K means Clustering

ManojKumar Chalamala

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Install the required Packages

```
#install.packages("tidyverse")
library(tidyverse)
```

```
## -- Attaching packages ---------------------------------------- tidyverse 1.2.1 --
```

```
## v ggplot2 3.2.1      v purrr   0.3.2
## v tibble  2.1.3      v dplyr   0.8.3
## v tidyr   1.0.0      v stringr 1.4.0
## v readr   1.3.1      v forcats 0.4.0
```

```
## -- Conflicts ------------------------------------------- tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
#install.packages("factoextra")
library(factoextra)
```

```
## Welcome! Related Books: `Practical Guide To Cluster Analysis in R` at https://goo.gl/13EFCZ
```

```
library(readr)
library(ISLR)
library(caret)
```

```
## Loading required package: lattice
```

```
##
## Attaching package: 'caret'
```

```
## The following object is masked from 'package:purrr':
##
##     lift
```

```
library(ggplot2)
```

Read the data

```
Univ <- read.csv("Universities.csv")
str(Univ)
```

```
## 'data.frame':    1302 obs. of  20 variables:
##  $ College.Name            : Factor w/ 1274 levels "Abilene Christian University",..: 8 1004
1005 1003 6 327 1084 7 43 88 ...
##  $ State                   : Factor w/ 51 levels "AK","AL","AR",..: 1 1 1 1 2 2 2 2 2 2 ...
##  $ Public..1...Private..2. : int  2 1 1 1 1 2 1 1 1 2 ...
##  $ X..appli..rec.d         : int  193 1852 146 2065 2817 345 1351 4639 7548 805 ...
##  $ X..appl..accepted       : int  146 1427 117 1598 1920 320 892 3272 6791 588 ...
##  $ X..new.stud..enrolled   : int  55 928 89 1162 984 179 570 1278 3070 287 ...
##  $ X..new.stud..from.top.10.: int  16 NA 4 NA NA NA 18 NA 25 67 ...
##  $ X..new.stud..from.top.25.: int  44 NA 24 NA NA 27 78 NA 57 88 ...
##  $ X..FT.undergrad         : int  249 3885 492 6209 3958 1367 2385 4051 16262 1376 ...
##  $ X..PT.undergrad         : int  869 4519 1849 10537 305 578 331 405 1716 207 ...
##  $ in.state.tuition        : int  7560 1742 1742 1742 1700 5600 2220 1500 2100 11660 ...
##  $ out.of.state.tuition    : int  7560 5226 5226 5226 3400 5600 4440 3000 6300 11660 ...
##  $ room                    : int  1620 1800 2514 2600 1108 1550 NA 1960 NA 2050 ...
##  $ board                   : int  2500 1790 2250 2520 1442 1700 NA NA NA 2430 ...
##  $ add..fees               : int  130 155 34 114 155 300 124 84 NA 120 ...
##  $ estim..book.costs       : int  800 650 500 580 500 350 300 500 600 400 ...
##  $ estim..personal..       : int  1500 2304 1162 1260 850 NA 600 NA 1908 900 ...
##  $ X..fac..w.PHD           : int  76 67 39 48 53 52 72 48 85 74 ...
##  $ stud..fac..ratio        : num  11.9 10 9.5 13.7 14.3 32.8 18.9 18.7 16.7 14 ...
##  $ Graduation.rate         : int  15 NA 39 NA 40 55 51 15 69 72 ...
```

a. Remove all records with missing measurements from the dataset.

```
# remove all the missing values from the dataset by using na.omit
MyData <- na.omit(Univ)

# remove all the categorical variables from the dataset
MyData <- MyData[, c(-1, -2, -3)]
```

b. For all the continuous measurements, run K-Means clustering. Make sure to normalize the measurements. How many clusters seem reasonable for describing these data? What was your optimal K?

```
# Scaling the data frame (z-score)
MyData <- scale(MyData)
View(MyData)
distance <- get_dist(MyData)
fviz_dist(distance)
```
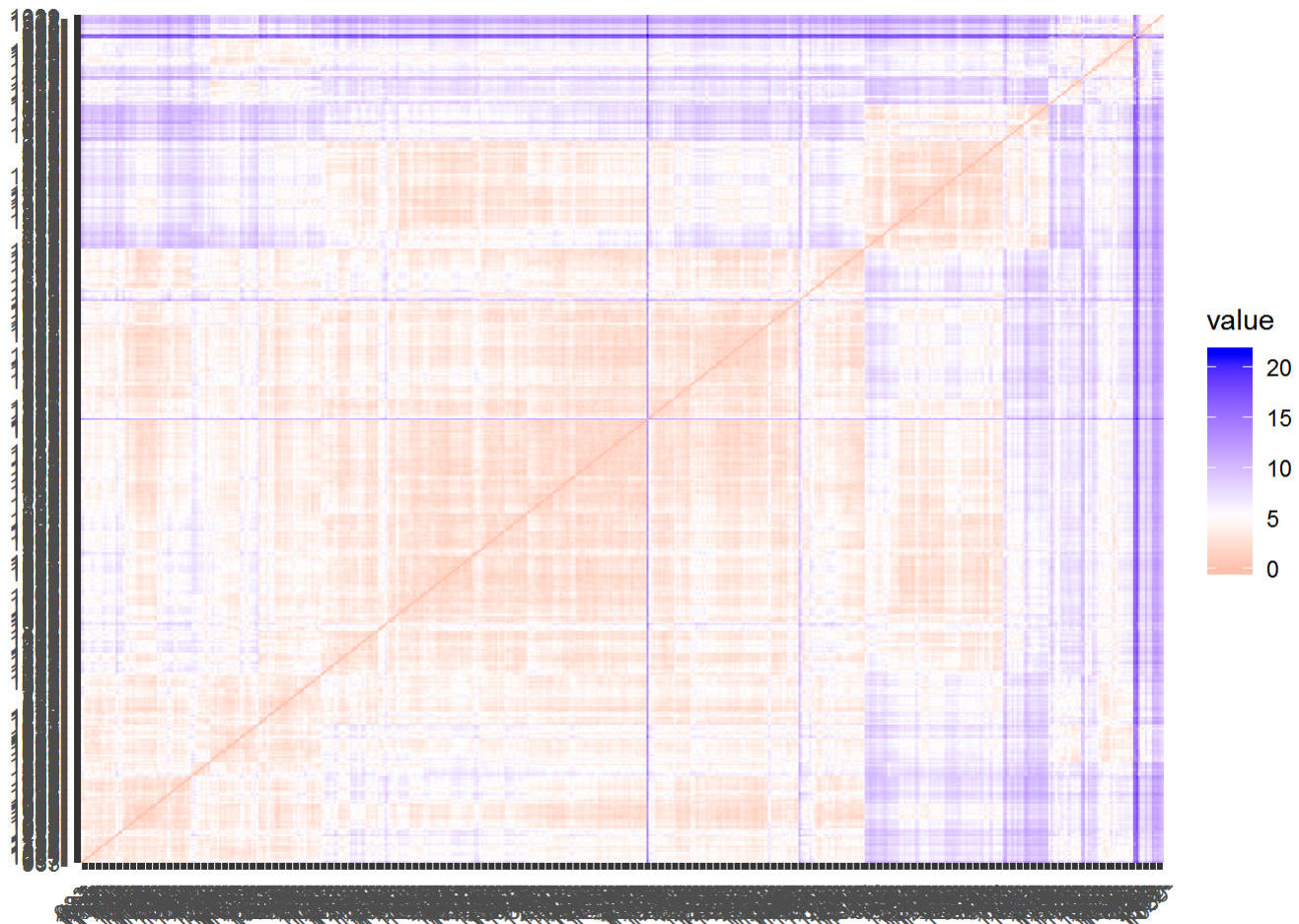


```
# Determining K
# WSS method - Let us use an "elbow chart" to determine k
fviz_nbclust(MyData, kmeans, method = "wss")
```

Optimal number of clusters
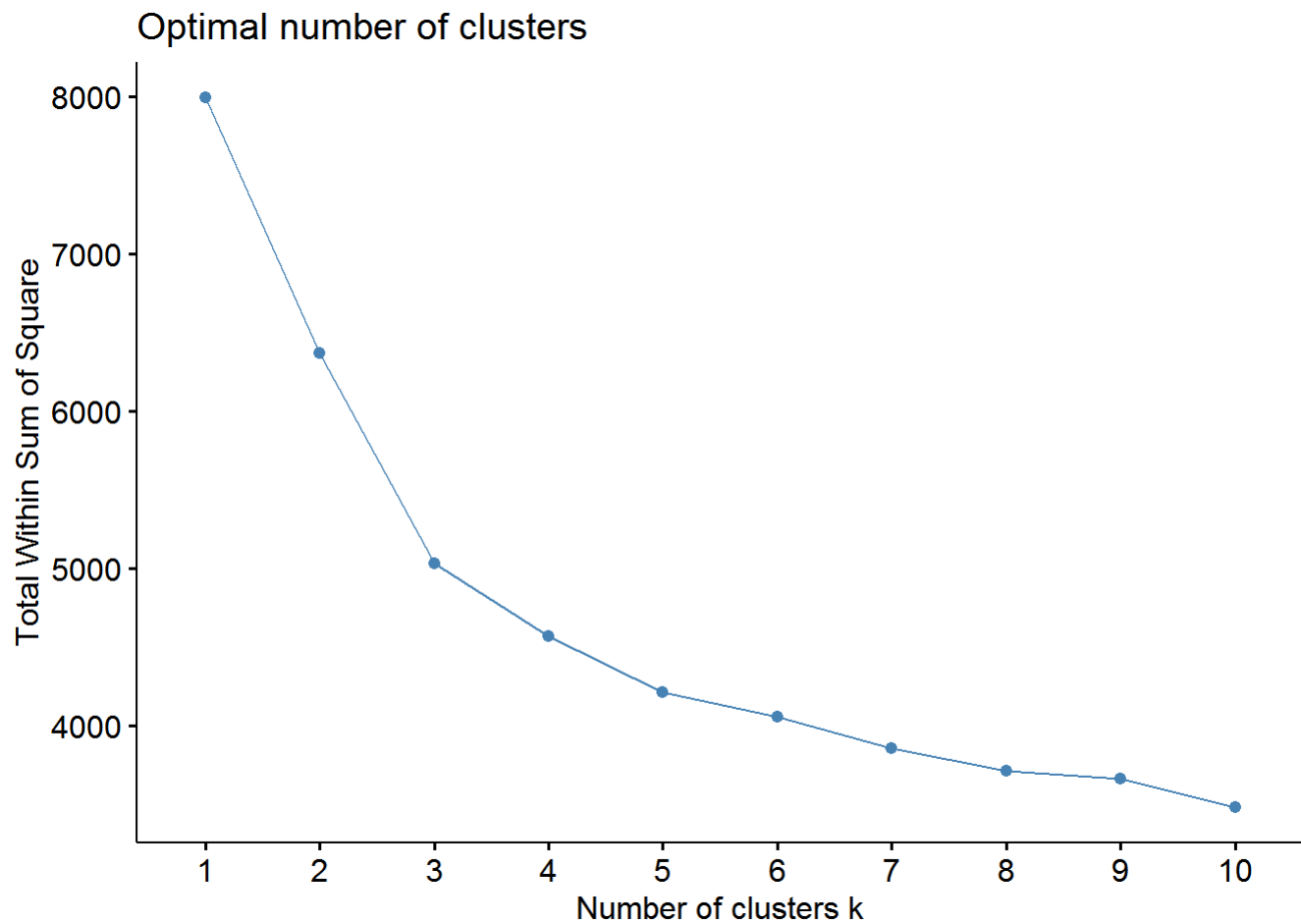

```
# The chart shows that the elbow point 3 provides the best value for k.

# Silhouette Method - Let us now apply the Silhouette Method to determine the number of clusters
fviz_nbclust(MyData, kmeans, method = "silhouette")
```

Optimal number of clusters
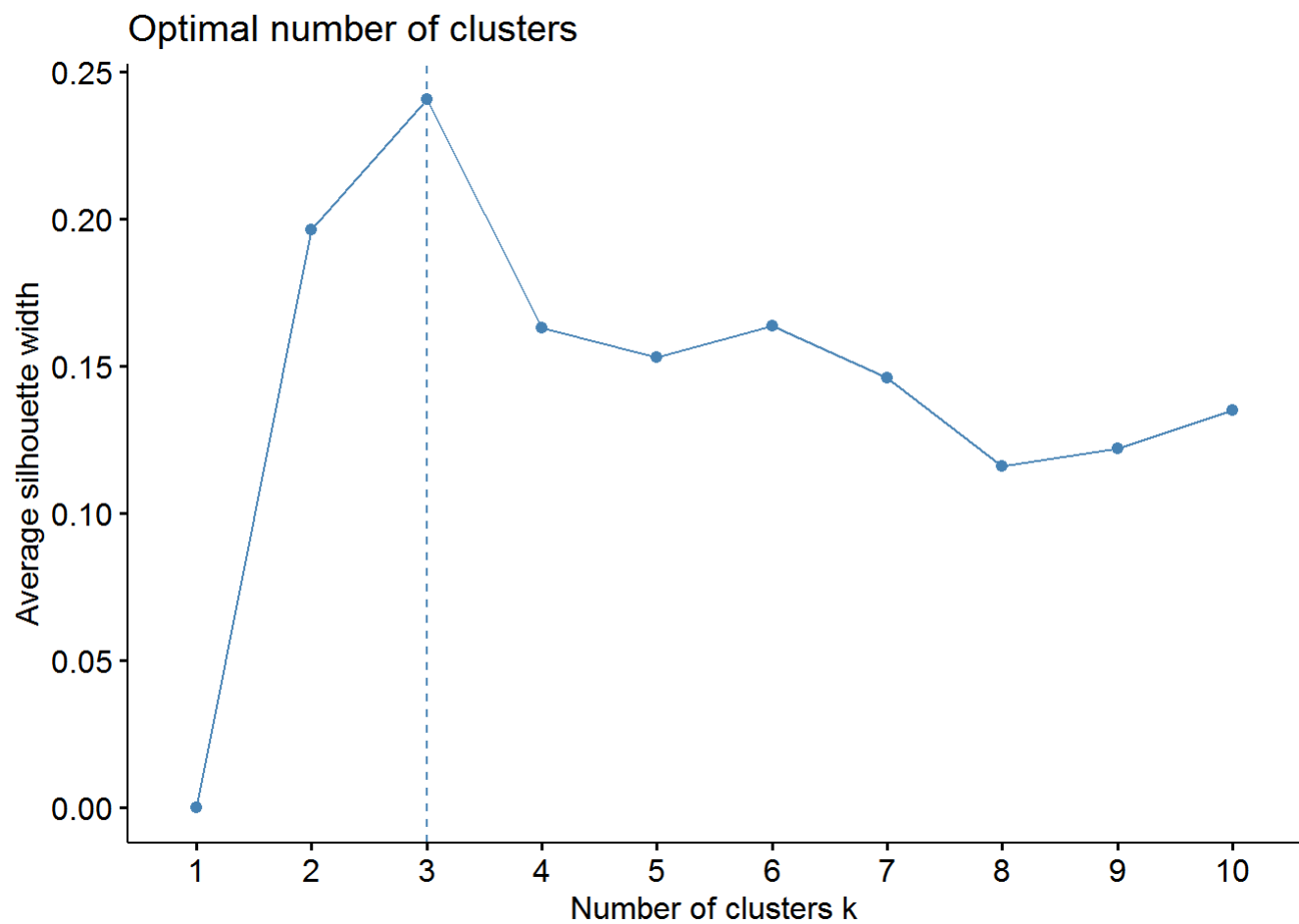

```
# We see that 3 is the ideal number of clusters.

# Run the Kmeans algorithm for clustering.
# We will choose an initial value of k = 3, number of restarts =15
k3 <- kmeans(MyData, centers = 3, nstart = 15)

# Visualize the output
k3$centers # output the centers
```

```
##    X..appli..rec.d X..appl..accepted X..new.stud..enrolled
## 1     -0.35953828      -0.34918455            -0.3171053
## 2      0.05140256      -0.04367128            -0.1683551
## 3      1.98179657       2.22992267             2.4447222
##    X..new.stud..from.top.10. X..new.stud..from.top.25. X..FT.undergrad
## 1               -0.5020886               -0.5128195      -0.2952142
## 2                0.8795798                0.8620961      -0.2324464
## 3                0.1334215                0.2545856       2.5228452
##    X..PT.undergrad in.state.tuition out.of.state.tuition        room
## 1      -0.1217682       -0.4036544           -0.5263964 -0.3588740
## 2      -0.3130216        1.0620416            1.1158839  0.6698444
## 3       1.7486849       -1.0500277           -0.4918168 -0.0388330
##         board    add..fees estim..book.costs estim..personal.. X..fac..w.PHD
## 1 -0.3938990 -0.05832646       -0.06621454        0.05935933     -0.5322257
## 2  0.7756859 -0.04496556        0.07122705       -0.39665857      0.7659627
## 3 -0.1745795  0.49531762        0.16358567        0.93858632      0.6840794
##    stud..fac..ratio Graduation.rate
## 1        0.2810858      -0.4171456
## 2       -0.7036167       0.8426062
## 3        0.6139980      -0.2538234
```

```
k3$size #No. of Universities in each cluster
```

```
## [1] 275 150  46
```

```
k3 # mean of each cluster
```

```
## K-means clustering with 3 clusters of sizes 275, 150, 46
##
## Cluster means:
##   X..appli..rec.d X..appl..accepted X..new.stud..enrolled
## 1     -0.35953828       -0.34918455            -0.3171053
## 2      0.05140256       -0.04367128            -0.1683551
## 3      1.98179657        2.22992267             2.4447222
##   X..new.stud..from.top.10. X..new.stud..from.top.25. X..FT.undergrad
## 1                -0.5020886                -0.5128195      -0.2952142
## 2                 0.8795798                 0.8620961      -0.2324464
## 3                 0.1334215                 0.2545856       2.5228452
##   X..PT.undergrad in.state.tuition out.of.state.tuition      room
## 1      -0.1217682      -0.4036544           -0.5263964 -0.3588740
## 2      -0.3130216       1.0620416            1.1158839  0.6698444
## 3       1.7486849      -1.0500277           -0.4918168 -0.0388330
##        board    add..fees estim..book.costs estim..personal.. X..fac..w.PHD
## 1 -0.3938990 -0.05832646       -0.06621454        0.05935933    -0.5322257
## 2  0.7756859 -0.04496556        0.07122705       -0.39665857     0.7659627
## 3 -0.1745795  0.49531762        0.16358567        0.93858632     0.6840794
##   stud..fac..ratio Graduation.rate
## 1        0.2810858      -0.4171456
## 2       -0.7036167       0.8426062
## 3        0.6139980      -0.2538234
##
## Clustering vector:
##     1    3   10   12   22   26   32   38   39   46   49   50   63   77   78
##     1    1    2    1    1    1    1    1    1    1    3    3    3    2    2
##    79   81   90   92   95   96   97  108  110  112  120  121  122  123  126
##     2    2    2    1    2    1    2    2    3    2    2    1    1    2    1
##   127  130  134  139  140  146  148  149  151  152  153  154  156  158  160
##     1    1    1    1    2    1    2    2    2    2    2    1    3    2    2
##   161  164  168  169  172  174  176  181  186  188  190  194  208  210  220
##     2    2    3    1    1    2    1    1    2    2    2    3    1    2    1
##   228  230  235  236  239  244  245  246  247  248  250  251  252  258  259
##     2    3    1    1    1    1    1    1    2    1    1    1    2    1    1
##   260  262  263  264  265  268  269  270  272  275  277  287  294  297  298
##     1    1    1    1    1    1    1    1    1    1    2    1    2    2    2
##   302  304  312  317  319  320  321  322  323  324  326  329  330  331  332
##     1    2    1    1    1    1    2    3    3    1    1    2    2    2    1
##   333  336  340  349  352  359  360  362  365  366  368  369  370  376  377
##     1    1    1    1    1    1    2    2    2    2    1    1    1    1    1
##   382  387  390  395  398  400  403  405  412  415  418  421  428  433  436
##     1    1    1    2    1    1    1    2    1    1    3    2    2    2    2
##   438  441  442  443  444  451  452  454  456  457  460  462  463  464  467
##     2    3    1    2    2    1    2    1    2    1    1    1    1    2    3
##   477  479  481  483  484  494  500  505  511  513  514  515  520  522  525
##     3    2    2    2    2    2    1    3    1    2    2    1    1    1    1
##   526  527  528  537  538  541  543  544  551  552  556  558  563  564  565
##     2    2    1    2    2    1    3    1    1    1    3    1    2    1    1
##   567  571  572  577  578  579  582  584  587  589  591  595  598  599  605
##     2    2    2    1    1    1    1    3    1    1    1    1    1    1    1
##   606  607  608  614  615  616  617  618  626  627  629  630  633  638  642
##     1    3    2    2    1    1    1    1    1    1    1    1    1    1    1
```

```
##  646  647  651  654  655  656  658  659  660  662  666  667  670  673  674
##    3    1    1    2    2    3    1    1    1    1    1    1    1    1    1
##  676  677  681  682  684  687  688  689  691  693  696  697  698  702  703
##    1    2    3    3    1    1    1    1    1    1    1    1    1    2    1
##  704  705  710  712  713  716  717  720  723  724  726  732  733  736  737
##    1    1    1    3    1    2    1    1    3    1    1    2    1    1    1
##  738  739  742  744  745  746  750  751  754  756  757  769  771  772  777
##    1    1    2    1    2    1    1    3    1    1    1    2    1    1    2
##  778  782  783  789  792  793  794  795  801  803  804  814  815  823  824
##    2    2    2    1    2    2    2    1    2    2    1    1    2    2    2
##  825  826  828  831  833  834  836  837  838  839  840  841  843  844  845
##    2    1    1    2    3    3    1    1    1    1    1    1    1    1    1
##  846  848  851  860  869  870  872  874  875  878  879  882  885  889  891
##    2    2    2    1    1    1    3    2    1    1    1    2    1    2    1
##  892  893  894  896  898  901  903  904  907  911  912  916  917  928  929
##    2    1    1    2    3    1    3    2    1    2    1    3    1    1    1
##  931  932  933  939  943  945  950  952  955  958  959  963  965  967  969
##    1    3    1    1    1    2    2    2    2    2    2    2    2    2    2
##  971  974  975  977  978  979  986  987  988  989  991  992  994  996  997
##    2    1    2    1    1    2    2    1    2    2    2    1    1    2    2
## 1001 1009 1010 1014 1017 1020 1021 1023 1024 1025 1026 1027 1029 1030 1031
##    1    1    1    1    1    1    2    3    1    2    3    2    2    2    1
## 1032 1033 1035 1036 1037 1039 1041 1043 1047 1048 1051 1052 1053 1055 1059
##    1    1    1    1    1    3    2    2    3    1    1    1    1    1    1
## 1060 1061 1064 1065 1075 1079 1081 1084 1087 1089 1090 1095 1096 1098 1101
##    2    1    1    2    1    1    1    1    1    1    1    1    1    1    1
## 1102 1105 1107 1110 1111 1115 1117 1118 1121 1125 1127 1131 1132 1138 1139
##    1    1    2    1    1    3    2    2    1    1    1    1    1    3    1
## 1143 1146 1152 1154 1156 1158 1163 1164 1166 1168 1172 1176 1177 1181 1185
##    1    1    1    1    1    1    2    2    1    3    3    1    3    3    1
## 1188 1189 1192 1194 1195 1196 1198 1204 1206 1212 1214 1218 1221 1222 1223
##    1    2    1    2    1    2    1    1    3    1    3    1    1    2    3
## 1227 1231 1232 1236 1237 1238 1239 1246 1253 1257 1258 1262 1268 1269 1273
##    1    1    1    1    2    1    2    2    2    2    1    2    2    2    1
## 1274 1275 1284 1285 1292 1302
##    1    1    1    1    1    1
##
## Within cluster sum of squares by cluster:
## [1] 2562.342 1424.892 1044.680
##  (between_SS / total_SS =  37.0 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"         "withinss"
## [5] "tot.withinss" "betweenss"    "size"          "iter"
## [9] "ifault"
```

```
k3$cluster[325] # Identify the cluster of the 325th observation as an example
```

```
## 911
##   2
```

```
fviz_cluster(k3, data = MyData) # Visualize the output
```


Cluster plot
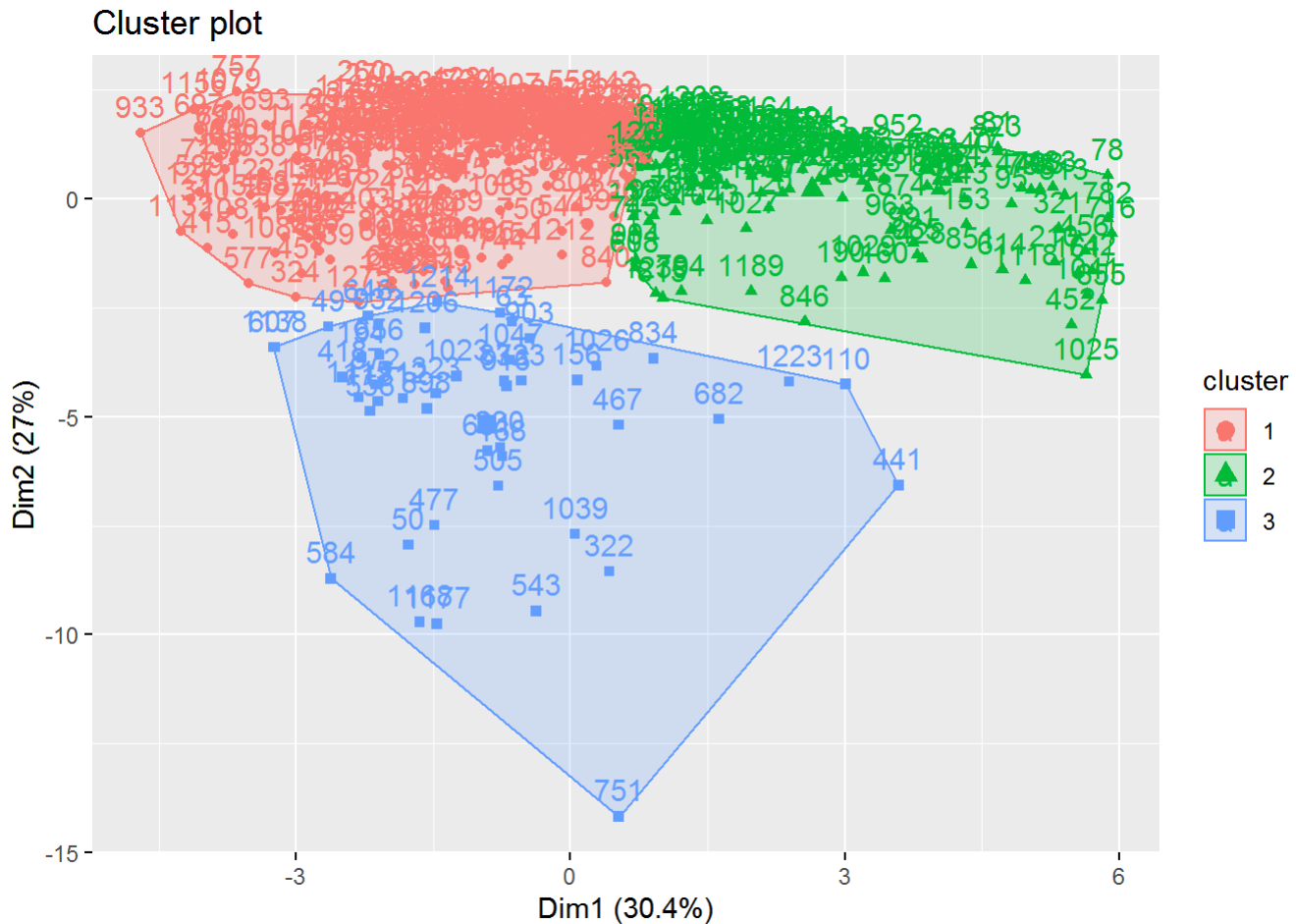
c. Compare the summary statistics for each cluster and describe each cluster in this context (e.g., "Universities with high tuition, low acceptance rate…")

```
# mean of each cluster
k3$centers
```

```
##    X..appli..rec.d X..appl..accepted X..new.stud..enrolled
## 1     -0.35953828      -0.34918455           -0.3171053
## 2      0.05140256      -0.04367128           -0.1683551
## 3      1.98179657       2.22992267            2.4447222
##    X..new.stud..from.top.10. X..new.stud..from.top.25. X..FT.undergrad
## 1                -0.5020886                -0.5128195      -0.2952142
## 2                 0.8795798                 0.8620961      -0.2324464
## 3                 0.1334215                 0.2545856       2.5228452
##    X..PT.undergrad in.state.tuition out.of.state.tuition       room
## 1     -0.1217682      -0.4036544           -0.5263964 -0.3588740
## 2     -0.3130216       1.0620416            1.1158839  0.6698444
## 3      1.7486849      -1.0500277           -0.4918168 -0.0388330
##        board   add..fees estim..book.costs estim..personal.. X..fac..w.PHD
## 1 -0.3938990 -0.05832646      -0.06621454        0.05935933     -0.5322257
## 2  0.7756859 -0.04496556       0.07122705       -0.39665857      0.7659627
## 3 -0.1745795  0.49531762       0.16358567        0.93858632      0.6840794
##    stud..fac..ratio Graduation.rate
## 1        0.2810858      -0.4171456
## 2       -0.7036167       0.8426062
## 3        0.6139980      -0.2538234
```

```
# Based on mean of each cluster compare the statistics of each cluster and described each cluste
r with High, low and medium context
ComparedData <- read.csv("ClusterComparison.csv") # Comparison of each cluster is stored in this
excel
ComparedData #Displays the comparison of each cluster for all columns
```

```
##                   Columns Cluster.1 Cluster.2 Cluster.3
## 1           appli. rec'd #      LOW    MEDIUM      HIGH
## 2          appl. accepted #      LOW    MEDIUM      HIGH
## 3       new stud. enrolled %      LOW    MEDIUM      HIGH
## 4   new stud. from top 10% #      LOW      HIGH    MEDIUM
## 5   new stud. from top 25% #      LOW      HIGH    MEDIUM
## 6           FT undergrad #      LOW    MEDIUM      HIGH
## 7             PT undergrad   MEDIUM       LOW      HIGH
## 8          n-state tuition o   MEDIUM      HIGH       LOW
## 9        ut-of-state tuition      LOW      HIGH    MEDIUM
## 10                     room      LOW      HIGH    MEDIUM
## 11                    board      LOW      HIGH    MEDIUM
## 12          add. fees estim.      LOW    MEDIUM      HIGH
## 13          book costs estim.      LOW    MEDIUM      HIGH
## 14             personal $ %   MEDIUM       LOW      HIGH
## 15             % fac. w/PHD      LOW      HIGH    MEDIUM
## 16          stud./fac. ratio   MEDIUM       LOW      HIGH
## 17           Graduation rate      LOW      HIGH    MEDIUM
```

```
# plot an empty scatter plot
windows()
plot(c(0), xaxt = 'n', ylab = "", type = "l",
ylim = c(min(k3$centers), max(k3$centers)), xlim = c(0, 18))
# label x-axes
axis(1, at = c(1:17), labels = names(k3$centers))
# plot centroids
for (i in c(1:3))
lines(k3$centers[i,], lty = i, lwd = 2, col = ifelse(i %in% c(1, 2, 3),
"black", "dark grey"))
# name clusters
text(x = 0.5, y = k3$centers[, 1], labels = paste("Cluster", c(1:3)))
```
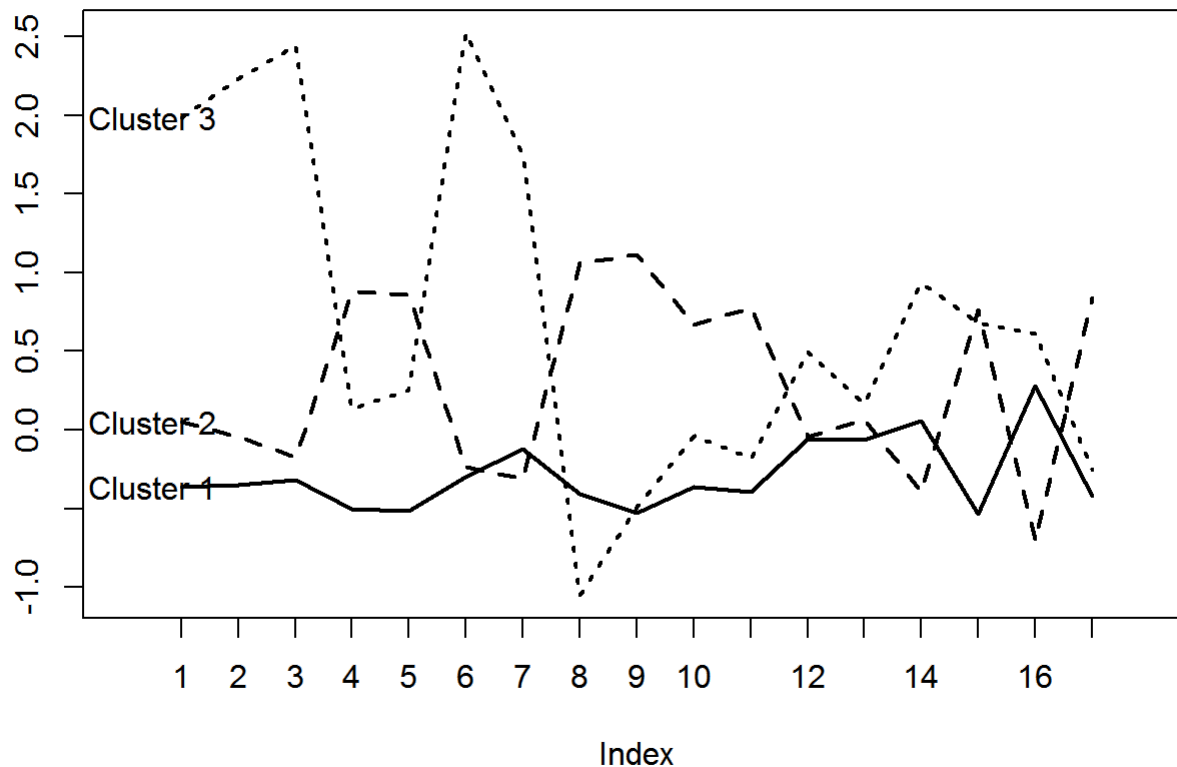

The above graph displays the comparison of summary stats of each cluster

d. Use the categorical measurements that were not used in the analysis (State and Private/Public) to characterize the different clusters. Is there any relationship between the clusters and the categorical information?

```
MyData1 <- Univ
MyData1 <- na.omit(MyData1)
View(MyData1)

MyData2 <- cbind(MyData1[,c(1:3)],k3$cluster)



MyData2$Public..1...Private..2. <- factor(MyData2$Public..1...Private..2.,levels = c(1,2),labels
= c("public","private"))

MyData2$`k3$cluster` <- factor(MyData2$`k3$cluster`,levels = c(1,2,3),labels = c("Low ","Medium"
, "High"))

head(MyData2)
```

```
##                              College.Name State Public..1...Private..2.
## 1            Alaska Pacific University    AK                    private
## 3      University of Alaska Southeast     AK                     public
## 10        Birmingham-Southern College    AL                    private
## 12                  Huntingdon College    AL                    private
## 22                   Talladega College    AL                    private
## 26 University of Alabama at Birmingham    AL                     public
##     k3$cluster
## 1          Low
## 3          Low
## 10      Medium
## 12         Low
## 22         Low
## 26         Low
```

```
ggplot(MyData2, aes(x=MyData2$Public..1...Private..2., y=MyData2$State, color=MyData2$`k3$cluste
r`)) + geom_point()
```
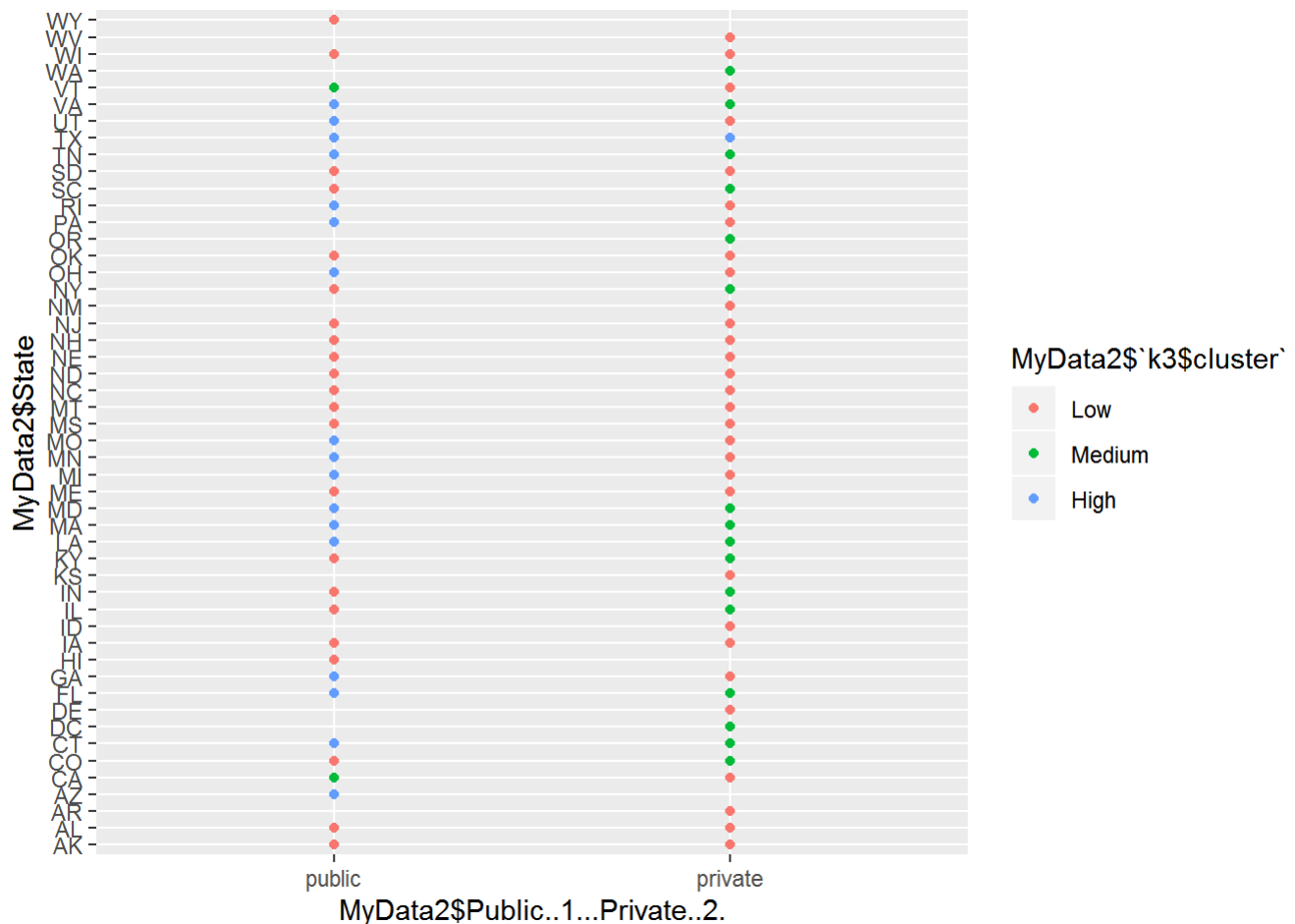
Based on the graph,

Cluster 1 shows equaivalent proportion of both Public and Private Universities

Cluster 2 shows more Public Universities when compared with private

Cluster 3 shows more Private Universities when compared with public

e. What other external information can explain the contents of some or all of these clusters?

```
MyData2[MyData2$`k3$cluster`=="Low ",]
```

```
##                                      College.Name State
## 1                        Alaska Pacific University    AK
## 3                   University of Alaska Southeast    AK
## 12                               Huntingdon College    AL
## 22                                Talladega College    AL
## 26              University of Alabama at Birmingham    AL
## 32                    Arkansas College (Lyon College)   AR
## 38                                   Hendrix College    AR
## 39                             John Brown University    AR
## 46                                 Harding University    AR
## 92                             Fresno Pacific College    CA
## 96                      Southern California College    CA
## 121                             Concordia University    CA
## 122                             Adams State College    CO
## 126                               Fort Lewis College    CO
## 127                               Mesa State College    CO
## 130                  University of Southern Colorado    CO
## 134              Western State College of Colorado    CO
## 139            Central Connecticut State University    CT
## 146                           Sacred Heart University    CT
## 154            Eastern Connecticut State University    CT
## 169                                   Wesley College    DE
## 172                         Bethune Cookman College    FL
## 176            Embry Riddle Aeronautical University    FL
## 181                        Florida Southern College    FL
## 208                             Brewton-Parker College    GA
## 220                                 Morehouse College    GA
## 235                                 Covenant College    GA
## 236              Savannah Coll. of Art and Design    GA
## 239                    University of Hawaii at Manoa    HI
## 244                                   Central College    IA
## 245                                   Clarke College    IA
## 246                                     Coe College    IA
## 248                                   Dordt College    IA
## 250                               Graceland College    IA
## 251                               Grand View College    IA
## 258                             Morningside College    IA
## 259                             Mount Mercy College    IA
## 260                       Mount Saint Clare College    IA
## 262                                 Simpson College    IA
## 263                         Saint Ambrose University    IA
## 264                       University of Northern Iowa    IA
## 265                          University of Dubuque    IA
## 268                                 Wartburg College    IA
## 269                       Teikyo Westmar University    IA
## 270                             William Penn College    IA
## 272                               Albertson College    ID
## 275                       Northwest Nazarene College    ID
## 287                                   Eureka College    IL
## 302                               McKendree College    IL
## 312                               Quincy University    IL
## 317    Southern Illinois University at Edwardsville    IL
## 319                           Saint Xavier University    IL
```

```
## 320              Trinity College    IL
## 324      Western Illinois University  IL
## 326            Anderson University    IN
## 332        University of Evansville   IN
## 333             Franklin College     IN
## 336              Hanover College     IN
## 340      University of Southern Indiana IN
## 349            Manchester College    IN
## 352           Oakland City College   IN
## 359    Saint Mary-of-the-Woods College IN
## 368              Baker University     KS
## 369             Bethany College     KS
## 370              Bethel College     KS
## 376       Kansas Wesleyan University   KS
## 377             McPherson College    KS
## 382               Tabor College     KS
## 387            Benedictine College   KS
## 390             Bellarmine College   KY
## 398            Georgetown College    KY
## 400         Kentucky Wesleyan College  KY
## 403           Murray State University  KY
## 412      Centenary College of Louisiana LA
## 415        Grambling State University  LA
## 442             Bradford College     MA
## 451              Gordon College     MA
## 454              Lesley College     MA
## 457        Bridgewater State College   MA
## 460        North Adams State College   MA
## 462         Westfield State College    MA
## 463         Worcester State College    MA
## 500         Salisbury State University  MD
## 511  University of Maine at Presque Isle ME
## 515   University of Maine at Farmington  ME
## 520              Thomas College     ME
## 522     University of Maine at Machias   ME
## 525              Adrian College     MI
## 528            Andrews University    MI
## 541            Madonna University    MI
## 544    Michigan Technological University MI
## 551           Spring Arbor College   MI
## 552       University of Detroit Mercy  MI
## 558        Center for Creative Studies  MI
## 564         College of Saint Benedict  MN
## 565        College of Saint Catherine  MN
## 577       Saint Cloud State University  MN
## 578          Saint John's University   MN
## 579    Saint Mary's College of Minnesota MN
## 582    University of Minnesota at Morris MN
## 587         Central Methodist College  MO
## 589             Columbia College     MO
## 591               Drury College     MO
## 595            Lindenwood College    MO
## 598          Missouri Valley College   MO
## 599     Missouri Western State College  MO
```

```
## 605              Southeast Missouri State University    MO
## 606                   Southwest Baptist University      MO
## 615                            Webster University       MO
## 616                          Westminster College        MO
## 617                        William Jewell College       MO
## 618                        William Woods University      MO
## 626                              Millsaps College       MS
## 627                           Mississippi College       MS
## 629                    Mississippi State University     MS
## 630              Mississippi Valley State University    MS
## 633                       University of Mississippi     MS
## 638              Montana State University-Billings      MT
## 642                        Rocky Mountain College       MT
## 647     University of North Carolina at Asheville       NC
## 651                             Bennett College       NC
## 658                               Elon College       NC
## 659                 Fayetteville State University      NC
## 660                     Gardner Webb University         NC
## 662                           Guilford College        NC
## 666                       Lenoir-Rhyne College        NC
## 667                         Livingstone College       NC
## 670                         Methodist College        NC
## 673              North Carolina Wesleyan College       NC
## 674                   Pembroke State University         NC
## 676                            Queens College        NC
## 684     University of North Carolina at Greensboro    NC
## 687                 Western Carolina University        NC
## 688     University of North Carolina at Wilmington    NC
## 689                           Wingate College        NC
## 691               Dickinson State University          ND
## 693                        University of Mary        ND
## 696                  University of North Dakota        ND
## 697               Valley City State University        ND
## 698                North Dakota State University        ND
## 703                            Dana College        NE
## 704                           Doane College        NE
## 705                         Hastings College        NE
## 710                       Peru State College        NE
## 713                     Wayne State College        NE
## 717                  Franklin Pierce College        NH
## 720                       Notre Dame College        NH
## 724                      Keene State College        NH
## 726                   Daniel Webster College        NH
## 733                   Georgian Court College        NJ
## 736               Jersey City State College        NJ
## 737                         Monmouth College        NJ
## 738                 Montclair State University        NJ
## 739           New Jersey Institute of Technology     NJ
## 744             Rutgers State University at Newark    NJ
## 746                     Saint Peter's College        NJ
## 750             Rutgers State University at Camden    NJ
## 754               Stockton College of New Jersey     NJ
## 756                      College of Santa Fe        NM
## 757                  College of the Southwest        NM
```

```
## 771              Canisius College          NY
## 772              Cazenovia College         NY
## 789                Elmira College          NY
## 795              Houghton College          NY
## 804                Marist College          NY
## 814                 Nyack College          NY
## 826        St. Bonaventure University      NY
## 828         St. John Fisher College        NY
## 836         SUNY College at Brockport      NY
## 837          SUNY College at Buffalo       NY
## 838         SUNY College at Cortland       NY
## 839         SUNY College at Fredonia       NY
## 840          SUNY College at Geneseo       NY
## 841        SUNY College at New Paltz       NY
## 843          SUNY College at Oswego        NY
## 844       SUNY College at Plattsburgh      NY
## 845          SUNY College at Potsdam       NY
## 860         SUNY College at Purchase       NY
## 869              Ashland University        OH
## 870          Baldwin-Wallace College       OH
## 875             Cedarville College         OH
## 878        College of Mount St. Joseph     OH
## 879   Franciscan University of Steubenville OH
## 885             Heidelberg College         OH
## 891                Malone College          OH
## 893            Mount Union College         OH
## 894             Muskingum College          OH
## 901               Tiffin University        OH
## 907               Ursuline College         OH
## 912               Xavier University        OH
## 917              Antioch University        OH
## 928          Oklahoma Baptist University    OK
## 929        Oklahoma Christian University    OK
## 931   University of Sci. and Arts of Oklahoma OK
## 933     Oklahoma Panhandle State University  OK
## 939            Oral Roberts University      OK
## 943              George Fox College        OR
## 974                Eastern College         PA
## 977               Gannon University        PA
## 978                Geneva College          PA
## 987                King's College          PA
## 992               Lincoln University       PA
## 994               Marywood College         PA
## 1001      Bloomsburg Univ. of Pennsylvania  PA
## 1009      Millersville University of Penn.  PA
## 1010      Shippensburg University of Penn.  PA
## 1014   Philadelphia Coll. of Textiles and Sci. PA
## 1017             Seton Hill College         PA
## 1020            Saint Vincent College       PA
## 1024                Thiel College          PA
## 1031             Waynesburg College         PA
## 1032            Westminster College        PA
## 1033              Wilkes University        PA
## 1035        York College of Pennsylvania    PA
```

```
## 1036         Allentown Coll. of St. Francis de Sales    PA
## 1037                            La Roche College        PA
## 1048                    Roger Williams University       RI
## 1051                    Central Wesleyan College        SC
## 1052                               The Citadel          SC
## 1053                            Claflin College         SC
## 1055                             Coker College          SC
## 1059                            Erskine College         SC
## 1061                           Lander University        SC
## 1064                           Newberry College         SC
## 1075                          Augustana College         SD
## 1079                            Huron University        SD
## 1081                   Northern State University        SD
## 1084                South Dakota State University       SD
## 1087                          Belmont University        TN
## 1089                    Carson-Newman College           TN
## 1090              Christian Brothers University         TN
## 1095                  Freed-Hardeman University          TN
## 1096                              King College          TN
## 1098                         Lambuth University          TN
## 1101                 Lincoln Memorial University         TN
## 1102                          Maryville College         TN
## 1105                           Milligan College         TN
## 1110                 Tennessee Wesleyan College          TN
## 1111                 Trevecca Nazarene College           TN
## 1121                   Angelo State University          TX
## 1125               East Texas Baptist University        TX
## 1127                   Hardin-Simmons University         TX
## 1131                   Incarnate Word College          TX
## 1132                            Lamar University        TX
## 1139              Our Lady of the Lake University       TX
## 1143                          Schreiner College         TX
## 1146               Southwestern Adventist College       TX
## 1152              Prairie View A. and M. University     TX
## 1154                 Texas Christian University          TX
## 1156                              Texas College        TX
## 1158                    Texas Lutheran College          TX
## 1166                   University of St. Thomas          TX
## 1176              Texas A&M University at Galveston      TX
## 1185            Westminster College of Salt Lake City    UT
## 1188                        Bridgewater College         VA
## 1192                      Emory & Henry College         VA
## 1195                          Hampton University        VA
## 1198                          Lynchburg College         VA
## 1204                     Randolph-Macon College          VA
## 1212                    Mary Washington College          VA
## 1218                   Virginia State University        VA
## 1221                 Virginia Wesleyan College           VA
## 1227                    Castleton State College         VT
## 1231                      Johnson State College         VT
## 1232                       Lyndon State College        VT
## 1236                  Southern Vermont College           VT
## 1238                            Trinity College        VT
## 1258                            Carroll College         WI
```

```
## 1273                                    Viterbo College      WI
## 1274                   University of Wisconsin-Stout         WI
## 1275               Univ. of Wisconsin at Eau Claire          WI
## 1284                    Wisconsin Lutheran College           WI
## 1285                    Alderson-Broaddus College            WV
## 1292                          Marshall University            WV
## 1302                        University of Wyoming            WY
##         Public..1...Private..2. k3$cluster
## 1                        private        Low
## 3                         public        Low
## 12                       private        Low
## 22                       private        Low
## 26                        public        Low
## 32                       private        Low
## 38                       private        Low
## 39                       private        Low
## 46                       private        Low
## 92                       private        Low
## 96                       private        Low
## 121                      private        Low
## 122                       public        Low
## 126                       public        Low
## 127                       public        Low
## 130                       public        Low
## 134                       public        Low
## 139                       public        Low
## 146                      private        Low
## 154                       public        Low
## 169                      private        Low
## 172                      private        Low
## 176                      private        Low
## 181                      private        Low
## 208                      private        Low
## 220                      private        Low
## 235                      private        Low
## 236                      private        Low
## 239                       public        Low
## 244                      private        Low
## 245                      private        Low
## 246                      private        Low
## 248                      private        Low
## 250                      private        Low
## 251                      private        Low
## 258                      private        Low
## 259                      private        Low
## 260                      private        Low
## 262                      private        Low
## 263                      private        Low
## 264                       public        Low
## 265                      private        Low
## 268                      private        Low
## 269                      private        Low
## 270                      private        Low
## 272                      private        Low
```

```
## 275                  private        Low
## 287                  private        Low
## 302                  private        Low
## 312                  private        Low
## 317                   public        Low
## 319                  private        Low
## 320                  private        Low
## 324                   public        Low
## 326                  private        Low
## 332                  private        Low
## 333                  private        Low
## 336                  private        Low
## 340                   public        Low
## 349                  private        Low
## 352                  private        Low
## 359                  private        Low
## 368                  private        Low
## 369                  private        Low
## 370                  private        Low
## 376                  private        Low
## 377                  private        Low
## 382                  private        Low
## 387                  private        Low
## 390                  private        Low
## 398                  private        Low
## 400                  private        Low
## 403                   public        Low
## 412                  private        Low
## 415                   public        Low
## 442                  private        Low
## 451                  private        Low
## 454                  private        Low
## 457                   public        Low
## 460                   public        Low
## 462                   public        Low
## 463                   public        Low
## 500                   public        Low
## 511                   public        Low
## 515                   public        Low
## 520                  private        Low
## 522                   public        Low
## 525                  private        Low
## 528                  private        Low
## 541                  private        Low
## 544                   public        Low
## 551                  private        Low
## 552                  private        Low
## 558                  private        Low
## 564                  private        Low
## 565                  private        Low
## 577                   public        Low
## 578                  private        Low
## 579                  private        Low
## 582                   public        Low
```

```
## 587                    private        Low
## 589                    private        Low
## 591                    private        Low
## 595                    private        Low
## 598                    private        Low
## 599                     public        Low
## 605                     public        Low
## 606                    private        Low
## 615                    private        Low
## 616                    private        Low
## 617                    private        Low
## 618                    private        Low
## 626                    private        Low
## 627                    private        Low
## 629                     public        Low
## 630                     public        Low
## 633                     public        Low
## 638                     public        Low
## 642                    private        Low
## 647                     public        Low
## 651                    private        Low
## 658                    private        Low
## 659                     public        Low
## 660                    private        Low
## 662                    private        Low
## 666                    private        Low
## 667                    private        Low
## 670                    private        Low
## 673                    private        Low
## 674                     public        Low
## 676                    private        Low
## 684                     public        Low
## 687                     public        Low
## 688                     public        Low
## 689                    private        Low
## 691                     public        Low
## 693                    private        Low
## 696                     public        Low
## 697                     public        Low
## 698                     public        Low
## 703                    private        Low
## 704                    private        Low
## 705                    private        Low
## 710                     public        Low
## 713                     public        Low
## 717                    private        Low
## 720                    private        Low
## 724                     public        Low
## 726                    private        Low
## 733                    private        Low
## 736                     public        Low
## 737                    private        Low
## 738                     public        Low
## 739                     public        Low
```

```
## 744                 public        Low
## 746                private        Low
## 750                 public        Low
## 754                 public        Low
## 756                private        Low
## 757                private        Low
## 771                private        Low
## 772                private        Low
## 789                private        Low
## 795                private        Low
## 804                private        Low
## 814                private        Low
## 826                private        Low
## 828                private        Low
## 836                 public        Low
## 837                 public        Low
## 838                 public        Low
## 839                 public        Low
## 840                 public        Low
## 841                 public        Low
## 843                 public        Low
## 844                 public        Low
## 845                 public        Low
## 860                 public        Low
## 869                private        Low
## 870                private        Low
## 875                private        Low
## 878                private        Low
## 879                private        Low
## 885                private        Low
## 891                private        Low
## 893                private        Low
## 894                private        Low
## 901                private        Low
## 907                private        Low
## 912                private        Low
## 917                private        Low
## 928                private        Low
## 929                private        Low
## 931                 public        Low
## 933                 public        Low
## 939                private        Low
## 943                private        Low
## 974                private        Low
## 977                private        Low
## 978                private        Low
## 987                private        Low
## 992                 public        Low
## 994                private        Low
## 1001                public        Low
## 1009                public        Low
## 1010                public        Low
## 1014               private        Low
## 1017               private        Low
```

```
## 1020            private      Low
## 1024            private      Low
## 1031            private      Low
## 1032            private      Low
## 1033            private      Low
## 1035            private      Low
## 1036            private      Low
## 1037            private      Low
## 1048            private      Low
## 1051            private      Low
## 1052             public      Low
## 1053            private      Low
## 1055            private      Low
## 1059            private      Low
## 1061             public      Low
## 1064            private      Low
## 1075            private      Low
## 1079            private      Low
## 1081             public      Low
## 1084             public      Low
## 1087            private      Low
## 1089            private      Low
## 1090            private      Low
## 1095            private      Low
## 1096            private      Low
## 1098            private      Low
## 1101            private      Low
## 1102            private      Low
## 1105            private      Low
## 1110            private      Low
## 1111            private      Low
## 1121             public      Low
## 1125            private      Low
## 1127            private      Low
## 1131            private      Low
## 1132             public      Low
## 1139            private      Low
## 1143            private      Low
## 1146            private      Low
## 1152             public      Low
## 1154            private      Low
## 1156            private      Low
## 1158            private      Low
## 1166            private      Low
## 1176             public      Low
## 1185            private      Low
## 1188            private      Low
## 1192            private      Low
## 1195            private      Low
## 1198            private      Low
## 1204            private      Low
## 1212             public      Low
## 1218             public      Low
## 1221            private      Low
```

```
## 1227                public    Low
## 1231                public    Low
## 1232                public    Low
## 1236                private   Low
## 1238                private   Low
## 1258                private   Low
## 1273                private   Low
## 1274                public    Low
## 1275                public    Low
## 1284                private   Low
## 1285                private   Low
## 1292                private   Low
## 1302                public    Low
```

```
# Cluster 1 shows equaivalent proportion of both Public and Private Universities

MyData2[MyData2$`k3$cluster`=="Medium",]
```

```
##                                  College.Name State Public..1...Private..2.
## 10                   Birmingham-Southern College    AL               private
## 77                     Claremont McKenna College    CA               private
## 78                          Harvey Mudd College    CA               private
## 79                              Pitzer College    CA               private
## 81                             Scripps College    CA               private
## 90                          Occidental College    CA               private
## 95                        Pepperdine University    CA               private
## 97          St. Mary's College of California    CA               private
## 108               University of San Francisco    CA               private
## 112                          Westmont College    CA                public
## 120              Loyola Marymount University    CA               private
## 123                          Colorado College    CO               private
## 140                      Connecticut College    CT               private
## 148                     Saint Joseph College    CT               private
## 149                           Trinity College    CT               private
## 151             University of Bridgeport    CT               private
## 152               University of Hartford    CT               private
## 153                      Wesleyan University    CT               private
## 158        Catholic University of America    DC               private
## 160          George Washington University    DC               private
## 161                   Georgetown University    DC               private
## 164                           Trinity College    DC               private
## 174       Florida Institute of Technology    FL               private
## 186                          Rollins College    FL               private
## 188                        Stetson University    FL               private
## 190                       University of Miami    FL               private
## 210                          Emory University    GA               private
## 228                           Spelman College    GA               private
## 247                           Cornell College    IA               private
## 252                          Grinnell College    IA               private
## 277                        Augustana College    IL               private
## 294          Illinois Wesleyan University    IL               private
## 297                               Knox College    IL               private
## 298                     Lake Forest College    IL               private
## 304                         Monmouth College    IL               private
## 321                University of Chicago    IL               private
## 329                        Butler University    IN               private
## 330                        DePauw University    IN               private
## 331                          Earlham College    IN               private
## 360                     Saint Mary's College    IN               private
## 362                         Taylor University    IN               private
## 365                     Valparaiso University    IN               private
## 366                          Wabash College    IN               private
## 395                           Centre College    KY               private
## 405               Transylvania University    KY               private
## 421                        Loyola University    LA               private
## 428                          Tulane University    LA               private
## 433                          Amherst College    MA               private
## 436                        Merrimack College    MA               private
## 438                          Bentley College    MA               private
## 443                       Brandeis University    MA               private
## 444                           Clark University    MA               private
```

```
## 452                   Harvard University   MA          private
## 456   Massachusetts Institute of Technology   MA          private
## 464                Mount Holyoke College   MA          private
## 479                   Wellesley College   MA          private
## 481                    Wheaton College   MA          private
## 483                    Williams College   MA          private
## 484      Worcester Polytechnic Institute   MA          private
## 494                    Goucher College   MD          private
## 513                    Bowdoin College   ME          private
## 514                      Colby College   ME          private
## 526                     Albion College   MI          private
## 527                       Alma College   MI          private
## 537                  Hillsdale College   MI          private
## 538                       Hope College   MI          private
## 563                   Carleton College   MN          private
## 567             University of St. Thomas   MN          private
## 571                  Hamline University   MN          private
## 572                 Macalester College   MN          private
## 608               Saint Louis University   MO          private
## 614                Washington University   MO          private
## 654                   Davidson College   NC          private
## 655                    Duke University   NC          private
## 677                      Salem College   NC          private
## 702                Creighton University   NE          private
## 716                  Dartmouth College   NH          private
## 732                      Drew University   NJ          private
## 742               Princeton University   NJ          private
## 745               Seton Hall University   NJ          private
## 769                   Alfred University   NY          private
## 777                 Clarkson University   NY          private
## 778                 Colgate University   NY          private
## 782                 Columbia University   NY          private
## 783                    Barnard College   NY          private
## 792                   Hartwick College   NY          private
## 793   Hobart and William Smith Colleges   NY          private
## 794                 Hofstra University   NY          private
## 801                   Le Moyne College   NY          private
## 803              Manhattanville College   NY          private
## 815                     Pace University   NY          private
## 823              Sarah Lawrence College   NY          private
## 824                  Skidmore College   NY          private
## 825                     Siena College   NY          private
## 831              St. Lawrence University   NY          private
## 846                Syracuse University   NY          private
## 848                     Union College   NY          private
## 851             University of Rochester   NY          private
## 874      Case Western Reserve University   OH          private
## 882                 Denison University   OH          private
## 889                    Kenyon College   OH          private
## 892                  Marietta College   OH          private
## 896                    Oberlin College   OH          private
## 904               University of Dayton   OH          private
## 911              Wittenberg University   OH          private
## 945                  Linfield College   OR          private
```

```
## 950                    Pacific University      OR              private
## 952                        Reed College        OR              private
## 955              University of Portland         OR              private
## 958                     Albright College        PA              private
## 959                    Allegheny College        PA              private
## 963                   Bucknell University        PA              private
## 965             Carnegie Mellon University        PA              private
## 967                      Chatham College        PA              private
## 969                  College Misericordia        PA              private
## 971                    Dickinson College        PA              private
## 975                  Elizabethtown College        PA              private
## 979                   Gettysburg College        PA              private
## 986                     Juniata College        PA              private
## 988                    Lafayette College        PA              private
## 989                   La Salle University        PA              private
## 991                    Lehigh University        PA              private
## 996                      Messiah College        PA              private
## 997                     Moravian College        PA              private
## 1021             Susquehanna University        PA              private
## 1025           University of Pennsylvania        PA              private
## 1027              University of Scranton         PA              private
## 1029               Villanova University        PA              private
## 1030       Washington and Jefferson College     PA              private
## 1041                    Brown University        RI              private
## 1043                  Providence College        RI              private
## 1060                   Furman University        SC              private
## 1065                Presbyterian College        SC              private
## 1107                     Rhodes College        TN              private
## 1117              University of the South        TN              private
## 1118                Vanderbilt University        TN              private
## 1163                  Trinity University        TX              private
## 1164                University of Dallas        TX              private
## 1189          College of William and Mary        VA               public
## 1194            Hampden - Sydney College        VA              private
## 1196                     Hollins College        VA              private
## 1222        Washington and Lee University        VA              private
## 1237             Saint Michael's College        VT              private
## 1239                University of Vermont        VT               public
## 1246                  Seattle University        WA              private
## 1253                    Whitman College        WA              private
## 1257                     Beloit College        WI              private
## 1262                Lawrence University        WI              private
## 1268                      Ripon College        WI              private
## 1269                 St. Norbert College        WI              private
##        k3$cluster
## 10         Medium
## 77         Medium
## 78         Medium
## 79         Medium
## 81         Medium
## 90         Medium
## 95         Medium
## 97         Medium
## 108        Medium
```

```
## 112      Medium
## 120      Medium
## 123      Medium
## 140      Medium
## 148      Medium
## 149      Medium
## 151      Medium
## 152      Medium
## 153      Medium
## 158      Medium
## 160      Medium
## 161      Medium
## 164      Medium
## 174      Medium
## 186      Medium
## 188      Medium
## 190      Medium
## 210      Medium
## 228      Medium
## 247      Medium
## 252      Medium
## 277      Medium
## 294      Medium
## 297      Medium
## 298      Medium
## 304      Medium
## 321      Medium
## 329      Medium
## 330      Medium
## 331      Medium
## 360      Medium
## 362      Medium
## 365      Medium
## 366      Medium
## 395      Medium
## 405      Medium
## 421      Medium
## 428      Medium
## 433      Medium
## 436      Medium
## 438      Medium
## 443      Medium
## 444      Medium
## 452      Medium
## 456      Medium
## 464      Medium
## 479      Medium
## 481      Medium
## 483      Medium
## 484      Medium
## 494      Medium
## 513      Medium
## 514      Medium
## 526      Medium
```

```
## 527        Medium
## 537        Medium
## 538        Medium
## 563        Medium
## 567        Medium
## 571        Medium
## 572        Medium
## 608        Medium
## 614        Medium
## 654        Medium
## 655        Medium
## 677        Medium
## 702        Medium
## 716        Medium
## 732        Medium
## 742        Medium
## 745        Medium
## 769        Medium
## 777        Medium
## 778        Medium
## 782        Medium
## 783        Medium
## 792        Medium
## 793        Medium
## 794        Medium
## 801        Medium
## 803        Medium
## 815        Medium
## 823        Medium
## 824        Medium
## 825        Medium
## 831        Medium
## 846        Medium
## 848        Medium
## 851        Medium
## 874        Medium
## 882        Medium
## 889        Medium
## 892        Medium
## 896        Medium
## 904        Medium
## 911        Medium
## 945        Medium
## 950        Medium
## 952        Medium
## 955        Medium
## 958        Medium
## 959        Medium
## 963        Medium
## 965        Medium
## 967        Medium
## 969        Medium
## 971        Medium
## 975        Medium
```

```
## 979       Medium
## 986       Medium
## 988       Medium
## 989       Medium
## 991       Medium
## 996       Medium
## 997       Medium
## 1021      Medium
## 1025      Medium
## 1027      Medium
## 1029      Medium
## 1030      Medium
## 1041      Medium
## 1043      Medium
## 1060      Medium
## 1065      Medium
## 1107      Medium
## 1117      Medium
## 1118      Medium
## 1163      Medium
## 1164      Medium
## 1189      Medium
## 1194      Medium
## 1196      Medium
## 1222      Medium
## 1237      Medium
## 1239      Medium
## 1246      Medium
## 1253      Medium
## 1257      Medium
## 1262      Medium
## 1268      Medium
## 1269      Medium
```

```
# Cluster 2 shows more Public Universities when compared with private

MyData2[MyData2$`k3$cluster`=="High",]
```

```
##                                       College.Name State
## 49                    Northern Arizona University    AZ
## 50                       University of Arizona       AZ
## 63               California Polytechnic-San Luis     CA
## 110             University of Southern California    CA
## 156            University of Connecticut at Storrs   CT
## 168                   University of Delaware         DE
## 194              University of Central Florida       FL
## 230                     University of Georgia        GA
## 322             University of Illinois - Urbana      IL
## 323             University of Illinois at Chicago    IL
## 418        Louisiana State University at Baton Rouge LA
## 441                       Boston University          MA
## 467                  Northeastern University         MA
## 477        University of Massachusetts at Amherst    MA
## 505        University of Maryland at College Park    MD
## 543                 Michigan State University        MI
## 556               Western Michigan University        MI
## 584            University of Minnesota Twin Cities    MN
## 607          Southwest Missouri State University     MO
## 646             Appalachian State University         NC
## 656                East Carolina University          NC
## 681    North Carolina State University at Raleigh    NC
## 682  University of North Carolina at Chapel Hill     NC
## 712          University of Nebraska at Lincoln       NE
## 723             University of New Hampshire          NH
## 751             Rutgers at New Brunswick             NJ
## 833                       SUNY at Albany             NY
## 834                     SUNY at Binghamton           NY
## 872         Bowling Green State University          OH
## 898                       Ohio University            OH
## 903               University of Cincinnati           OH
## 916             Miami University at Oxford           OH
## 932             Oklahoma State University            OK
## 1023                    Temple University            PA
## 1026      University of Pittsburgh-Main Campus       PA
## 1039       Pennsylvania State Univ. Main Campus      PA
## 1047             University of Rhode Island          RI
## 1115       University of Tennessee at Knoxville      TN
## 1138            University of North Texas            TX
## 1168          University of Texas at Austin          TX
## 1172                    Baylor University            TX
## 1177        Texas A&M Univ. at College Station       TX
## 1181                  University of Utah             UT
## 1206       Virginia Commonwealth University         VA
## 1214              George Mason University            VA
## 1223              University of Virginia             VA
##        Public..1...Private..2. k3$cluster
## 49                 public          High
## 50                 public          High
## 63                 public          High
## 110                private         High
## 156                public          High
```

```
## 168                  private        High
## 194                   public        High
## 230                   public        High
## 322                   public        High
## 323                   public        High
## 418                   public        High
## 441                  private        High
## 467                  private        High
## 477                   public        High
## 505                   public        High
## 543                   public        High
## 556                   public        High
## 584                   public        High
## 607                   public        High
## 646                   public        High
## 656                   public        High
## 681                   public        High
## 682                   public        High
## 712                   public        High
## 723                   public        High
## 751                   public        High
## 833                   public        High
## 834                   public        High
## 872                   public        High
## 898                   public        High
## 903                   public        High
## 916                   public        High
## 932                   public        High
## 1023                  public        High
## 1026                  public        High
## 1039                  public        High
## 1047                  public        High
## 1115                  public        High
## 1138                  public        High
## 1168                  public        High
## 1172                 private        High
## 1177                  public        High
## 1181                  public        High
## 1206                  public        High
## 1214                  public        High
## 1223                  public        High
```

```
# Cluster 3 shows more Private Universities when compared with public

k3$withinss
```

```
## [1] 2562.342 1424.892 1044.680
```

```
k3$iter
```

```
## [1] 3
```

f. Consider Tufts University, which is missing some information. Compute the Euclidean distance of this record from each of the clusters that you found above (using only the measurements that you have). Which cluster is it closest to? Impute the missing values for Tufts by taking the average of the cluster on those measurements.

```
MyData3 <- read.csv("Universities.csv")
# Considering Tufts University
MyData4 <- MyData3[ MyData3$College.Name== "Tufts University",]
View(MyData4)
# Compute Euclidian Distance
dist(rbind(MyData4[, -c(1, 2, 3,10)], k3$centers[1,]))
```

```
##          476
## 2 29819.09
```

```
dist(rbind(MyData4[, -c(1, 2, 3,10)], k3$centers[2,]))
```

```
##          476
## 2 29817.8
```

```
dist(rbind(MyData4[, -c(1, 2, 3,10)], k3$centers[3,]))
```

```
##          476
## 2 29816.76
```

Based on the above distances it is closest to Cluster 3

Impute the missing values for Tufts by taking the average of the cluster on those measurements

```
MyData5 <- read.csv("Universities.csv")
MyData5 <- na.omit(MyData5)
MyData5 <- cbind(MyData5,k3$cluster)
View(MyData5)
#Filter the values which falls under cluster3
MyData6 <- filter(MyData5, MyData5$`k3$cluster` == 3)
MyData7 <- mean(MyData6[,c(10)])
MyData7
```

```
## [1] 3500.565
```

```
MyData4$X..PT.undergrad <- MyData7
# After filling missing value with mean
MyData4
```

```
##         College.Name State Public..1...Private..2. X..appli..rec.d
## 476 Tufts University    MA                        2            7614
##     X..appl..accepted X..new.stud..enrolled X..new.stud..from.top.10.
## 476              3605                  1205                        60
##     X..new.stud..from.top.25. X..FT.undergrad X..PT.undergrad
## 476                        90            4598        3500.565
##     in.state.tuition out.of.state.tuition room board add..fees
## 476            19701                19701 3038  2930       503
##     estim..book.costs estim..personal.. X..fac..w.PHD stud..fac..ratio
## 476               600               928            99             10.3
##     Graduation.rate
## 476              92
```