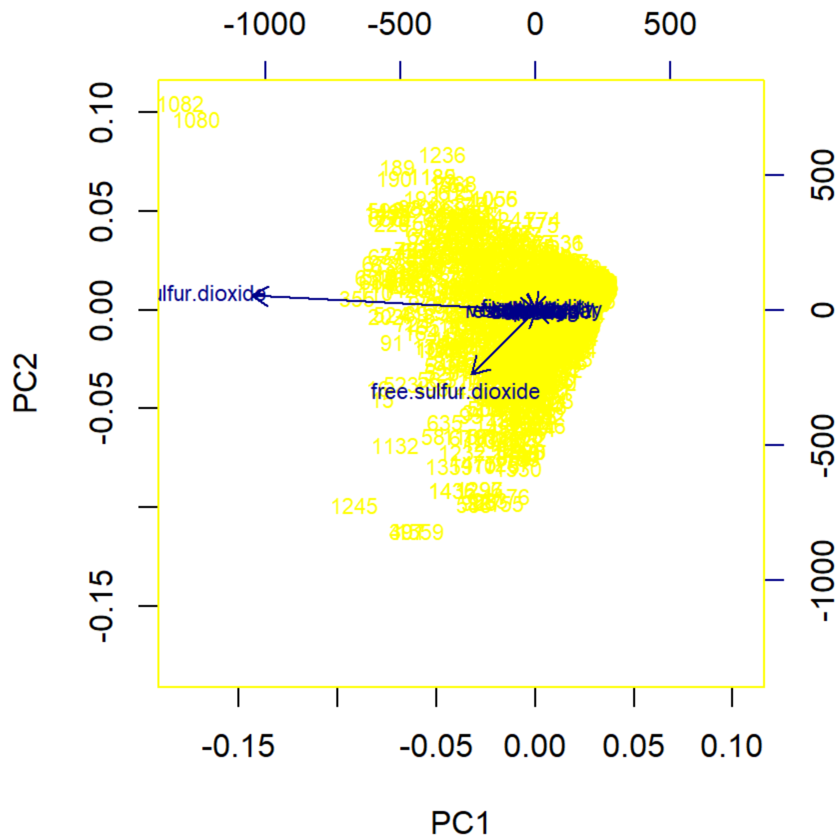
```
##
## Loadings:
##                      Factor1 Factor2 Factor3
## fixed.acidity         0.779   0.448  -0.172
## volatile.acidity             -0.640
## citric.acid           0.482   0.703
## residual.sugar        0.263           0.177
## chlorides             0.237
## free.sulfur.dioxide                   0.676
## total.sulfur.dioxide  0.108           0.989
## density               0.888
## pH                   -0.557  -0.404
## sulphates             0.140   0.321
## alcohol              -0.477   0.505  -0.126
## quality              -0.192   0.540  -0.133
##
##                Factor1 Factor2 Factor3
## SS loadings      2.361   1.931   1.537
## Proportion Var   0.197   0.161   0.128
## Cumulative Var   0.197   0.358   0.486
```

This shows there is high loading in Factor 1 and then of Factor2.

Generating biplot for the analysis

```
require(graphics)
biplot(prin, scale = TRUE, col=c("yellow","blue4"),cex=c(0.7,0.7))
```

```
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length =
## arrow.len): zero-length arrow is of indeterminate angle and so skipped
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length =
## arrow.len): zero-length arrow is of indeterminate angle and so skipped
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length =
## arrow.len): zero-length arrow is of indeterminate angle and so skipped
## Warning in arrows(0, 0, y[, 1L] * 0.8, y[, 2L] * 0.8, col = col[2L], length =
## arrow.len): zero-length arrow is of indeterminate angle and so skipped
```



This biplot suggests that there is high correlation between each of the variables and less contribution in PC1 scores.

Problem 3

Loading the dataset

```
Pottery <- read.csv("C:\\Users\\PREET PAUL\\Desktop\\Presidency University M.Sc. Notes\\3rd Seme
ster\\Pottery.csv")
View(Pottery)
head(Pottery,5)
```

```
##   X Al2O3 Fe2O3  MgO  CaO Na2O  K2O TiO2   MnO   BaO
## 1 1  18.8  9.52 2.00 0.79 0.40 3.20 1.01 0.077 0.015
## 2 2  16.9  7.33 1.65 0.84 0.40 3.05 0.99 0.067 0.018
## 3 3  18.2  7.64 1.82 0.77 0.40 3.07 0.98 0.087 0.014
## 4 4  16.9  7.29 1.56 0.76 0.40 3.05 1.00 0.063 0.019
## 5 5  17.8  7.24 1.83 0.92 0.43 3.12 0.93 0.061 0.019
```

Creating a new dataframe after eliminating the index column “x”

```
data <- Pottery[-c(1)]
head(data,5)
```

```
##   Al2O3 Fe2O3  MgO  CaO Na2O  K2O TiO2   MnO   BaO
## 1  18.8  9.52 2.00 0.79 0.40 3.20 1.01 0.077 0.015
## 2  16.9  7.33 1.65 0.84 0.40 3.05 0.99 0.067 0.018
## 3  18.2  7.64 1.82 0.77 0.40 3.07 0.98 0.087 0.014
## 4  16.9  7.29 1.56 0.76 0.40 3.05 1.00 0.063 0.019
## 5  17.8  7.24 1.83 0.92 0.43 3.12 0.93 0.061 0.019
```

Creating the Distance Matrix

```
DM <- dist(data)
DM
```

```
##            1         2         3         4         5         6         7
## 2   2.9247408                                                            
## 3   1.9862278 1.3493762                                                  
## 4   2.9665151 0.1273460 1.3717146                                        
## 5   2.5016339 0.9307723 0.5909323 0.9600542                              
## 6   2.0789250 1.9647203 0.7228651 1.9911768 1.0743021                    
## 7   3.5098771 1.0416823 2.0452301 1.1184404 1.5490077 2.5026066          
## 8   2.2679350 1.2367401 0.5513021 1.2856846 0.4666101 0.8192680 1.7360415
## 9   3.8441162 1.1420271 2.4656914 1.1318149 2.0287200 3.0543084 1.2577440
## 10  4.9806920 2.3494638 3.6859772 2.3434404 3.2314370 4.2652332 2.1504116
## 11  6.3982699 3.6491814 4.9438460 3.6278768 4.4558588 5.4846120 3.3989665
## 12  5.0953984 2.4658362 3.7855288 2.4803373 3.3000826 4.3296178 1.9608238
## 13  4.7588244 2.2094282 3.5235569 2.2294165 3.0647789 4.0902769 1.7481147
## 14  2.4289286 0.6176026 1.1290461 0.7038679 0.9099681 1.7538338 1.3314567
## 15  2.6190483 0.5968526 1.4282104 0.6736928 1.1957801 2.0890412 1.2772568
## 16  3.5646095 1.2898163 2.4555346 1.3243115 2.0975941 3.0661546 1.4079830
## 17  1.7165154 1.9075628 0.6961695 1.9555370 1.1280519 0.5458773 2.4626258
## 18  2.5816059 0.7520971 1.4327966 0.8565378 1.1710154 2.0350764 1.0305300
## 19  1.9645928 2.0864405 0.8195279 2.1118942 1.2262288 0.2095328 2.6377172
## 20  2.1963989 1.1985929 0.4109903 1.2229424 0.5194035 0.8511574 1.8973837
## 21  2.4672868 0.9761153 0.6023363 1.0052960 0.2934962 1.0370752 1.6213898
## 22  5.7078810 3.9189603 4.7781120 3.9647710 4.4299098 5.1176213 3.7786685
## 23  5.8690727 3.8281370 4.8921759 3.8550048 4.5128805 5.3297648 3.6681174
## 24  5.3798443 3.5519502 4.4328427 3.5923837 4.0863148 4.7826465 3.4412155
## 25  8.8037058 6.8795190 7.8924980 6.9197381 7.5017315 8.2625837 6.5708859
## 26  6.6270666 5.0414051 5.8363041 5.0968665 5.5127039 6.1268391 4.8373266
## 27  8.7051048 6.4165277 7.6499085 6.4288255 7.2125089 8.1503692 6.1083083
## 28 10.4430689 7.9482467 9.1421963 7.9574682 8.6498294 9.5562299 7.5670928
## 29  9.0512444 7.0478106 8.0410961 7.0874521 7.6324149 8.3808236 6.7234345
## 30  9.1090400 6.8311912 7.9754030 6.8534734 7.5180363 8.3807855 6.4655785
## 31  8.0918725 6.7990747 7.4402544 6.8653044 7.1532725 7.6322461 6.5570811
## 32  8.2835997 6.4084454 7.3347860 6.4515837 6.9424218 7.6422492 6.0998906
## 33  7.5033988 5.7949487 6.6515681 5.8444901 6.2911599 6.9344995 5.5093001
## 34  8.6206200 6.2517564 7.4176499 6.2648244 6.9448770 7.8179632 5.8842036
## 35  8.4870353 6.1592085 7.2980754 6.1753397 6.8304621 7.6811578 5.7923740
## 36  8.5031745 6.4516643 6.6192897 6.3919065 6.2846579 6.5428549 6.5149328
## 37  8.0077198 5.3664674 6.0684591 5.3006668 5.6096635 6.2670368 5.3242793
## 38  8.2858480 6.1527766 6.3787068 6.0908253 6.0267743 6.3309906 6.2110091
## 39  7.9337942 5.8131349 6.0326466 5.7499963 5.6887726 5.9968226 5.8963980
## 40  8.4358714 7.1533020 6.8339249 7.1009739 6.6761733 6.5281775 7.3462443
## 41  8.7089540 6.4915854 6.7846368 6.4298196 6.4109778 6.7603444 6.5083532
## 42  8.6084991 6.5471155 6.7190316 6.4873761 6.3807778 6.6354548 6.5977496
## 43  9.1296623 6.6983874 7.1763842 6.6361523 6.7578240 7.2409212 6.6611696
## 44  8.1027326 5.3060065 6.2085149 5.2430159 5.7135348 6.4983279 5.1954485
## 45  8.1771455 6.3795925 6.3746856 6.3207070 6.1063260 6.2375417 6.5079322
##            8         9        10        11        12        13        14
## 2                                                                        
## 3                                                                        
## 4                                                                        
## 5                                                                        
## 6                                                                        
## 7                                                                        
```

```
## 8
## 9   2.2838564
## 10  3.4890706  1.2499896
## 11  4.7717679  2.6953681  1.6286930
## 12  3.5423424  1.5079954  0.7431124  1.7253571
## 13  3.2980244  1.2698524  0.7463518  2.0012826  0.3744663
## 14  1.0353420  1.5074790  2.6883432  4.0730210  2.8191383  2.5260277
## 15  1.3878375  1.2994356  2.4287620  3.8084070  2.5680025  2.2598035  0.3898923
## 16  2.2910923  0.7580923  1.5660453  3.1056614  1.8114795  1.5115664  1.3750582
## 17  0.8277572  2.9780803  4.1747230  5.4577876  4.2565103  3.9913663  1.5431737
## 18  1.3049659  1.4771378  2.5811025  3.9802117  2.5908721  2.2818837  0.5561591
## 19  0.9454650  3.1718928  4.3865132  5.6187056  4.4555011  4.2096633  1.8506888
## 20  0.4445998  2.2684199  3.4764961  4.7220786  3.5850524  3.3351501  1.0173171
## 21  0.4210998  2.0415252  3.2409827  4.4662640  3.3259202  3.0904320  0.9141324
## 22  4.4430224  3.2441652  2.9698273  3.7577819  3.2591155  3.2533074  3.8722088
## 23  4.5883759  2.9150700  2.3261309  3.0290698  2.6655650  2.6958880  3.8864529
## 24  4.0926651  2.8583821  2.6553926  3.5793364  2.9661204  2.9392252  3.5211017
## 25  7.5655594  6.0072281  5.1725558  5.0216848  5.3271543  5.4733352  6.9199371
## 26  5.4882927  4.3946032  4.0100121  4.5535448  4.2218883  4.2472422  4.9548786
## 27  7.3843428  5.3515846  4.2241354  3.6729047  4.3856074  4.5912609  6.6038444
## 28  8.8335117  6.9454927  5.8553532  4.9437182  5.9357339  6.2176090  8.2002616
## 29  7.7048040  6.2073830  5.3859946  5.1192493  5.5210443  5.6916786  7.1114267
## 30  7.6443159  5.8426984  4.8496021  4.3984920  4.9718633  5.1937847  6.9934409
## 31  7.0791088  6.2637210  5.9037182  6.2868646  6.0514515  6.0924289  6.6577502
## 32  6.9706939  5.6083253  4.9463850  5.0473690  5.1108039  5.2386202  6.4251215
## 33  6.2743194  5.0593007  4.5437480  4.9198501  4.7127722  4.7920034  5.7596376
## 34  7.0723792  5.2312243  4.2570217  3.8791475  4.3830841  4.6174778  6.4553640
## 35  6.9420735  5.1612445  4.2347610  3.9488862  4.3635088  4.5873668  6.3457130
## 36  6.5432675  6.6287653  6.9167565  6.5615161  6.9244725  7.0642795  6.9168387
## 37  5.9483065  5.1081043  4.9639017  4.2213615  5.0069072  5.2294020  5.9246989
## 38  6.2929518  6.2897394  6.5526965  6.1971610  6.5698718  6.7157234  6.6330488
## 39  5.9613321  5.9749612  6.2652136  5.9488221  6.2899791  6.4244464  6.2943912
## 40  6.8231885  7.6807878  8.3188055  8.3848280  8.3310329  8.3798439  7.4928473
## 41  6.6867075  6.5619233  6.7442432  6.2826260  6.7476978  6.9155585  6.9870716
## 42  6.6327867  6.7162743  6.9997607  6.6521751  7.0046991  7.1491737  7.0153373
## 43  7.0649232  6.6055870  6.5913278  5.8944466  6.5955144  6.8060844  7.2259079
## 44  6.0585365  4.8273683  4.4411612  3.4941909  4.4974999  4.7630169  5.8718902
## 45  6.3448819  6.7119465  7.1420403  6.9415103  7.1486158  7.2478364  6.8114457
##            15         16         17         18         19         20         21
## 2
## 3
## 4
## 5
## 6
## 7
## 8
## 9
## 10
## 11
## 12
## 13
## 14
```

```
## 15
## 16  1.1614754
## 17  1.8782101  2.8749195
## 18  0.5123602  1.2917492  1.8341063
## 19  2.1829359  3.1813544  0.5655882  2.1364138
## 20  1.3273244  2.3289339  0.8603005  1.3848050  0.9351861
## 21  1.2124512  2.1442549  1.0879324  1.2431657  1.1600987  0.3298848
## 22  3.8341957  3.0606705  4.8976976  3.9786480  5.2173902  4.5266576  4.3678431
## 23  3.7644787  2.8548073  5.1418356  3.9341343  5.4260399  4.6261636  4.4496335
## 24  3.4853552  2.7313081  4.5833339  3.6380957  4.8734403  4.1620217  4.0069880
## 25  6.7932003  5.9248819  8.0449249  6.9360306  8.3669326  7.6237175  7.4412878
## 26  4.9178196  4.2071516  5.8803409  5.0471066  6.2145376  5.5733089  5.4314061
## 27  6.3850000  5.3999713  7.9868297  6.5466066  8.2654942  7.3969538  7.1823404
## 28  8.0234428  7.0920711  9.4620888  8.1680711  9.6904506  8.8710031  8.6249536
## 29  6.9979761  6.1625900  8.1863062  7.1400675  8.4929441  7.7675745  7.5744722
## 30  6.8422885  5.8790503  8.2353266  6.9728038  8.5029210  7.7060383  7.4824040
## 31  6.6574072  6.0410599  7.3663509  6.7570317  7.7123463  7.1895051  7.0677023
## 32  6.3586830  5.4933892  7.4438561  6.4703982  7.7509915  7.0742547  6.8899614
## 33  5.7201581  4.9137183  6.7220436  5.8199948  7.0289251  6.3846207  6.2210955
## 34  6.3160574  5.3396835  7.7160126  6.4369393  7.9377102  7.1375086  6.9055379
## 35  6.2207339  5.2556698  7.5758657  6.3371483  7.7990687  7.0149994  6.7869168
## 36  6.9883607  7.1884314  6.9583055  7.0708813  6.6698757  6.5043804  6.3187313
## 37  5.8660366  5.7184916  6.5583699  6.0047450  6.4161236  5.8913296  5.6441443
## 38  6.6959738  6.8564298  6.7389691  6.7832905  6.4621314  6.2562814  6.0623145
## 39  6.3529244  6.5411960  6.4007844  6.4469991  6.1272184  5.9138537  5.7242944
## 40  7.6660994  8.1420028  7.0050514  7.6965479  6.6130175  6.8041304  6.7103745
## 41  7.0344934  7.1389675  7.1602322  7.1199495  6.8951827  6.6548082  6.4487729
## 42  7.0910962  7.2745059  7.0549292  7.1667853  6.7632959  6.6043656  6.4169249
## 43  7.2233959  7.1985068  7.5975229  7.3301599  7.3847971  7.0247831  6.7959389
## 44  5.7646688  5.4301471  6.7304007  5.9148106  6.6498392  6.0083465  5.7443102
## 45  6.9071320  7.2431779  6.6744195  6.9778829  6.3520417  6.2965375  6.1442494
##            22         23         24         25         26         27         28
## 2
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## 16
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## 18
## 19
## 20
## 21
```

```
## 22
## 23  1.1191769
## 24  0.5786156  0.9455163
## 25  3.2991710  3.2791722  3.6697778
## 26  1.2479123  1.9209763  1.6704589  2.4573237
## 27  3.7832634  3.1064489  3.9361664  2.3084594  3.6577295
## 28  5.1976557  4.8002744  5.4350004  2.9425343  4.8676093  2.2977269
## 29  3.5173996  3.5910958  3.9120429  0.6852452  2.6798129  2.6016445  2.7269384
## 30  3.6554903  3.3298366  3.9240852  1.5015319  3.2450988  1.4679499  1.7645005
## 31  3.1302417  3.8495285  3.5724256  2.6242980  1.9532691  4.7052274  5.3190127
## 32  2.6197170  2.8952116  3.0428344  1.2714637  1.7839563  2.9777214  3.5697204
## 33  1.9496307  2.3703394  2.3309449  1.9191959  1.0225287  3.3749036  4.3275195
## 34  3.3253746  2.8345866  3.4687911  2.2118917  3.1912563  1.6183405  2.2821098
## 35  3.1247978  2.6990609  3.2785602  2.1087959  2.9569613  1.8154022  2.4821185
## 36  8.1632779  8.1438679  7.9743247 10.0305494  9.0034021  9.4626360  9.5359852
## 37  6.5217257  6.2446765  6.3430635  7.9770246  7.3496972  7.0463239  7.1858064
## 38  7.8250105  7.7834481  7.6312475  9.6915141  8.6782674  9.0940750  9.1957112
## 39  7.5965732  7.5488905  7.3930801  9.5288735  8.4708220  8.9224298  9.1093235
## 40  9.3739678  9.5273071  9.1516716 11.7033446 10.2591289 11.3838388 11.6610638
## 41  8.0301941  7.9581089  7.8487811  9.7566189  8.8577742  9.1098613  9.1100560
## 42  8.2194596  8.2050926  8.0316140 10.0760588  9.0569768  9.5175149  9.5641807
## 43  7.9334338  7.7779013  7.7796360  9.3529356  8.7095507  8.5800253  8.4402927
## 44  6.0371902  5.6374290  5.8718615  7.2284156  6.8260413  6.1257702  6.2679359
## 45  8.4308013  8.4567295  8.2231010 10.5004181  9.3082890  9.9869749 10.1970616
##           29         30         31         32         33         34         35
## 2
## 3
## 4
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## 21
## 22
## 23
## 24
## 25
## 26
## 27
## 28
```

```
## 29
## 30  1.5515170
## 31  2.6471428  3.8677758
## 32  1.3666854  1.9815504  2.0315314
## 33  2.1433730  2.6560303  1.8048438  0.9709938
## 34  2.3278282  1.0565515  4.1943787  2.2695596  2.6538953
## 35  2.2254242  1.1270909  3.9530495  2.0427139  2.3905014  0.3005478
## 36  9.7811636  9.4243644 10.2775898  9.5442477  9.3763617  8.8308030  8.8042352
## 37  7.7825164  7.1963911  8.7798436  7.6917140  7.6376016  6.6127212  6.6430232
## 38  9.4542298  9.0700243  9.9823116  9.2085159  9.0418278  8.4665212  8.4414374
## 39  9.3098671  8.9381492  9.8089385  9.0570833  8.8678334  8.3378933  8.3109339
## 40 11.4879111 11.2967864 11.4683051 11.0615573 10.7367903 10.6830784 10.6055881
## 41  9.5020137  9.0753375 10.1426604  9.3007617  9.1787943  8.4774516  8.4651200
## 42  9.8231966  9.4583236 10.3195181  9.5753499  9.4116549  8.8597535  8.8310688
## 43  9.0803242  8.5757207  9.9838618  8.9980069  8.9691703  8.0164356  8.0346786
## 44  7.0610651  6.3442517  8.2892222  7.0294122  7.0384931  5.7558361  5.8159460
## 45 10.2746890  9.9834730 10.5979968  9.9890647  9.7552996  9.3945206  9.3534170
##            36         37         38         39         40         41         42
## 2
## 3
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## 24
## 25
## 26
## 27
## 28
## 29
## 30
## 31
## 32
## 33
## 34
## 35
```

```
## 36
## 37  2.8096619
## 38  0.4848752  2.4082990
## 39  0.8147938  2.2668677  0.4395009
## 40  2.6176526  5.0966170  2.8339021  2.8539713
## 41  0.6550580  2.3441632  0.5180820  0.8893852  3.1790580
## 42  0.3178836  2.8294257  0.4723706  0.8371434  2.5683701  0.6206134
## 43  1.6785738  1.7770228  1.4726568  1.6528415  4.2065322  1.0714052  1.6593493
## 44  3.8593011  1.0822223  3.4577601  3.3250050  6.1297881  3.3701792  3.8749226
## 45  0.9877510  3.4000371  1.1779389  1.1617302  1.8330109  1.5469845  1.0242080
##           43         44
## 2
## 3
## 4
## 5
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## 28
## 29
## 30
## 31
## 32
## 33
## 34
## 35
## 36
## 37
## 38
## 39
## 40
## 41
## 42
```

```
## 43
## 44  2.6980372
## 45  2.5117392  4.4676868
```

Performing metric multidimensional scaling

```
library(MASS)
result3 <- cmdscale(DM, k=2, eig=T)
result3
```

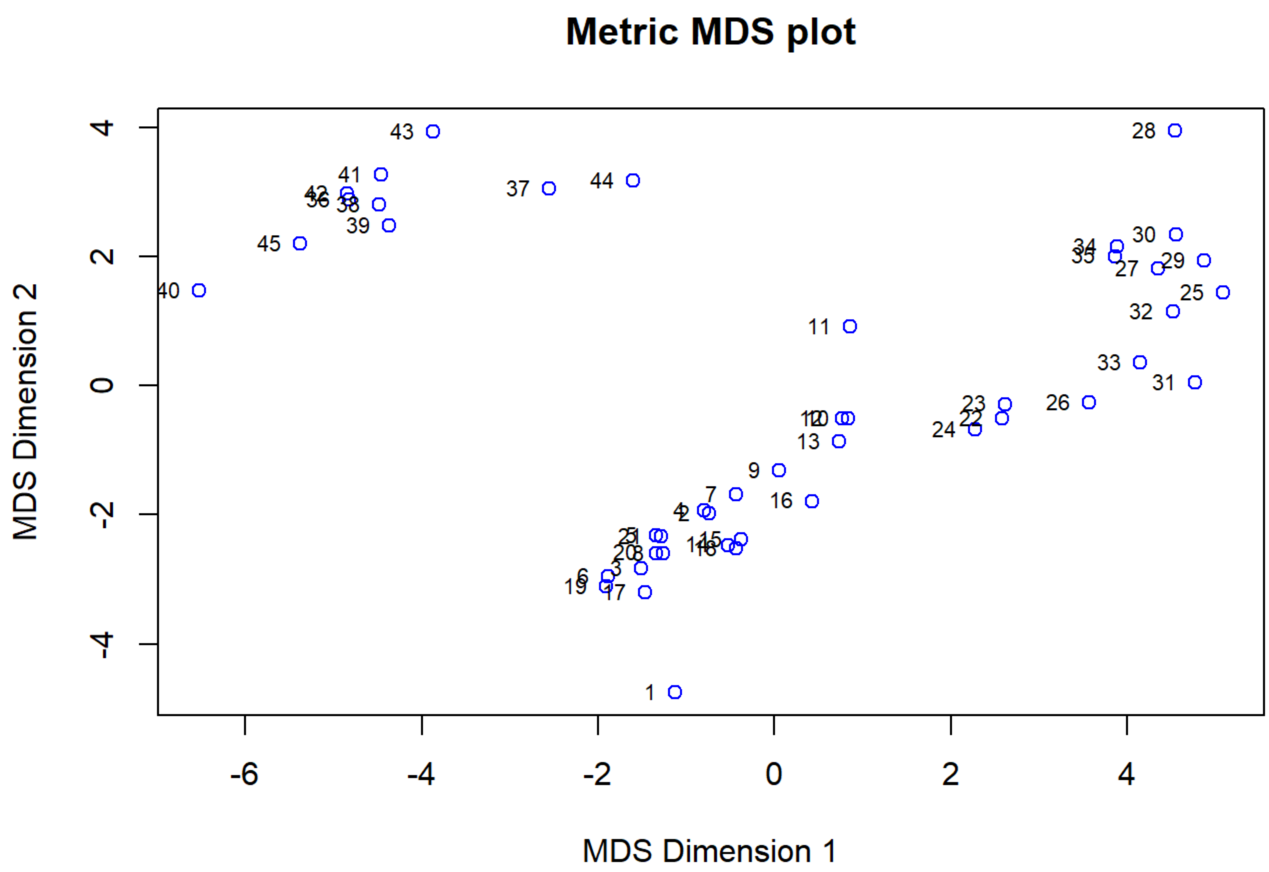
```
## $points
##              [,1]        [,2]
##  [1,] -1.12846613 -4.75148079
##  [2,] -0.73482683 -1.97439636
##  [3,] -1.51059389 -2.82757428
##  [4,] -0.79380335 -1.92987115
##  [5,] -1.34389686 -2.32247550
##  [6,] -1.88056878 -2.95630749
##  [7,] -0.42922498 -1.68212629
##  [8,] -1.26223731 -2.59400277
##  [9,]  0.05923424 -1.31233014
## [10,]  0.83909636 -0.50579000
## [11,]  0.85936094  0.90899306
## [12,]  0.76835310 -0.50376169
## [13,]  0.73487974 -0.86252664
## [14,] -0.52475459 -2.46800110
## [15,] -0.37922510 -2.37772806
## [16,]  0.42797346 -1.78604506
## [17,] -1.46497978 -3.20639681
## [18,] -0.42891018 -2.51840557
## [19,] -1.90586812 -3.10666740
## [20,] -1.34225216 -2.59202696
## [21,] -1.28064249 -2.33000126
## [22,]  2.57929991 -0.50553600
## [23,]  2.61639294 -0.28594279
## [24,]  2.28051036 -0.67555996
## [25,]  5.08780051  1.44595125
## [26,]  3.56655495 -0.25985799
## [27,]  4.34861198  1.81516968
## [28,]  4.54996985  3.94392245
## [29,]  4.87484070  1.93331566
## [30,]  4.55036420  2.33663337
## [31,]  4.77583845  0.04797429
## [32,]  4.51712798  1.14699412
## [33,]  4.14616064  0.35898282
## [34,]  3.88223484  2.15020401
## [35,]  3.85957654  2.00571860
## [36,] -4.81898394  2.87678215
## [37,] -2.55483061  3.04531286
## [38,] -4.48460428  2.80536630
## [39,] -4.36653520  2.48199788
## [40,] -6.52484064  1.47665576
## [41,] -4.46279611  3.27122401
## [42,] -4.84799638  2.97553789
## [43,] -3.87123174  3.93494662
## [44,] -1.60109289  3.17529275
## [45,] -5.38101937  2.19783654
##
## $eig
##  [1]  4.576144e+02  2.438495e+02  4.394545e+01  4.148068e+00  2.775338e+00
##  [6]  7.659476e-01  5.609699e-01  1.487223e-02  2.490874e-04  6.061675e-14
## [11]  5.395506e-14  3.085517e-14  1.752090e-14  1.437982e-14  1.379196e-14
```

```
## [16]  8.668990e-15  6.618089e-15  6.281056e-15  5.940582e-15  4.796410e-15
## [21]  4.618829e-15  4.203426e-15  3.401747e-15  2.387073e-15  8.903397e-16
## [26]  8.263687e-16 -1.941409e-15 -1.962393e-15 -2.107718e-15 -5.504986e-15
## [31] -6.235891e-15 -6.694958e-15 -6.876674e-15 -7.125445e-15 -8.294612e-15
## [36] -8.933064e-15 -1.095725e-14 -1.207173e-14 -1.249679e-14 -1.507591e-14
## [41] -1.521982e-14 -1.524731e-14 -1.632771e-14 -3.365819e-14 -4.346460e-14
##
## $x
## NULL
##
## $ac
## [1] 0
##
## $GOF
## [1] 0.9307249 0.9307249
```

Creating 2-D MDS plot

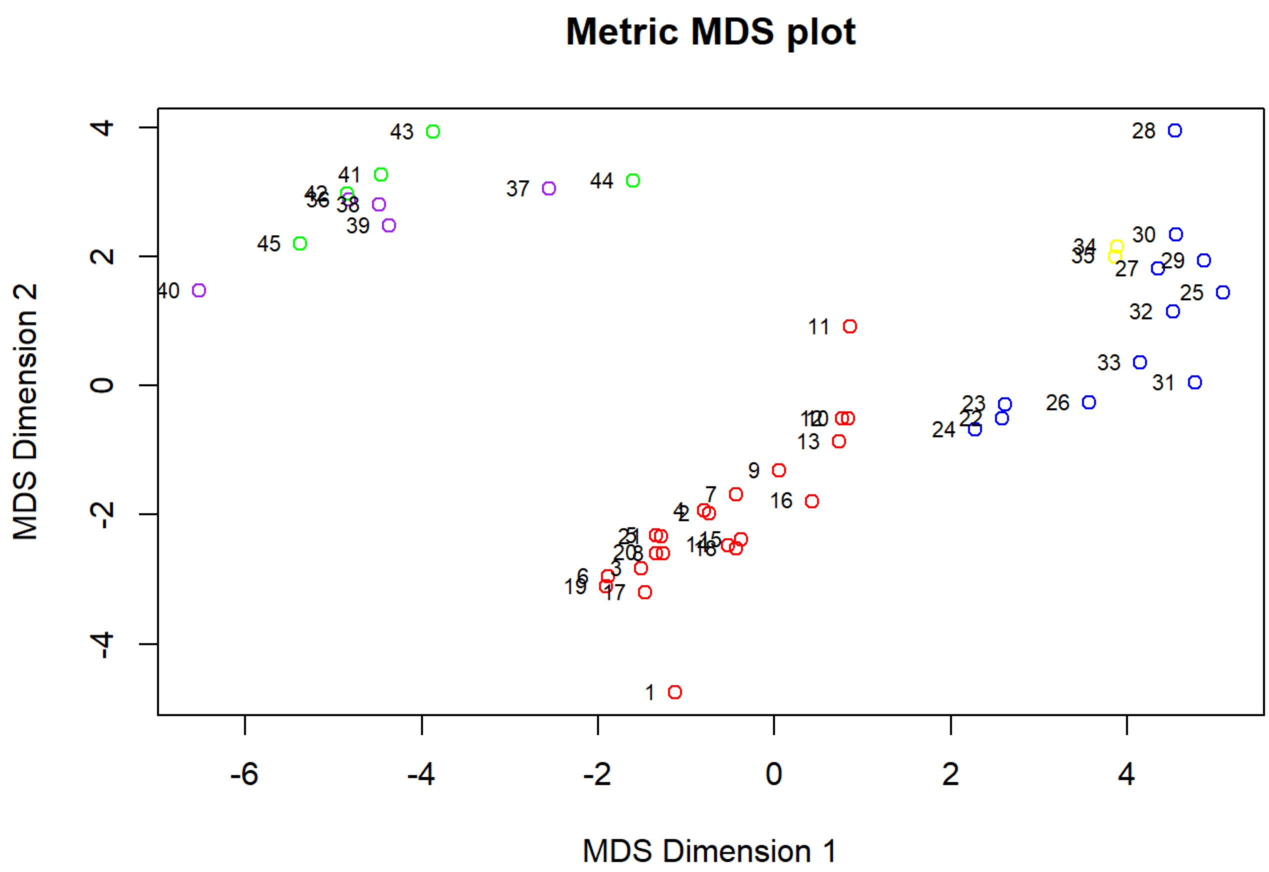
```
x <- result3$points[,1]
y <- result3$points[,2]

plot(x, y, type="n",xlab="MDS Dimension 1",ylab="MDS Dimension 2",
     main="Metric MDS plot")
points(x, y,lty=2, col="blue")
text(x, y, cex=0.7, pos=2)
```



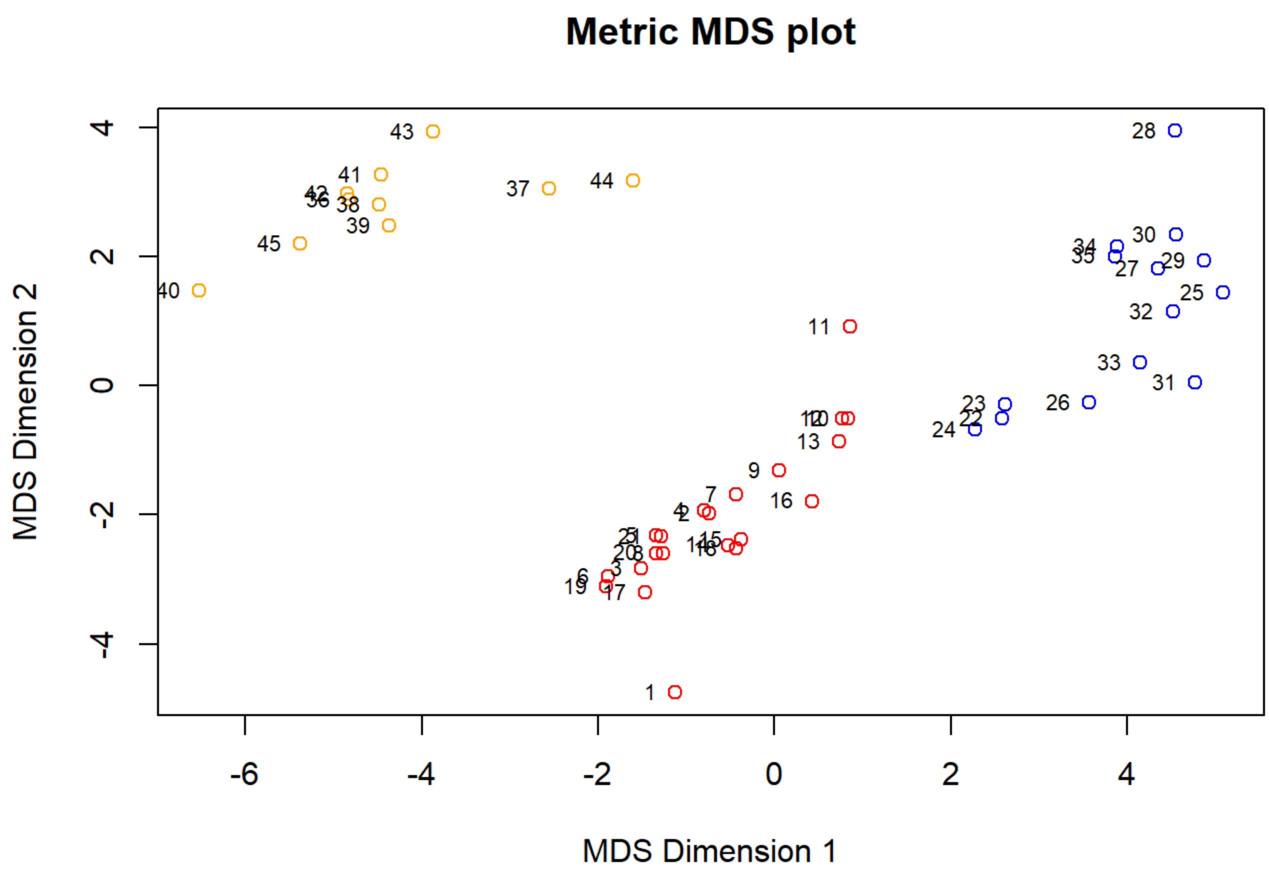
Modifying the plot using the given information for different kiln

```
kiln <- c(rep("red",21),rep("blue",12),rep("yellow",2),rep("purple",5),rep("green",5))
plot(x, y, type="p",xlab="MDS Dimension 1",ylab="MDS Dimension 2",
      main="Metric MDS plot",col=kiln)
text(x, y, pos=2, cex=0.7)
```



Modifying the plot using the given information for different regions

```
region <- c(rep("red",21),rep("blue",14),rep("orange",10))
plot(x, y, type="p",xlab="MDS Dimension 1",ylab="MDS Dimension 2",
      main="Metric MDS plot",col=region)
text(x, y, pos=2, cex=0.7)
```



Problem 4

Loading the dataset

```
garden <- read.csv("C:\\Users\\PREET PAUL\\Desktop\\Presidency University M.Sc. Notes\\3rd Semes
ter\\Garden.csv")
head(garden,5)
```

```
##                                    X Begonia..Bertinii.bolivienis.
## 1      Begonia (Bertinii bolivienis)                          0.00
## 2            Broom (Cytisus praecox)                          0.91
## 3                Camellia (Japonica)                          0.49
## 4                   Dahlia (Tartini)                          0.47
## 5 Forget-me-not (Myosotis sylvatica)                          0.43
##   Broom..Cytisus.praecox. Camellia..Japonica. Dahlia..Tartini.
## 1                    0.91                0.49             0.47
## 2                    0.00                0.67             0.59
## 3                    0.67                0.00             0.59
## 4                    0.59                0.59             0.00
## 5                    0.90                0.57             0.61
##   Forget.me.not..Myosotis.sylvatica. Fuchsia..Marinka. Geranium..Rubin.
## 1                               0.43              0.23             0.31
## 2                               0.90              0.79             0.70
## 3                               0.57              0.29             0.54
## 4                               0.61              0.52             0.44
## 5                               0.00              0.44             0.54
##   Gladiolus..Flowersong. Heather..Erica.carnea. Hydrangae..Hortensis.
## 1                   0.49                   0.57                  0.76
## 2                   0.57                   0.57                  0.58
## 3                   0.71                   0.57                  0.58
## 4                   0.26                   0.89                  0.62
## 5                   0.49                   0.50                  0.39
##   Iris..Versicolor. Lily..lilium.regale. Lily.of.the.valley..Convallaria.
## 1              0.32                 0.51                             0.59
## 2              0.77                 0.69                             0.75
## 3              0.63                 0.69                             0.75
## 4              0.75                 0.53                             0.77
## 5              0.46                 0.51                             0.35
##   Peony..Paeonia.lactiflora. Pink.carnation..Dianthus. Red.rose..Rosa.rugosa.
## 1                       0.37                      0.74                   0.84
## 2                       0.68                      0.54                   0.41
## 3                       0.68                      0.70                   0.75
## 4                       0.38                      0.58                   0.37
## 5                       0.52                      0.54                   0.82
##   Scotch.rose..Rosa.pimpinella. Tulip..Tulipa.sylevstris.
## 1                          0.94                      0.44
## 2                          0.20                      0.50
## 3                          0.70                      0.79
## 4                          0.48                      0.48
## 5                          0.77                      0.59
```

```
View(garden)
```

Creating new dataset after eliminating the 1st column

```
data1 <- garden[-c(1)]
```

Performing Non-metric MDS

```
library(MASS)
DM1 <- dist(data1)  #Distance matrix of the dataset
y <- cmdscale(data1, k=2)
result4 <- isoMDS(DM1, y, k=2)
```

```
## initial  value 16.163317
## iter   5 value 12.503665
## iter   5 value 12.499820
## iter   5 value 12.496624
## final  value 12.496624
## converged
```

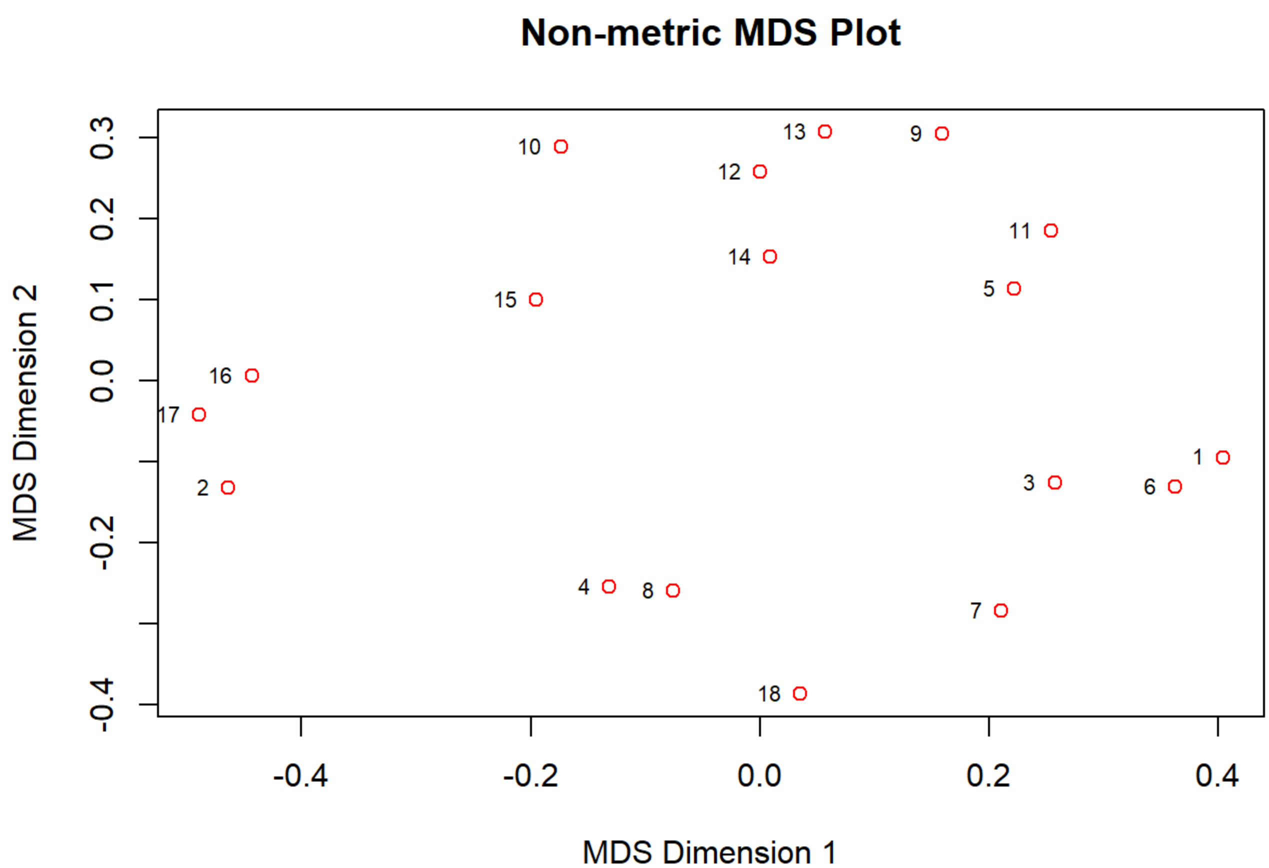
```
result4
```

```
## $points
##                [,1]         [,2]
##  [1,]  0.4045552703 -0.094740145
##  [2,] -0.4643132101 -0.132617312
##  [3,]  0.2576059227 -0.126118056
##  [4,] -0.1312892824 -0.254790848
##  [5,]  0.2223348167  0.112931398
##  [6,]  0.3625600545 -0.131030241
##  [7,]  0.2107348102 -0.284543457
##  [8,] -0.0753771664 -0.259857381
##  [9,]  0.1588832847  0.304169667
## [10,] -0.1737449485  0.288659273
## [11,]  0.2545265767  0.184419693
## [12,]  0.0003833766  0.257996619
## [13,]  0.0570302057  0.306519271
## [14,]  0.0093908213  0.152511682
## [15,] -0.1954026522  0.099778629
## [16,] -0.4434632630  0.005797364
## [17,] -0.4895645115 -0.042245762
## [18,]  0.0351498947 -0.386840396
##
## $stress
## [1] 12.49662
```

Creating 2-D MDS plot

```
x1 <- result4$points[,1]
y1 <- result4$points[,2]

plot(x1, y1, type="n",xlab="MDS Dimension 1", ylab="MDS Dimension 2",
     main="Non-metric MDS Plot")
points(x1, y1, col="red")
text(x1, y1, cex=0.7, pos=2)
```



Obtaining Kruskal’s stress value

```
cat("Kruskal's stress value is",result4$stress)
```

```
## Kruskal's stress value is 12.49662
```

Problem 5

Loading the dataset

```
fitness <- read.csv("C:\\Users\\PREET PAUL\\Desktop\\Presidency University M.Sc. Notes\\3rd Seme
ster\\Fitness.csv")
head(fitness,5)
```

```
##       X Weight Waist Pulse Chins Situps Jumps
## 1 ind01   86.6    36    50     5    162    60
## 2 ind02   85.7    37    52     2    110    60
## 3 ind03   87.5    38    58    12    101   101
## 4 ind04   73.5    35    62    12    105    37
## 5 ind05   85.7    35    46    13    155    58
```

```
View(fitness)
```

Creating new dataset after eliminating the 1st column

```
data2 <- fitness[-c(1)]
```

Conducting any Test of Significance

```
# Performing Pearsonian Chi-square test of significance
physiological <- data2[,c(1,2,3)]
exercise <- data2[,c(4,5,6)]

chisq.test(physiological, exercise)
```

```
##
##  Pearson's Chi-squared test
##
## data:  physiological
## X-squared = 31.962, df = 38, p-value = 0.7439
```

From the above, we clearly see that p-value is greater than 0.05. S, we can say that the two sets of variables are dependent to one another.

Obtaining the Correlation matrix of 6 variables

```
R1 <- cor(data2)
R1
```

```
##            Weight     Waist       Pulse      Chins     Situps       Jumps
## Weight  1.0000000  0.8705315 -0.36598748 -0.3889028 -0.4926890 -0.22557969
## Waist   0.8705315  1.0000000 -0.35289213 -0.5522321 -0.6455980 -0.19149937
## Pulse  -0.3659875 -0.3528921  1.00000000  0.1506480  0.2250381  0.03493306
## Chins  -0.3889028 -0.5522321  0.15064802  1.0000000  0.6957274  0.49576018
## Situps -0.4926890 -0.6455980  0.22503808  0.6957274  1.0000000  0.66920608
## Jumps  -0.2255797 -0.1914994  0.03493306  0.4957602  0.6692061  1.00000000
```

Performing Canonical Correlation Analysis

```
cca <- cancor(physiological, exercise)
cca
```

```
## $cor
## [1] 0.79603773 0.19974558 0.07272713
##
## $xcoef
##                [,1]         [,2]         [,3]
## Weight -0.015977614 -0.038696261  0.003810726
## Waist   0.113338114  0.084703278 -0.036009533
## Pulse  -0.001888831 -0.007269599 -0.033452939
##
## $ycoef
##                [,1]          [,2]         [,3]
## Chins  -0.015212736 -0.0167974765  0.056110718
## Situps -0.003861064  0.0004926267 -0.004534031
## Jumps   0.003203262  0.0047356452  0.001918459
##
## $xcenter
## Weight  Waist  Pulse
## 81.005 35.400 56.100
##
## $ycenter
##  Chins Situps  Jumps
##   9.45 145.55  70.30
```

Canonical coefficient of physiological

```
cca$xcoef
```

```
##                [,1]         [,2]         [,3]
## Weight -0.015977614 -0.038696261  0.003810726
## Waist   0.113338114  0.084703278 -0.036009533
## Pulse  -0.001888831 -0.007269599 -0.033452939
```

Canonical coefficient of exercise

```
cca$ycoef
```

```
##                [,1]          [,2]         [,3]
## Chins  -0.015212736 -0.0167974765  0.056110718
## Situps -0.003861064  0.0004926267 -0.004534031
## Jumps   0.003203262  0.0047356452  0.001918459
```

Canonical Variates

```
phys1 <- as.matrix(physiological) %*% cca$xcoef[,1]
phys2 <- as.matrix(physiological) %*% cca$xcoef[,2]
phys3 <- as.matrix(physiological) %*% cca$xcoef[,3]
exer1 <- as.matrix(exercise) %*% cca$ycoef[,1]
exer2 <- as.matrix(exercise) %*% cca$ycoef[,2]
exer3 <- as.matrix(exercise) %*% cca$ycoef[,3]
```

Correlation between Physiological variables & their Canonical covariates

```
cor(physiological, cbind(phys1, phys2, phys3))
```

```
##              [,1]       [,2]        [,3]
## Weight  0.6200900 -0.7731740  0.13300535
## Waist   0.9249323 -0.3789365  0.03012218
## Pulse  -0.3325980  0.0445614 -0.94201532
```

Correlation between Exercise variables & their Canonical covariates

```
cor(exercise, cbind(exer1, exer2, exer3))
```

```
##              [,1]      [,2]        [,3]
## Chins  -0.7281842 0.2311696  0.64521969
## Situps -0.8177403 0.5734073 -0.05004876
## Jumps  -0.1624810 0.9565018  0.24228947
```

Correlation between Exercise variables & Canonical covariates of Physiological variable

```
cor(exercise, cbind(phys1, phys2, phys3))
```

```
##              [,1]       [,2]         [,3]
## Chins  -0.5796621 0.04617511  0.046924973
## Situps -0.6509521 0.11453557 -0.003639903
## Jumps  -0.1293410 0.19105701  0.017621017
```

Correlation between Physiological variables & Canonical covariates of Exercise variable

```
cor(physiological, cbind(exer1, exer2, exer3))
```

```
##              [,1]         [,2]         [,3]
## Weight  0.4936150 -0.154438083  0.009673097
## Waist   0.7362810 -0.075690884  0.002190700
## Pulse  -0.2647605  0.008900944 -0.068510066
```