Math 189 HW 6

Group Members:

Yaqi Chen (PID: A15742547; Section: A03)

Yuetong Lyu (PID: A 13779993; Section: A04)

Siyi He (PID: A13400569; Section: A03)

Zhenyuan Xu (PID: A92067995; Section: A02)

Jiawei Chao (PID: A138001; Section: A02)

Problem 1A

Standardized Data:

```
place <- read.table('Places_Rated.txt')
place <- place[,1:9]
std <- scale(place)

#Eigenvalues and Eigenvectors
pca <- prcomp(std)
pca$sdev
pca$rotation

#Proportion
pca_var <- pca$sdev^2
proportion <- pca_var/sum(pca_var)
proportion

#Scree Plot
png(file = 'Scree.png', width = 640, height = 480)
plot(proportion, xlab = 'Principla Component', ylab = 'Proportion of Variance
Explained', ylim = c(0,1),
     xaxt = 'n', type = 'b', col = 'blue', cex = 2, pch = 20, cex.lab = 1.5)
axis(1, at = c(1:9), labels = c(1:9))
dev.off()

#Cumulative Plot
```

```
png(file = 'Cumulative.png', width = 640, height = 480)
plot(cumsum(proportion), xlab = 'Principla Component', ylab = 'Cumulative
Proportion of Variance Explained',
     ylim = c(0,1), xaxt = 'n', type = 'b', col = 'black', cex = 2, pch = 20,
cex.lab = 1.5)
axis(1, at = c(1:9), labels = c(1:9))
dev.off()
```

Output: (Standardized)

Eigenvalues and Eigenvectors:

```
> pca$sdev
[1] 1.8461560 1.1018059 1.0684003 0.9596446 0.8679199 0.7940793 0.7021736
0.5639490 0.3469900
> pca$rotation
           PC1          PC2          PC3          PC4          PC5          PC6
PC7          PC8
v1 0.2064140   0.2178353 -0.689955982  0.13732125 -0.3691499  0.37460469
-0.08470577 -0.36230833
v2 0.3565216   0.2506240 -0.208172230  0.51182871  0.2334878 -0.14163983
-0.23063862  0.61385513
v3 0.4602146  -0.2994653 -0.007324926  0.01470183 -0.1032405 -0.37384804
 0.01386761 -0.18567612
v4 0.2812984   0.3553423  0.185104981 -0.53905047 -0.5239397  0.08092329
 0.01860646  0.43002477
v5 0.3511508  -0.1796045  0.146376283 -0.30290371  0.4043485  0.46759180
-0.58339097 -0.09359866
v6 0.2752926  -0.4833821  0.229702548  0.33541103 -0.2088191  0.50216981
 0.42618186  0.18866756
v7 0.4630545  -0.1947899 -0.026484298 -0.10108039 -0.1050976 -0.46188072
-0.02152515 -0.20398969
v8 0.3278879   0.3844746 -0.050852640 -0.18980082  0.5295406  0.08991578
 0.62787789 -0.15059597
v9 0.1354123   0.4712833  0.607314475  0.42176994 -0.1596201  0.03260813
-0.14974066 -0.40480926
           PC9
v1  0.0013913515
v2  0.0136003402
v3 -0.7163548935
v4 -0.0586084614
v5  0.0036294527
v6  0.1108401911
v7  0.6857582127
```
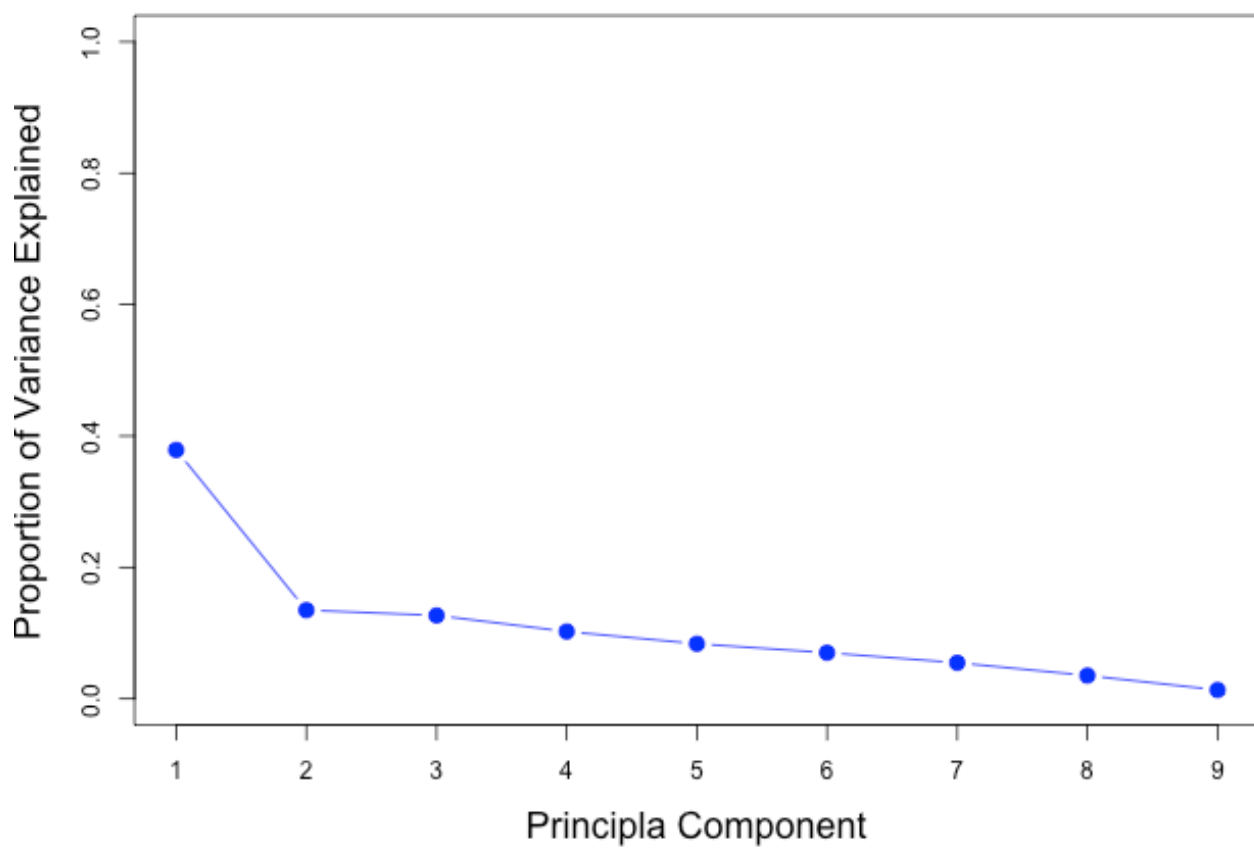
```
v8 -0.0255062915
v9  0.0004377942
```
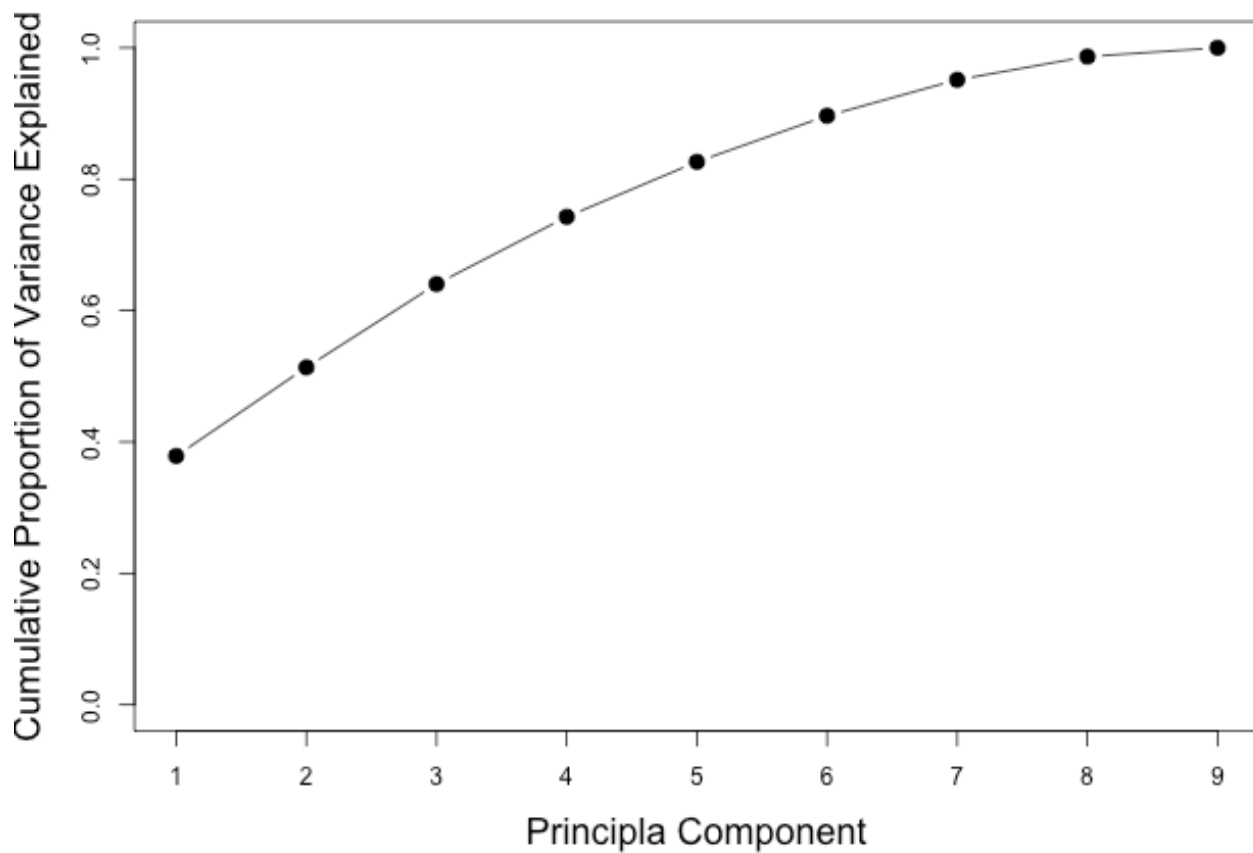
Proportion:

```
> proportion
[1] 0.37869909 0.13488624 0.12683102 0.10232420 0.08369832 0.07006243 0.05478308
0.03533761 0.01337801
```

Scree Plot:

Cumulative Plot:

Raw Data:

```
#Eigenvalues and Eigenvectors
pca_raw <- prcomp(place, scale = FALSE)
pca_raw$sdev
pca_raw$rotation

#Proportion
pca_raw_var <- pca_raw$sdev^2
proportion_raw <- pca_raw_var/sum(pca_raw_var)
proportion

#Scree Plot
png(file = 'Scree_raw.png', width = 640, height = 480)
plot(proportion_raw, xlab = 'Principla Component', ylab = 'Proportion of Variance
Explained', ylim = c(0,1),
     xaxt = 'n', type = 'b', col = 'blue', cex = 2, pch = 20, cex.lab = 1.5)
axis(1, at = c(1:9), labels = c(1:9))
dev.off()
```

```
#Cumulative Plot
png(file = 'Cumulative_raw.png', width = 640, height = 480)
plot(cumsum(proportion_raw), xlab = 'Principla Component', ylab = 'Cumulative
Proportion of Variance Explained',
    ylim = c(0,1), xaxt = 'n', type = 'b', col = 'black', cex = 2, pch = 20,
cex.lab = 1.5)
axis(1, at = c(1:9), labels = c(1:9))
dev.off()
```

Output: (Raw)

Eigenvalues and Eigenvectors:

```
> pca_raw$sdev
[1] 4941.0190 2099.5249 1279.8592 1037.4757  691.6200  490.7665  304.6472
 258.8357  104.7026
> pca_raw$rotation
          PC1           PC2           PC3           PC4           PC5           PC6
     PC7          PC8
v1 0.006416346 -0.015459527  0.006692298  0.02631066  0.016278231  0.001186617
 0.08140848 -0.04213801
v2 0.269142181 -0.937207188  0.082641934  0.17775057 -0.083842278  0.048638182
 0.02668780 -0.01211847
v3 0.178318724  0.020539870 -0.027761041  0.02656157 -0.159075722 -0.929492918
 0.13706121  0.24135975
v4 0.028134276  0.010901921 -0.037610931 -0.09903536  0.116013534  0.053976191
 0.94477955 -0.26682693
v5 0.149302463 -0.018757344 -0.971531831  0.03839697 -0.146649668  0.092235051
-0.01354542  0.04150769
v6 0.025190912  0.001395877 -0.041507669 -0.02163938 -0.106255968 -0.253188491
-0.24115526 -0.92915944
v7 0.930859522  0.282260587  0.151026851 -0.02775471  0.008673762  0.167554494
-0.04296041 -0.01594931
v8 0.069824043 -0.103848215 -0.149571984 -0.06903276  0.954262248 -0.173348306
-0.12711706 -0.01878071
v9 0.025130829 -0.173359958 -0.012743344 -0.97453606 -0.102240592 -0.005152175
-0.07016097  0.05439799
            PC9
v1  0.9951449417
v2 -0.0229330011
v3  0.0013718748
v4 -0.0876894940
v5  0.0094188168
```
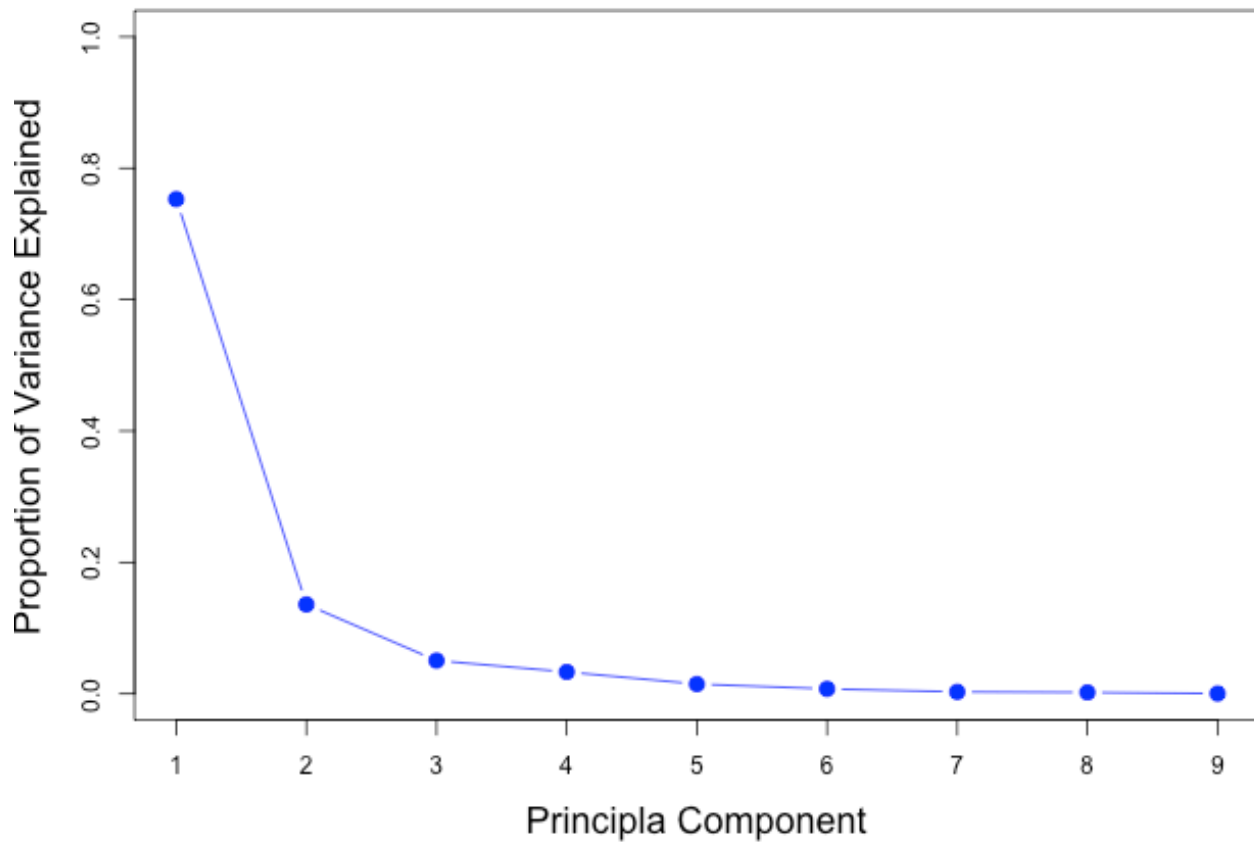
```
v6 -0.0168655619
v7  0.0005985854
v8 -0.0050315892
v9  0.0327178331
```
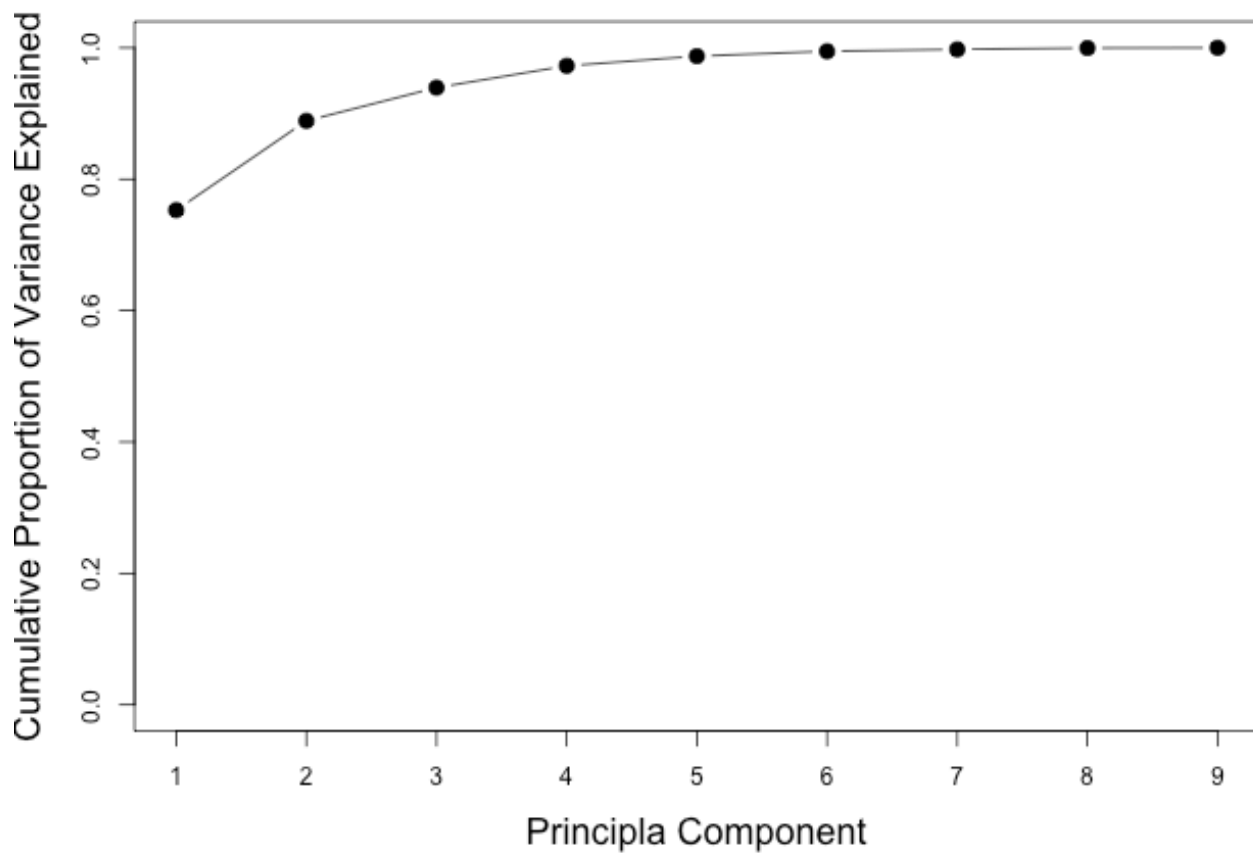
Proportion:

```
> proportion_raw
[1] 0.752903473 0.135940329 0.050516197 0.033194192 0.014751677 0.007427731
0.002862205 0.002066115
[9] 0.000338081
```

Scree Plot:

Cumulative Plot:

Cumulative Proportion of Variance Explained vs Principla Component

Problem 1B

According to the plots in 1A, the number of principle components is 5.

The corresponding loading vectors are the first 5 eigenvectors.

```r
for (i in 1:5){
    loading <- t(pca$rotation)[i,1:9]
    print(loading)
}
```

```r
#Projecting the observations
biplot(pca, scale = 0)
```

Output:

```
        v1          v2          v3          v4          v5          v6          v7          v8
      v9
0.2064140 0.3565216 0.4602146 0.2812984 0.3511508 0.2752926 0.4630545 0.3278879
0.1354123


        v1          v2          v3          v4          v5          v6          v7
   v8
0.2178353   0.2506240  -0.2994653   0.3553423  -0.1796045  -0.4833821  -0.1947899
 0.3844746
        v9
0.4712833


         v1            v2            v3            v4            v5            v6
      v7
-0.689955982  -0.208172230  -0.007324926   0.185104981   0.146376283   0.229702548
-0.026484298
          v8            v9
-0.050852640   0.607314475


         v1            v2            v3            v4            v5            v6
  v7
 0.13732125   0.51182871   0.01470183  -0.53905047  -0.30290371   0.33541103
-0.10108039
         v8            v9
-0.18980082   0.42176994


        v1          v2          v3          v4          v5          v6          v7
    v8
-0.3691499   0.2334878  -0.1032405  -0.5239397   0.4043485  -0.2088191  -0.1050976
 0.5295406
        v9
-0.1596201
```