Assignment 8.3: Clustering

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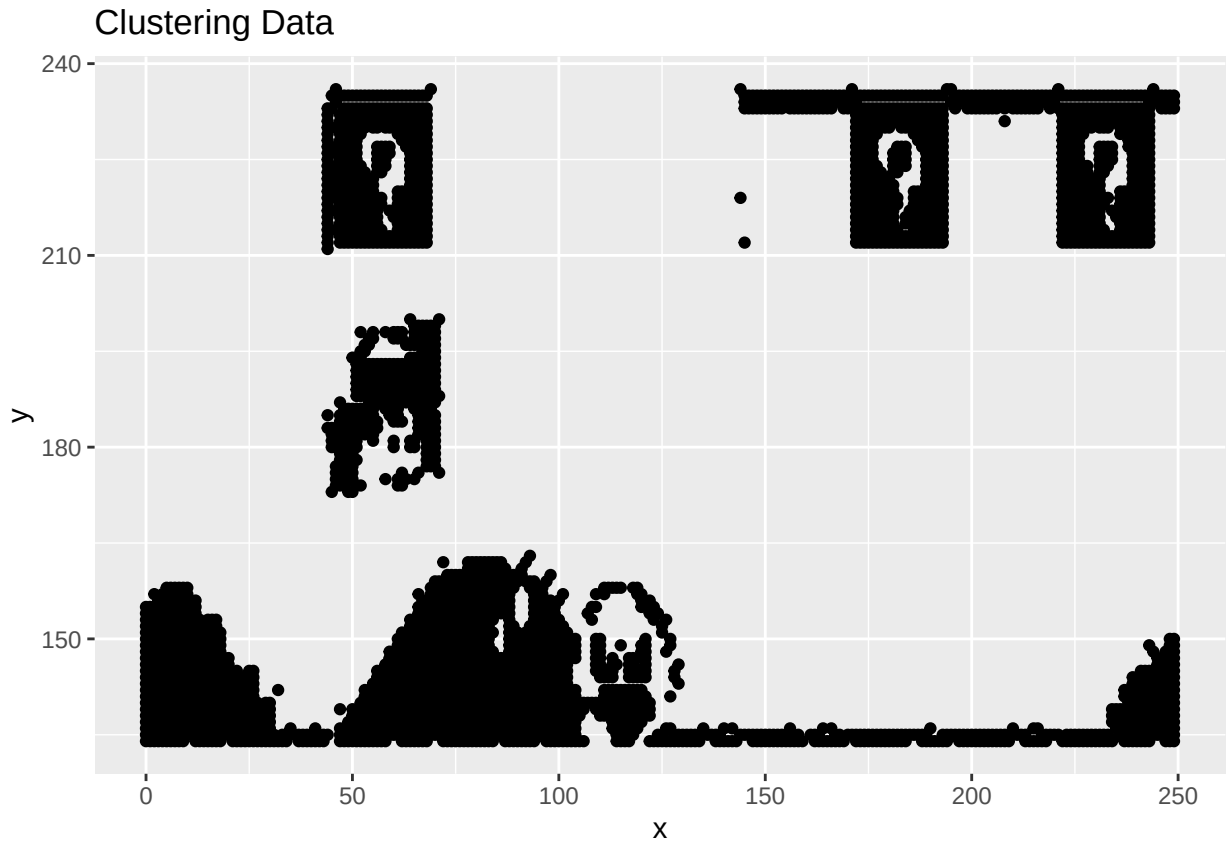
```
ggplot(clustering_df, aes(x=x, y=y)) + geom_point() + xlab('x') + ylab('y') + ggtitle("Clustering Data")
```




```
clustering_df<-scale(clustering_df)
head(clustering_df)
```

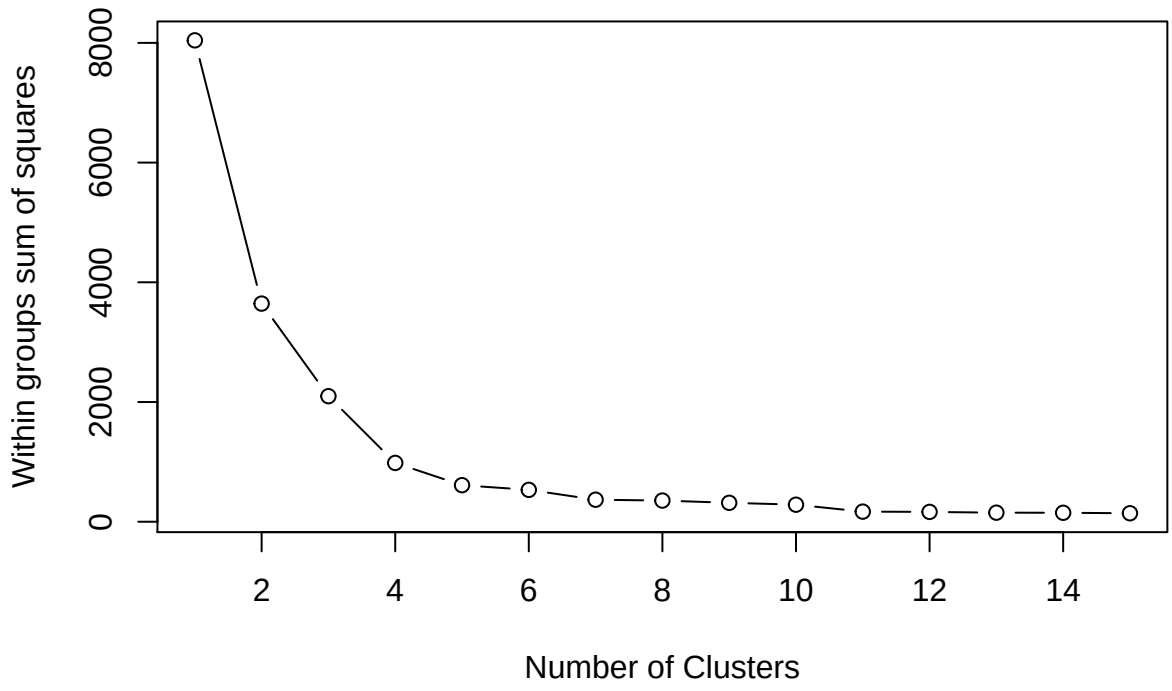
```
##               x        y
## [1,] -0.8482235 1.561107
## [2,] -0.5415045 1.561107
## [3,]  0.4586659 1.561107
## [4,]  0.8187273 1.561107
## [5,]  1.1254462 1.561107
## [6,]  1.1387818 1.561107
```

```r
library(cluster)
library(factoextra)
```

```
## Warning: package 'factoextra' was built under R version 4.0.2
```

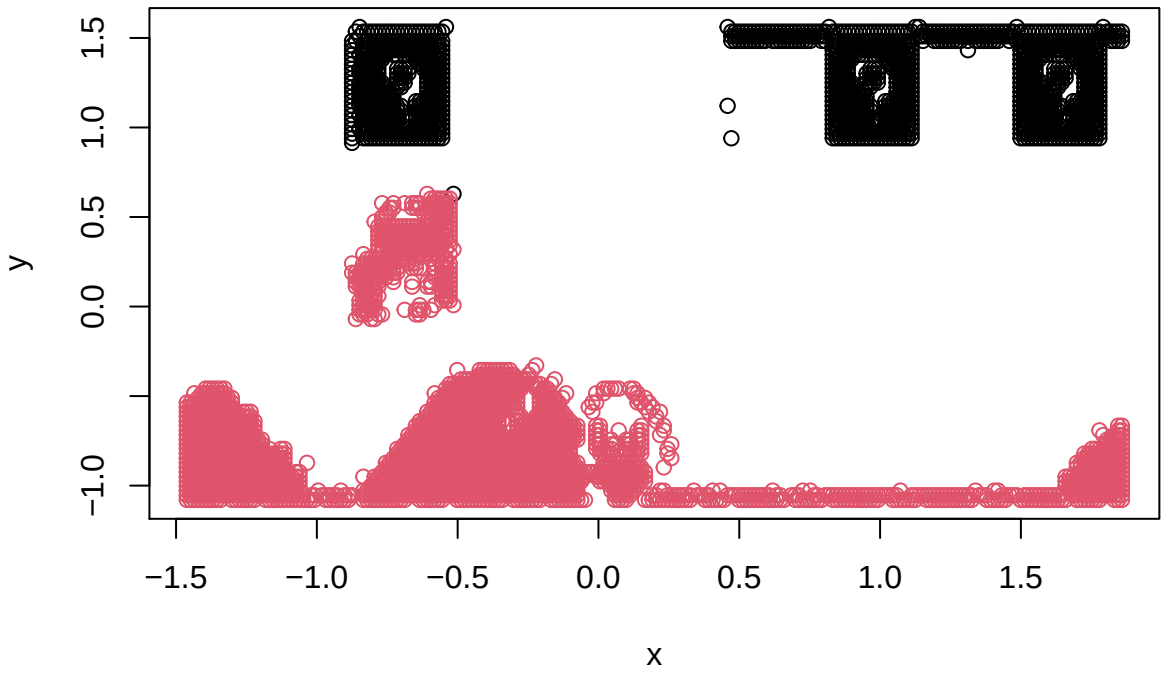
```
## Welcome! Want to learn more? See two factoextra-related books at https://goo.gl/ve3WBa
```

```r
wssplot <- function(data, nc=15, seed=1234){
                  wss <- (nrow(data)-1)*sum(apply(data,2,var))
                      for (i in 2:nc){
                set.seed(seed)
                    wss[i] <- sum(kmeans(data, centers=i)$withinss)}
             plot(1:nc, wss, type="b", xlab="Number of Clusters",
                          ylab="Within groups sum of squares")
             wss
}
wssplot(clustering_df)
```

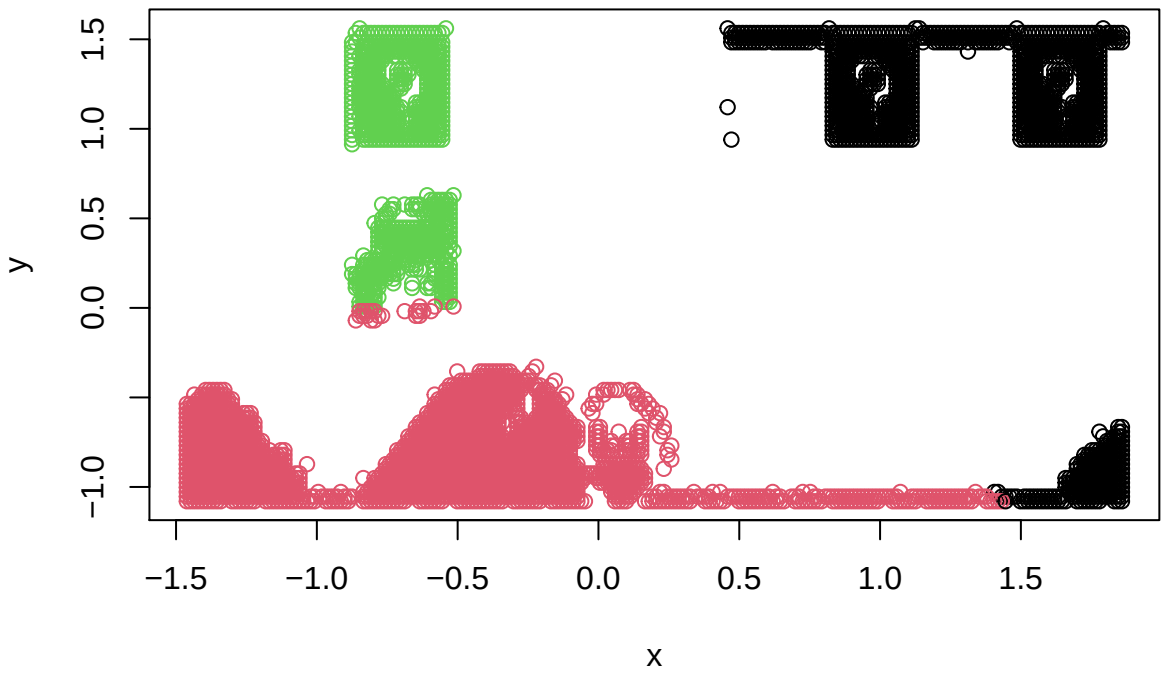



```
##  [1] 8042.0000 3644.3577 2097.5918  982.5633  610.6719  532.5799  368.2815
##  [8]  353.6523  316.3358  284.9604  168.8087  164.3646  151.6366  149.6875
## [15]  141.9250
```

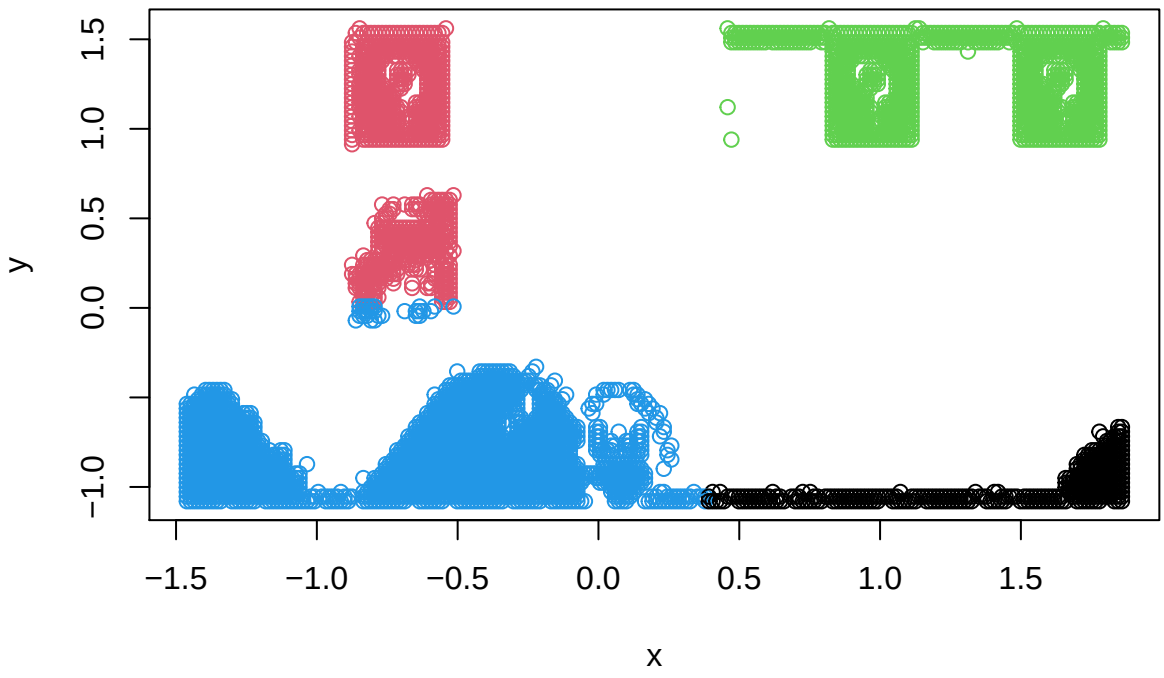
```
cluster_2<-kmeans(clustering_df, 2)
plot(clustering_df, col = cluster_2$cluster)
```



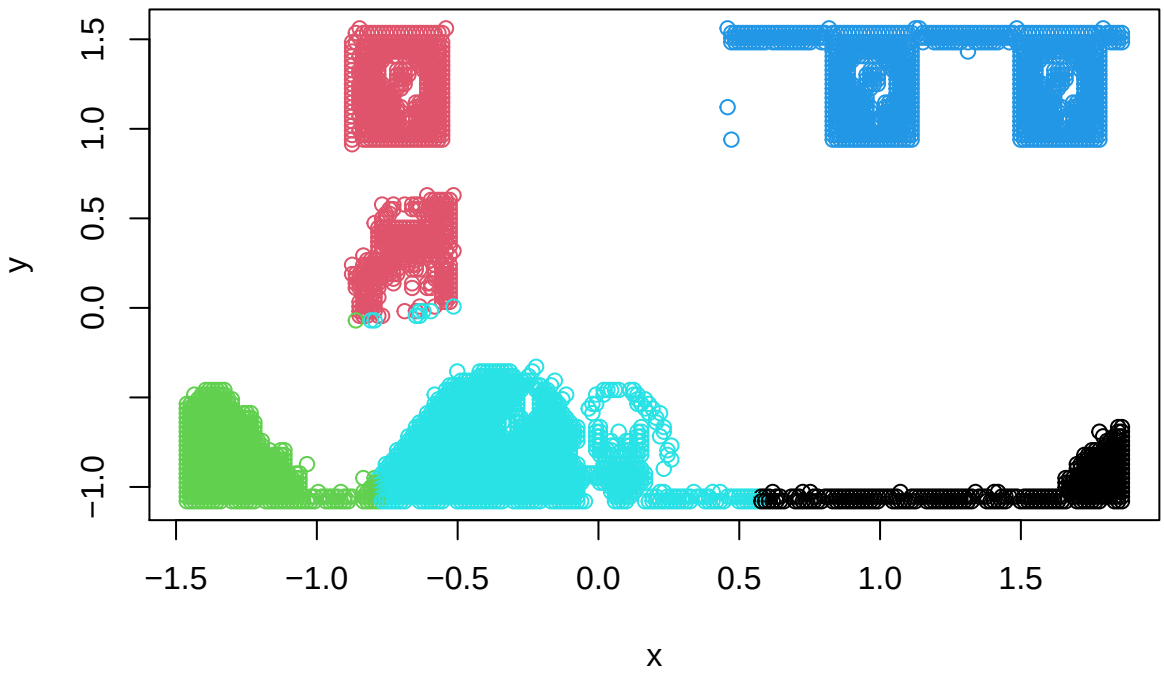

```
cluster_3<-kmeans(clustering_df, 3)
plot(clustering_df, col = cluster_3$cluster)
```



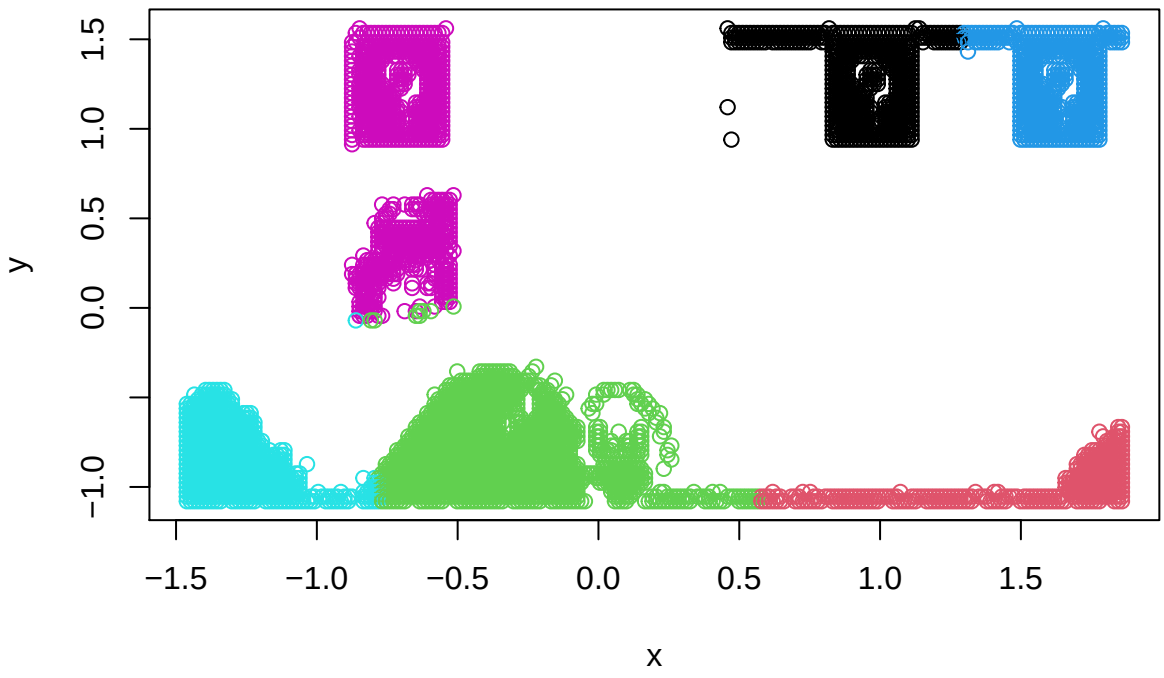

```
cluster_4<-kmeans(clustering_df, 4)
plot(clustering_df, col = cluster_4$cluster)
```



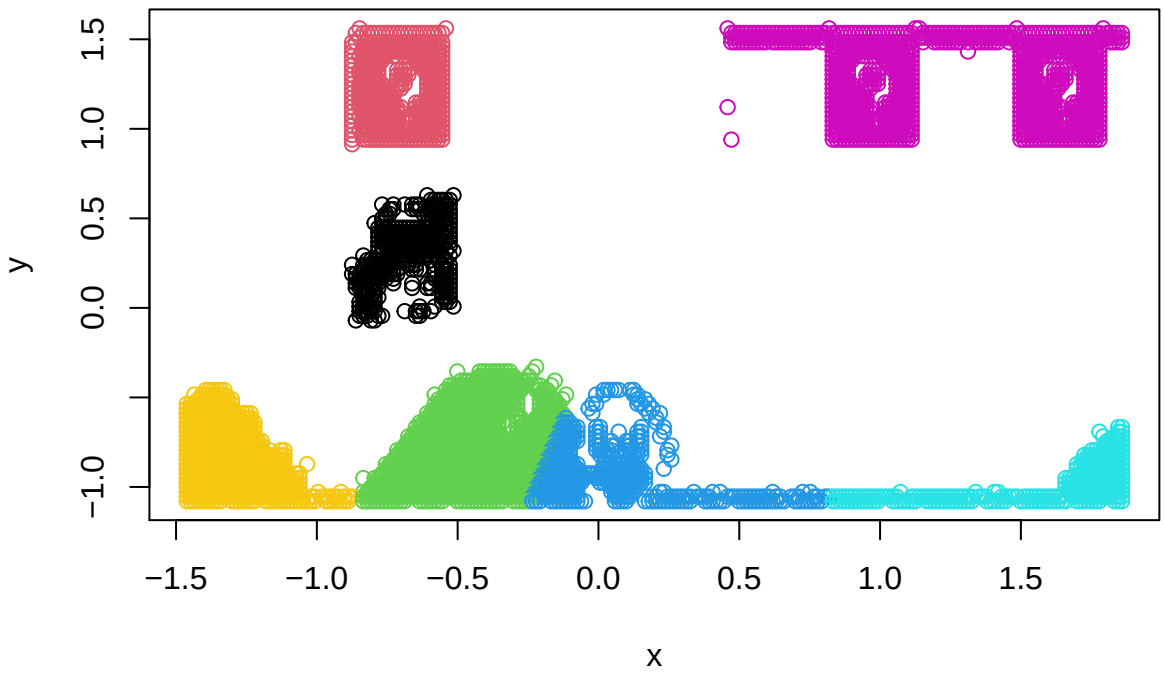

```
cluster_5<-kmeans(clustering_df, 5)
plot(clustering_df, col = cluster_5$cluster)
```



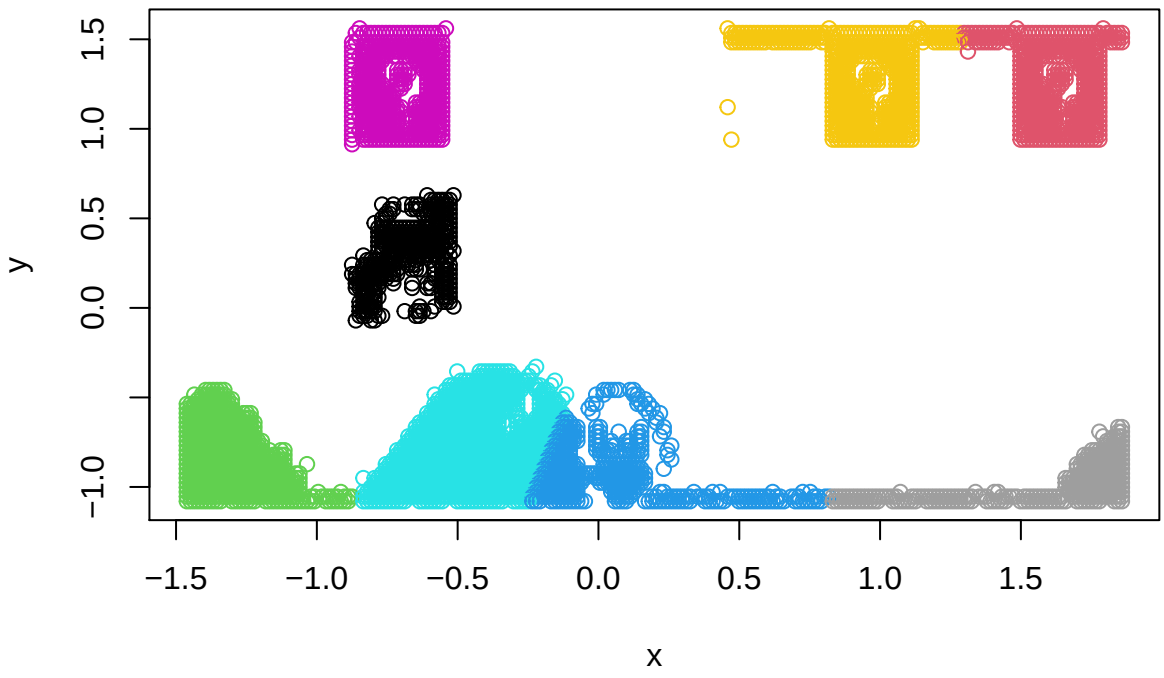

```
cluster_6<-kmeans(clustering_df, 6)
plot(clustering_df, col = cluster_6$cluster)
```



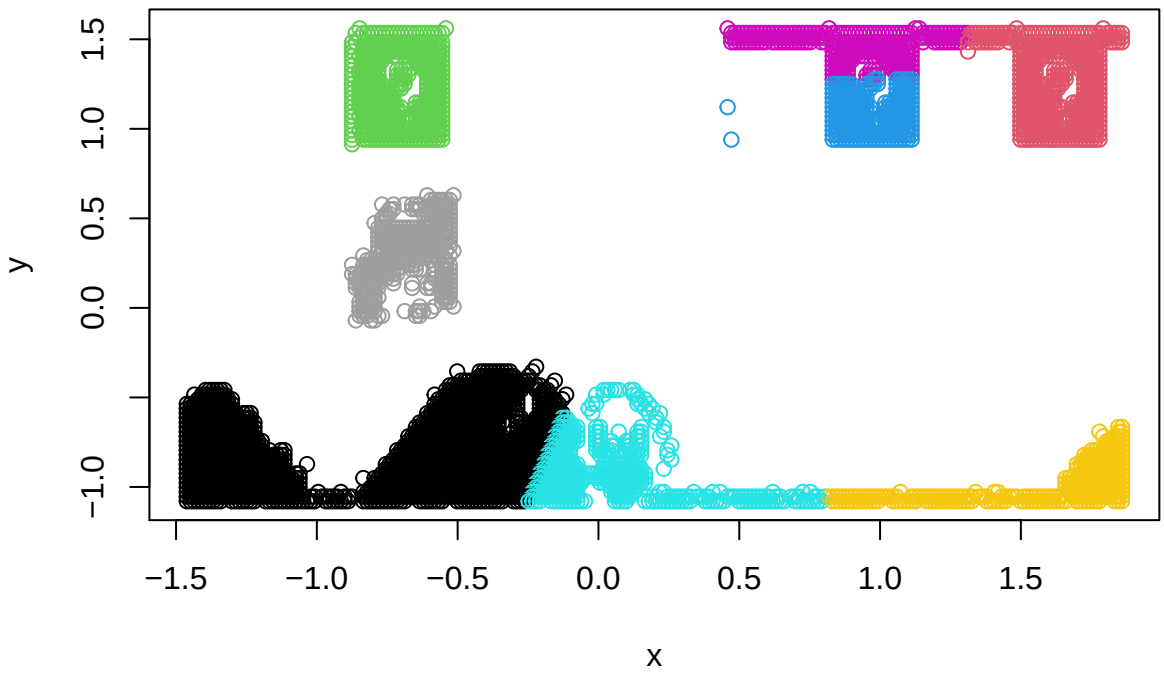

```
cluster_7<-kmeans(clustering_df, 7)
plot(clustering_df, col = cluster_7$cluster)
```



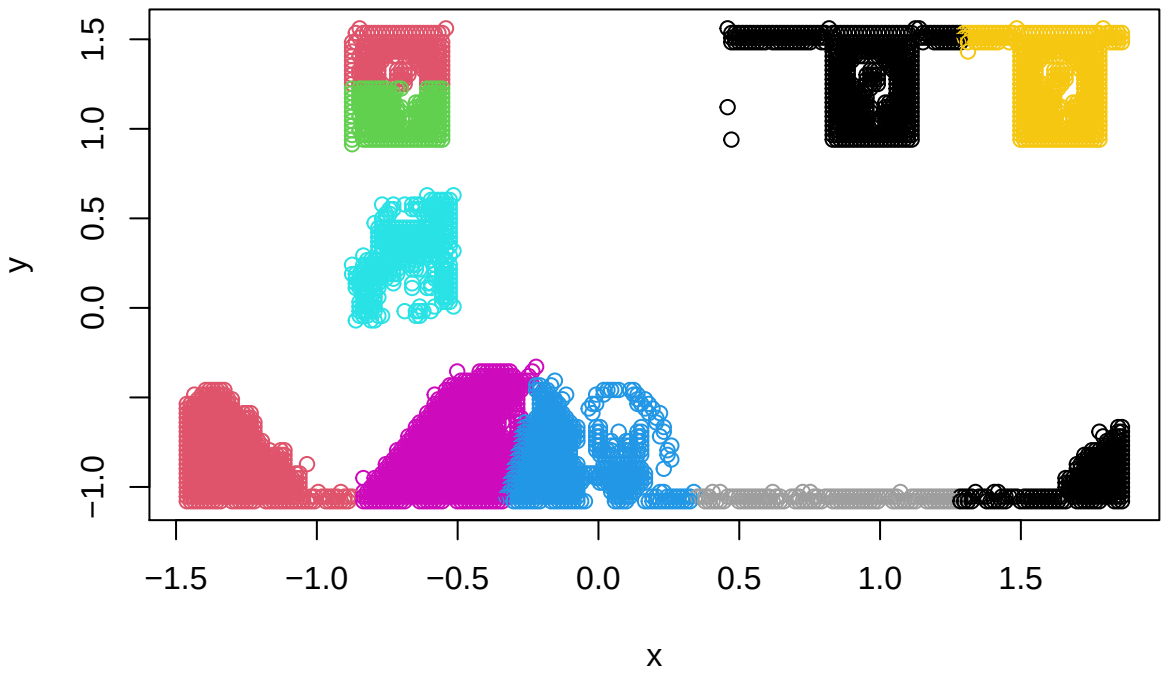

```
cluster_8<-kmeans(clustering_df, 8)
plot(clustering_df, col = cluster_8$cluster)
```



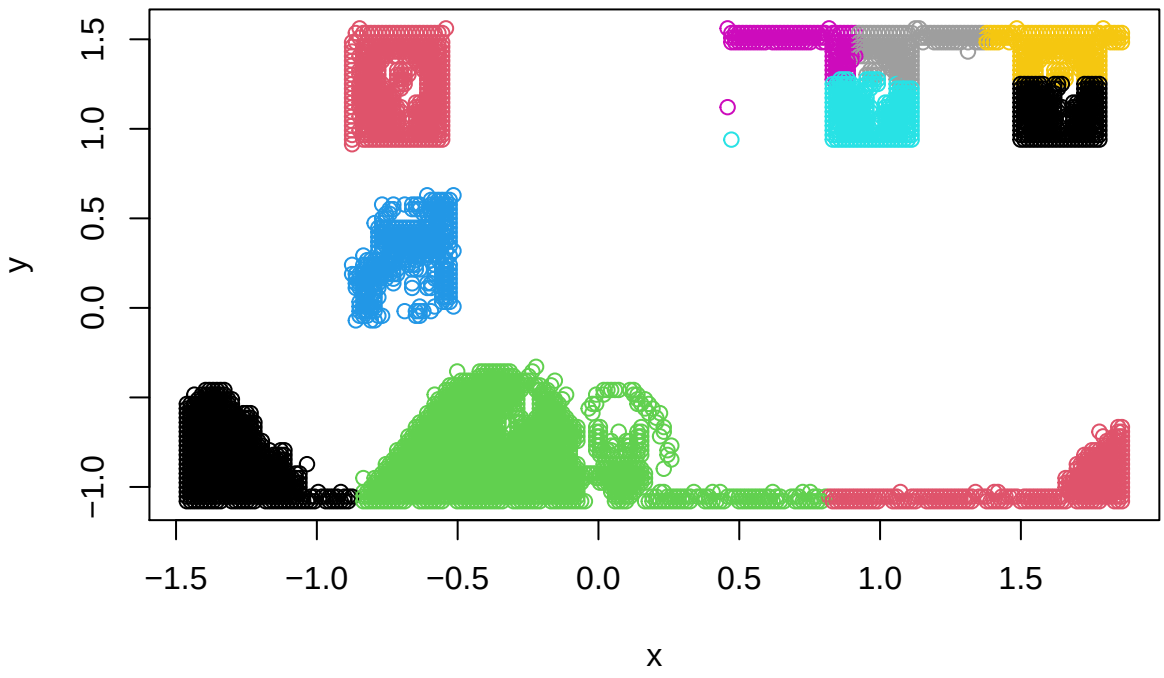

```
cluster_9<-kmeans(clustering_df, 9)
plot(clustering_df, col = cluster_9$cluster)
```



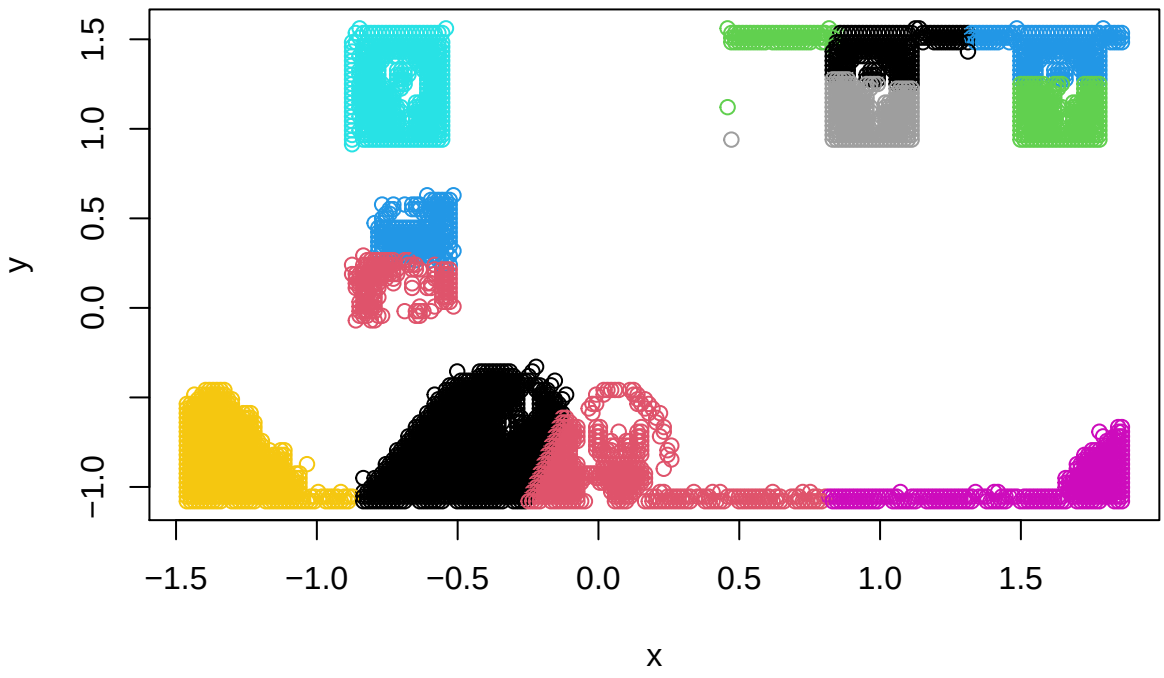

```
cluster_10<-kmeans(clustering_df, 10)
plot(clustering_df, col = cluster_10$cluster)
```



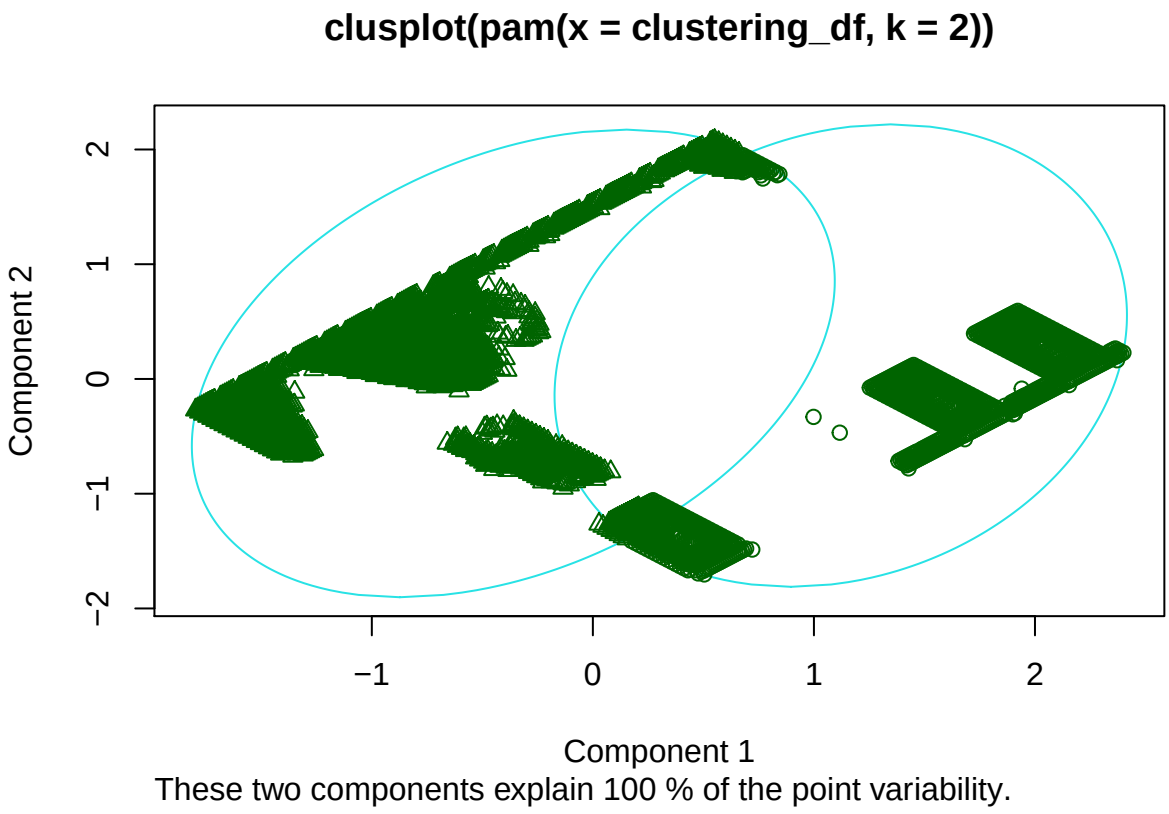

```
cluster_11<-kmeans(clustering_df, 11)
plot(clustering_df, col = cluster_11$cluster)
```



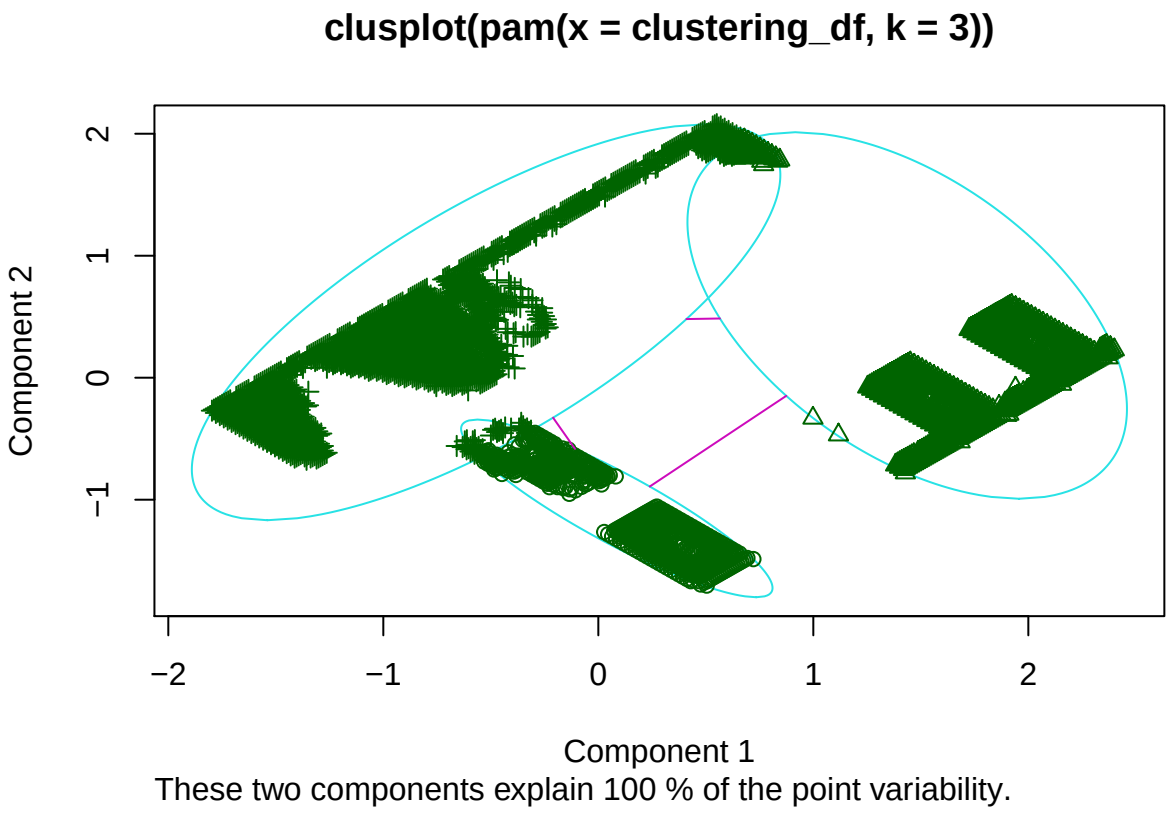

```
cluster_12<-kmeans(clustering_df, 12)
plot(clustering_df, col = cluster_12$cluster)
```




```
clusplot(pam(clustering_df, 2))
```

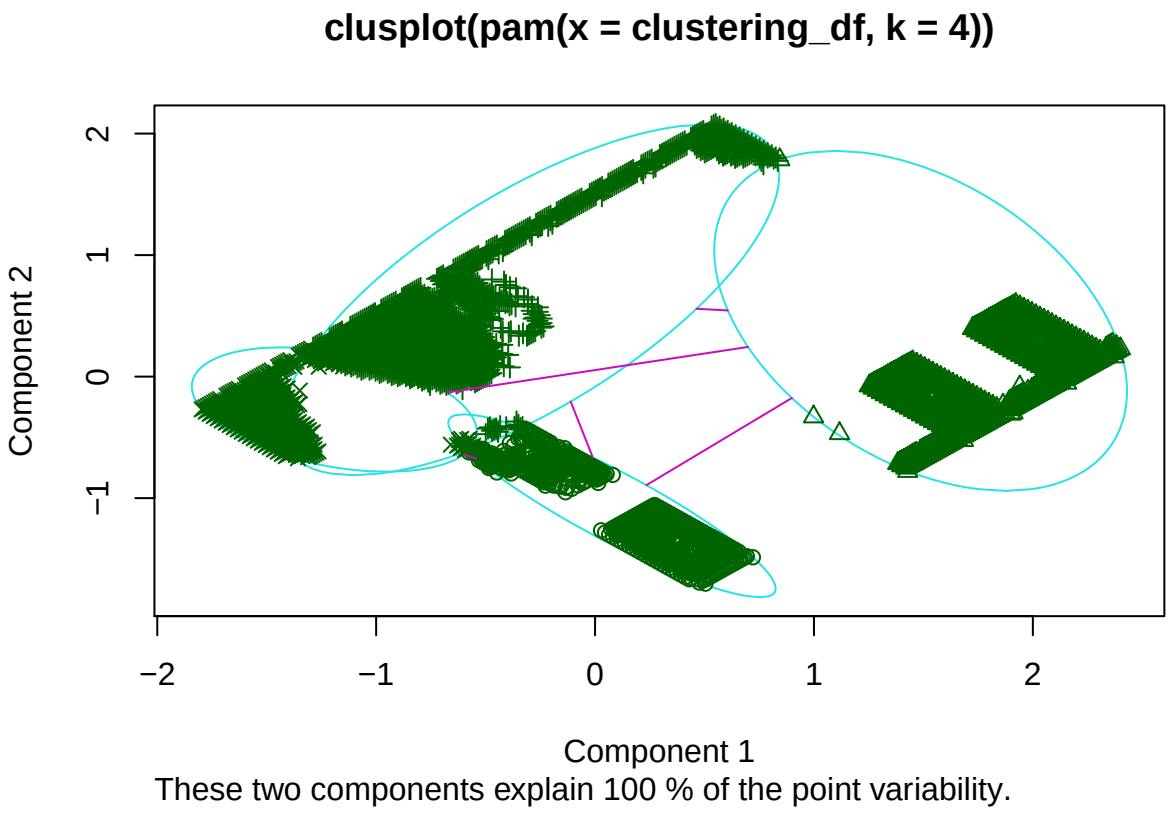



```
clusplot(pam(clustering_df, 3))
```

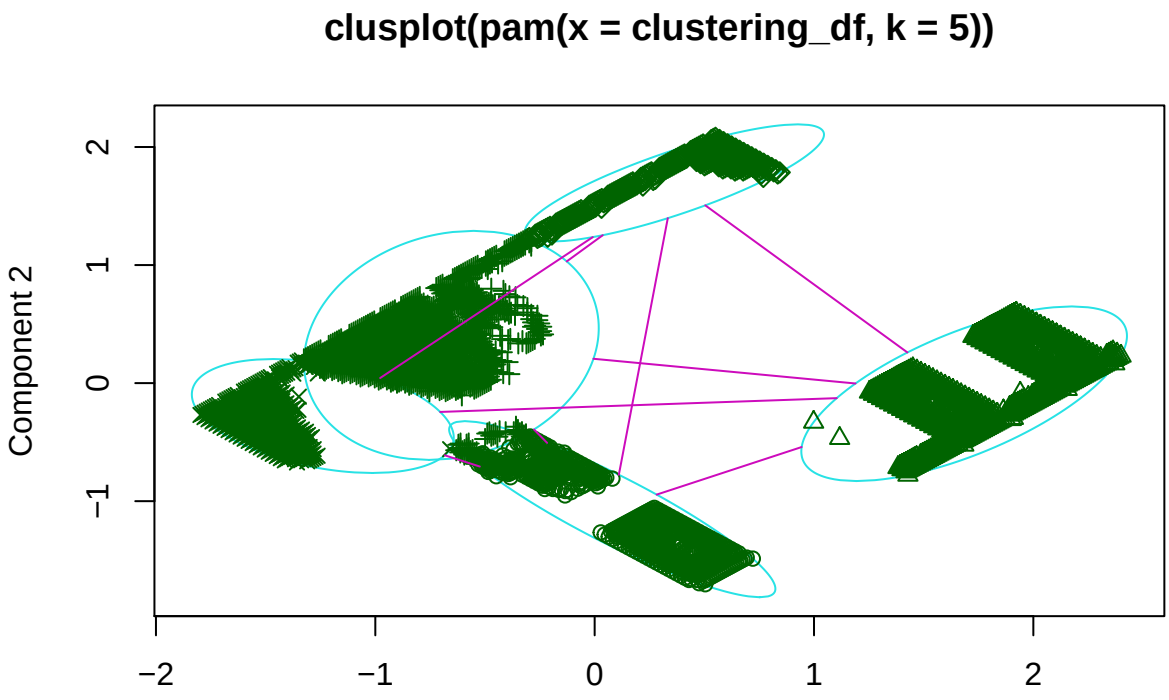


These two components explain 100 % of the point variability.

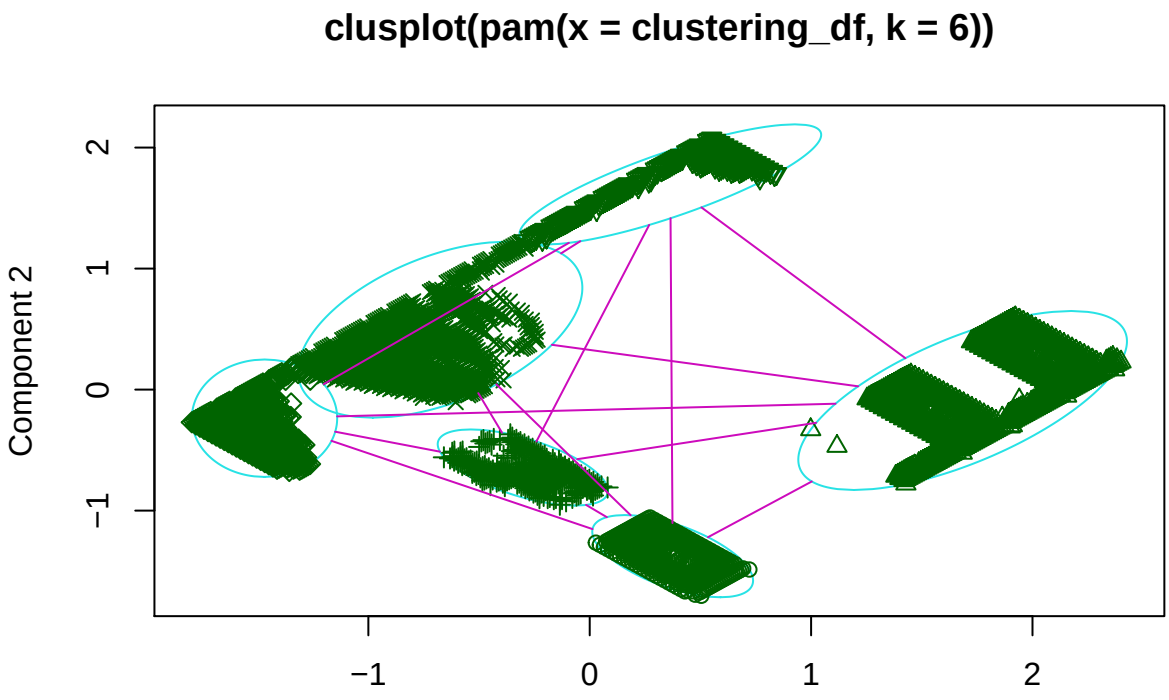
```
clusplot(pam(clustering_df, 4))
```



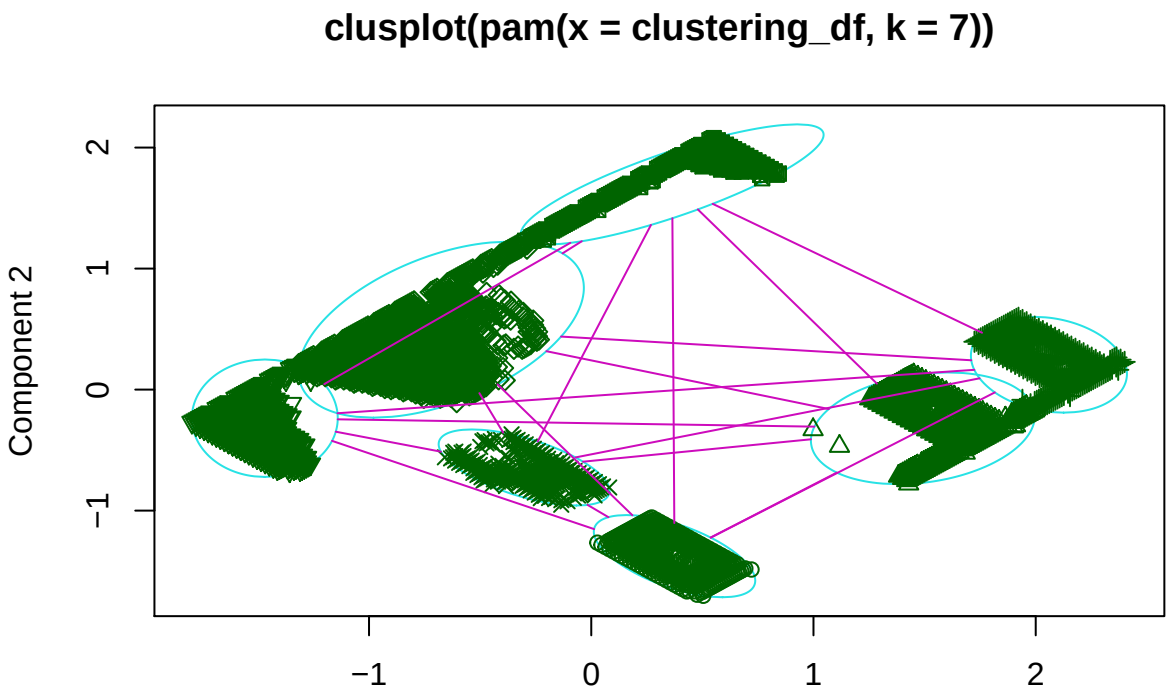

```
clusplot(pam(clustering_df, 5))
```



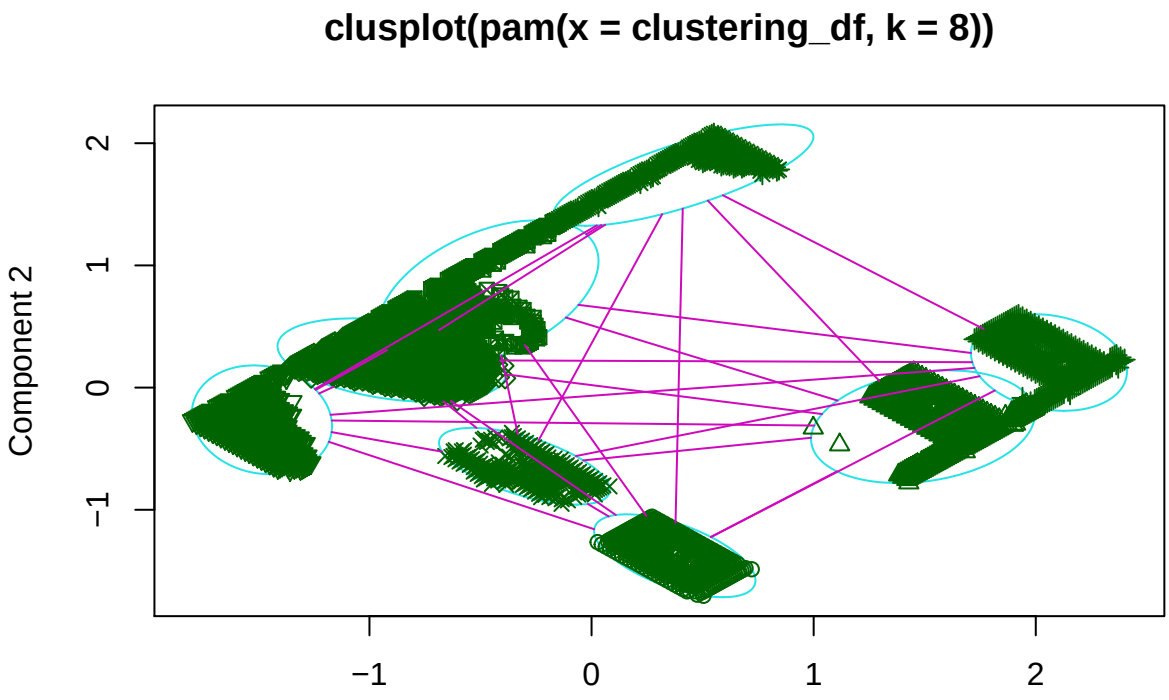

```
clusplot(pam(clustering_df, 6))
```



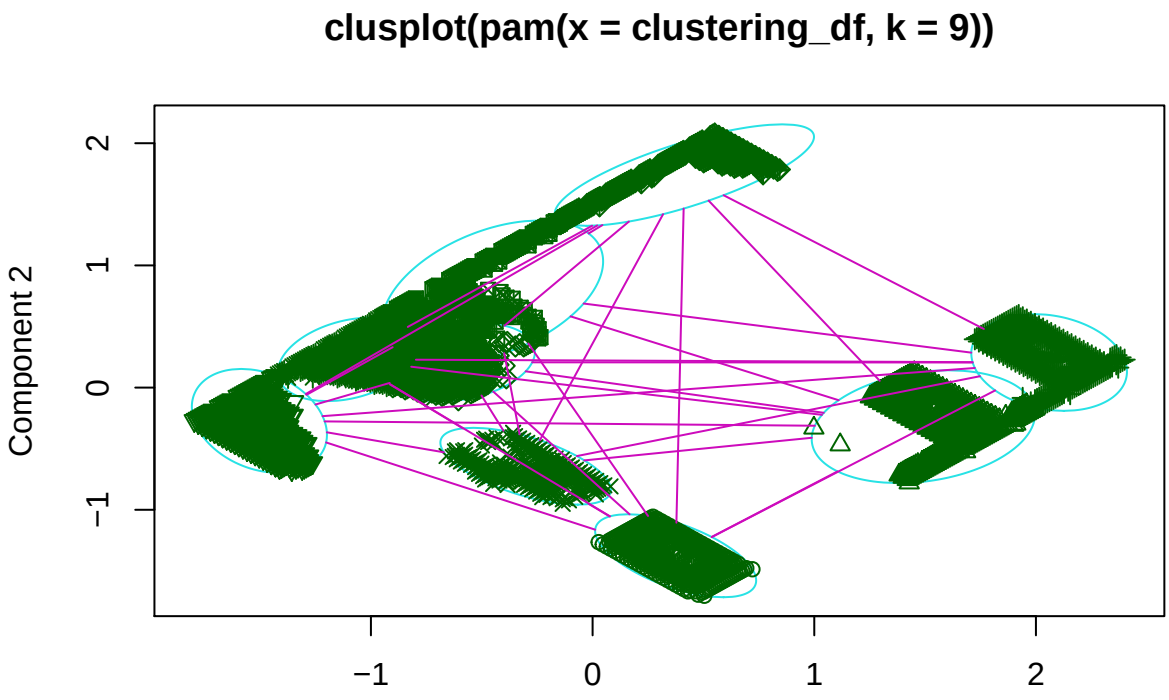

```
clusplot(pam(clustering_df, 7))
```



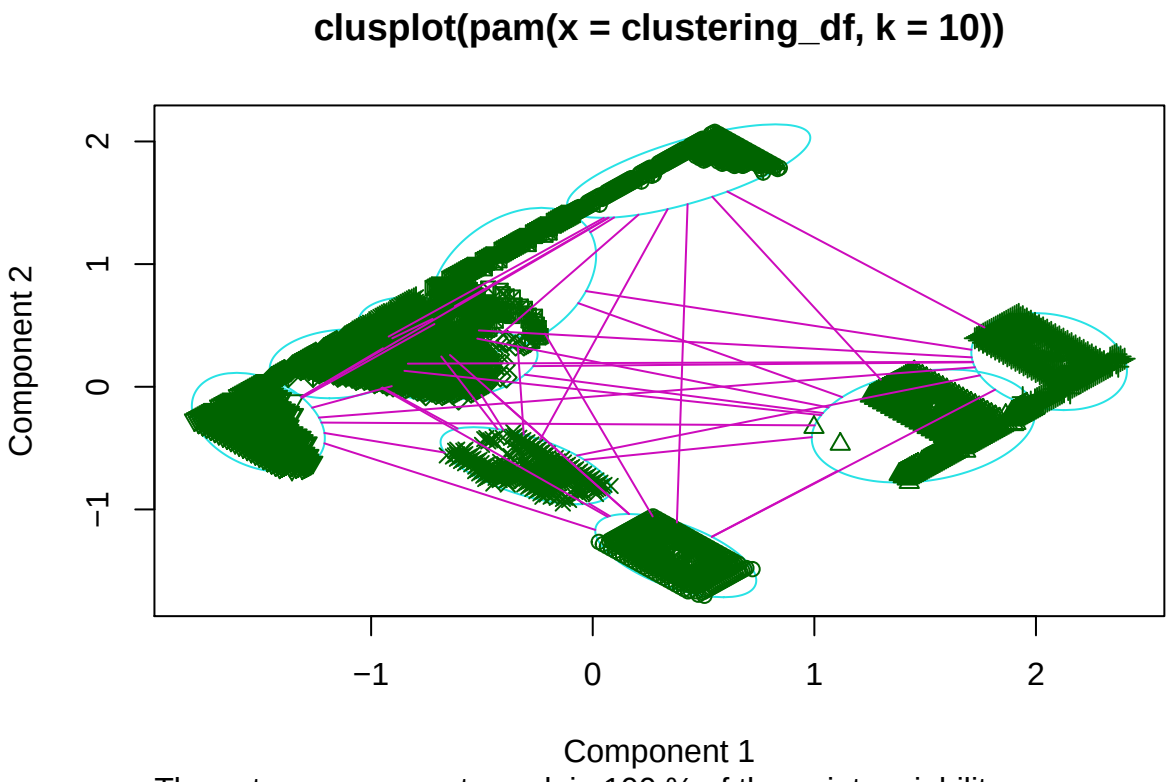

```
clusplot(pam(clustering_df, 8))
```



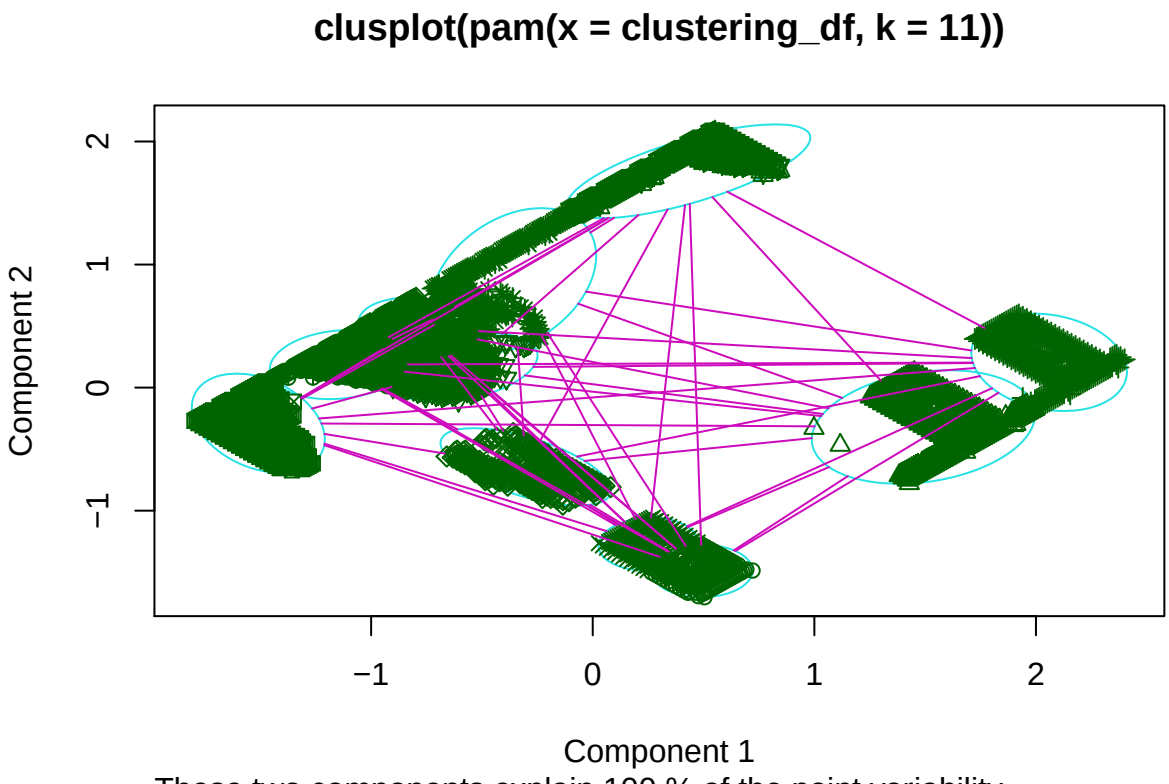

```
clusplot(pam(clustering_df, 9))
```



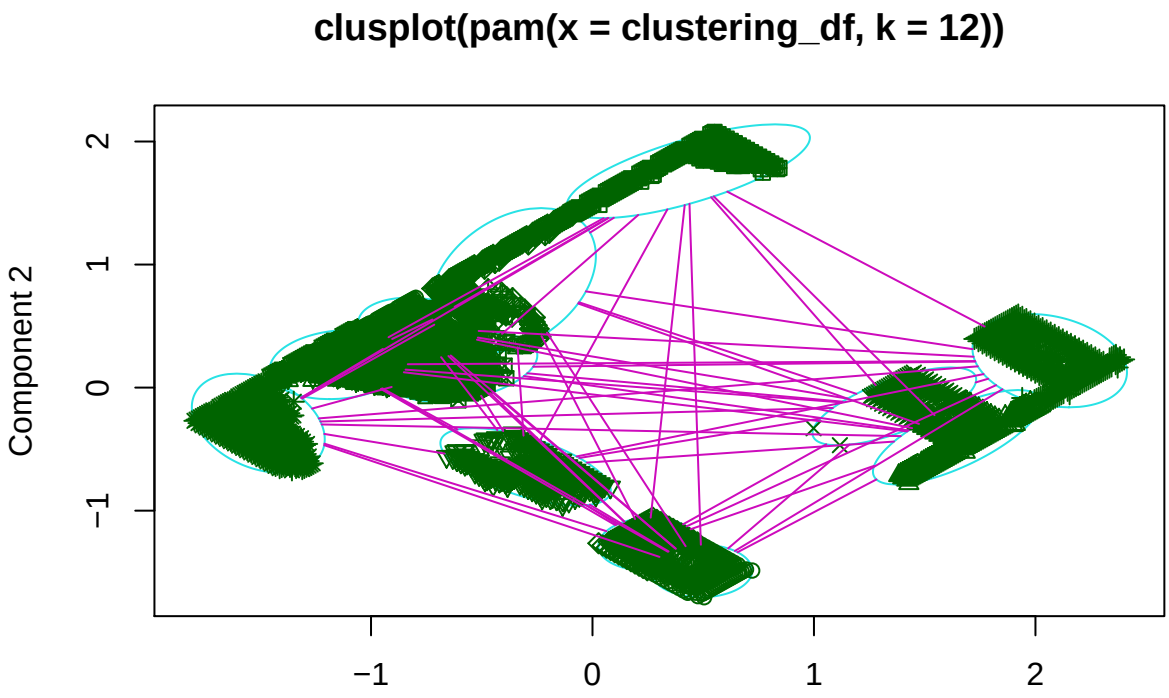

```
clusplot(pam(clustering_df, 10))
```




```
clusplot(pam(clustering_df, 11))
```




```
clusplot(pam(clustering_df, 12))
```



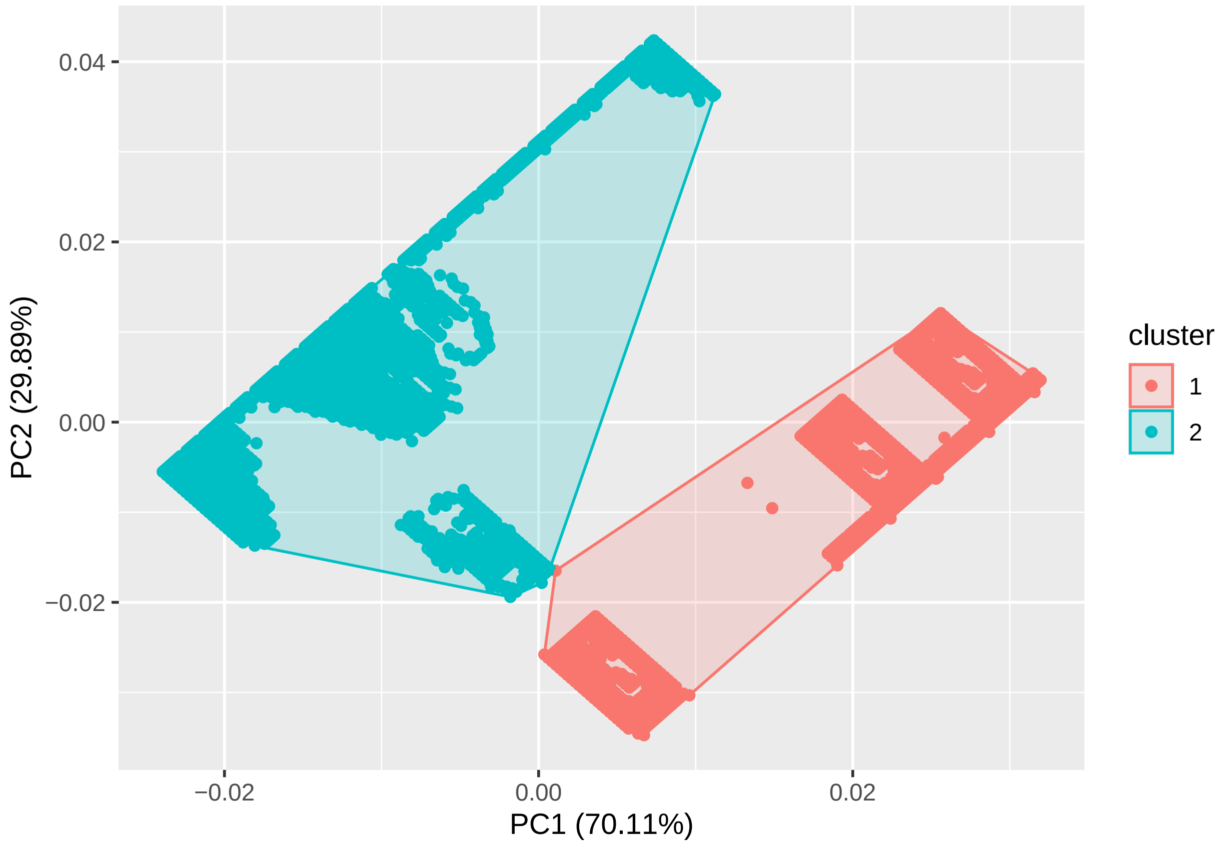

```
##install.packages("ggfortify")
library(ggfortify)
```

```
## Warning: package 'ggfortify' was built under R version 4.0.2
```

```
autoplot(cluster_2, clustering_df, frame = TRUE)
```

```
## Warning: `select_()` is deprecated as of dplyr 0.7.0.
## Please use `select()` instead.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_warnings()` to see where this warning was generated.

## Warning: `group_by_()` is deprecated as of dplyr 0.7.0.
## Please use `group_by()` instead.
## See vignette('programming') for more help
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_warnings()` to see where this warning was generated.
```




```
cluster_2$centers
```

```
##            x          y
## 1  0.6489063  1.2571500
## 2 -0.3568359 -0.6913114
```

```
cluster_k<- list()
for (i in 2:12) {
  cluster_k[[i]] <- kmeans(clustering_df, i)
}
cluster_k
```

```
## [[1]]
## NULL
##
## [[2]]
## K-means clustering with 2 clusters of sizes 2595, 1427
##
## Cluster means:
##            x          y
## 1 -0.3568359 -0.6913114
## 2  0.6489063  1.2571500
##
## Clustering vector:
##    [1] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
```

```
##   [38] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##   [75] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##  [112] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##  [149] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##  [186] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##  [223] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##  [260] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##  [297] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##  [334] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##  [371] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##  [408] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##  [445] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##  [482] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##  [519] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##  [556] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##  [593] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##  [630] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##  [667] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##  [704] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##  [741] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##  [778] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##  [815] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##  [852] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##  [889] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##  [926] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##  [963] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
## [1000] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
## [1037] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
## [1074] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
## [1111] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
## [1148] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
## [1185] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
## [1222] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
## [1259] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
## [1296] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
## [1333] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
## [1370] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
## [1407] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [1444] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [1481] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [1518] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [1555] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [1592] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [1629] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [1666] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [1703] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [1740] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [1777] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [1814] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [1851] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [1888] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [1925] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [1962] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [1999] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
```

```
## [2036] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [2073] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [2110] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [2147] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [2184] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [2221] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [2258] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [2295] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [2332] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [2369] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [2406] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [2443] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [2480] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [2517] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [2554] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [2591] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [2628] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [2665] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
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##
## Within cluster sum of squares by cluster:
## [1] 2235.423 1379.822
##  (between_SS / total_SS =  55.0 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
##
## [[3]]
## K-means clustering with 3 clusters of sizes 2255, 1426, 341
##
## Cluster means:
##            x          y
## 1 -0.6241498 -0.6453636
## 2  0.6497223  1.2575905
## 3  1.4104215 -0.9912878
##
## Clustering vector:
##    [1] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
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##
## Within cluster sum of squares by cluster:
## [1]  898.64282 1378.07217   76.95713
##  (between_SS / total_SS =  70.7 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
##
## [[4]]
## K-means clustering with 4 clusters of sizes 1945, 338, 985, 754
##
## Cluster means:
##            x          y
## 1 -0.6150938 -0.8013866
## 2  1.4196187 -0.9906559
## 3  1.2586128  1.2721827
## 4 -0.6939089  0.8493881
##
## Clustering vector:
##    [1] 4 4 3 3 3 3 3 3 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 3 3 3 3 3 3
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##
## Within cluster sum of squares by cluster:
## [1] 551.86203  73.69142 177.01665 179.99325
##  (between_SS / total_SS =  87.8 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
##
## [[5]]
```

```
## K-means clustering with 5 clusters of sizes 338, 464, 521, 1945, 754
##
## Cluster means:
##           x          y
## 1  1.4196187 -0.9906559
## 2  1.6222263  1.2583422
## 3  0.9347803  1.2845090
## 4 -0.6150938 -0.8013866
## 5 -0.6939089  0.8493881
##
## Clustering vector:
##    [1] 5 5 3 3 3 3 2 2 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 3 3 3 3 3 3
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##
## Within cluster sum of squares by cluster:
## [1]  73.69142  24.58883  36.27618 551.86203 179.99325
##  (between_SS / total_SS =  89.2 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
##
## [[6]]
## K-means clustering with 6 clusters of sizes 287, 453, 748, 569, 985, 980
##
## Cluster means:
##             x          y
## 1  1.56663641 -0.9775317
## 2  0.04852981 -0.9013642
## 3 -0.69513141  0.8558284
## 4 -1.28733754 -0.8403549
## 5  1.25861275  1.2721827
## 6 -0.46825394 -0.7410490
##
## Clustering vector:
##    [1] 3 3 5 5 5 5 5 5 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 5 5 5 5 5 5
##   [38] 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
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##
## Within cluster sum of squares by cluster:
## [1]  31.53744  38.32528 175.95228  25.87924 177.01665  83.86858
##  (between_SS / total_SS =  93.4 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
##
## [[7]]
## K-means clustering with 7 clusters of sizes 441, 569, 985, 341, 286, 984, 416
##
## Cluster means:
##             x          y
## 1 -0.71027100  1.2249978
## 2 -1.28733754 -0.8403549
## 3  1.25861275  1.2721827
```

```
## 4 -0.67716791  0.2920086
## 5  1.56929810 -0.9772649
## 6 -0.45003907 -0.7716581
## 7  0.07433762 -0.9036722
##
## Clustering vector:
##    [1] 1 1 3 3 3 3 3 3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3 3 3 3 3 3
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## [3997] 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
##
## Within cluster sum of squares by cluster:
## [1]  19.52538  25.87924 177.01665  13.78287  30.95007  65.95642  35.17087
##  (between_SS / total_SS =  95.4 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
##
## [[8]]
## K-means clustering with 8 clusters of sizes 550, 281, 341, 560, 526, 985, 441, 338
##
## Cluster means:
##            x          y
## 1 -0.5280962 -0.9280690
## 2  1.5823687 -0.9757179
## 3 -0.6771679  0.2920086
## 4 -1.2934898 -0.8367851
## 5 -0.3244840 -0.6111989
## 6  1.2586128  1.2721827
## 7 -0.7102710  1.2249978
## 8  0.1338769 -0.9414023
##
## Clustering vector:
##    [1] 7 7 6 6 6 6 6 6 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 6 6 6 6 6 6
##   [38] 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6
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## [3997] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##
## Within cluster sum of squares by cluster:
## [1]  21.20268  28.16435  13.78287  24.08252  20.61176 177.01665  19.52538
## [8]  28.63480
##  (between_SS / total_SS =  95.9 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
##
## [[9]]
## K-means clustering with 9 clusters of sizes 441, 341, 521, 464, 281, 560, 526, 550, 338
##
## Cluster means:
##            x          y
## 1 -0.7102710  1.2249978
## 2 -0.6771679  0.2920086
## 3  0.9347803  1.2845090
## 4  1.6222263  1.2583422
## 5  1.5823687 -0.9757179
```

```
## 6 -1.2934898 -0.8367851
## 7 -0.3244840 -0.6111989
## 8 -0.5280962 -0.9280690
## 9  0.1338769 -0.9414023
##
## Clustering vector:
##    [1] 1 1 3 3 3 3 4 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3 3 3 3 3 3
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## [3849] 6 6 6 6 6 6 6 6 6 6 6 6 6 6 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8
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## [3960] 9 9 9 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
## [3997] 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
##
## Within cluster sum of squares by cluster:
## [1] 19.52538 13.78287 36.27618 24.58883 28.16435 24.08252 20.61176 21.20268
## [9] 28.63480
##  (between_SS / total_SS =  97.3 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
##
## [[10]]
## K-means clustering with 10 clusters of sizes 441, 984, 425, 286, 247, 341, 416, 163, 569, 150
##
## Cluster means:
##              x          y
## 1  -0.71027100  1.2249978
## 2  -0.45003907 -0.7716581
## 3   1.64399735  1.2350671
## 4   1.56929810 -0.9772649
## 5   0.96525699  1.0930832
## 6  -0.67716791  0.2920086
## 7   0.07433762 -0.9036722
## 8   1.16463492  1.4608797
## 9  -1.28733754 -0.8403549
## 10  0.75187146  1.4672100
##
## Clustering vector:
##    [1]  1  1 10 10  8  8  8  3  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
##   [25]  1  1  1  1  1  1  1 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
##   [49] 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10  8  8  8  8  8
##   [73]  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8
##   [97]  8  8  8  8  8  8  8  8  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3
##  [121]  3  3  3  3  3  3  3  3  3  3  3  3  1 10 10 10 10 10 10 10 10 10 10 10 10
##  [145] 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10  8  8  8  8  8  8  8  8  8
##  [169]  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  3  3  3  3  3  3  3
##  [193]  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1 10
##  [217] 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
##  [241] 10 10 10 10 10 10 10 10  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8
##  [265]  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  3  3  3  3  3  3  3  3  3  3
##  [289]  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  1  1  1  1  1  1  1
##  [313]  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1 10 10 10 10 10 10 10 10
##  [337] 10 10  8  8  8  8  8  8  8  8  8  8  8  8  8  3  3  3  3  3  3  3  3  3  3
##  [361]  3  3  3  3  3  3  3  3  3  3  3  3  3  1  1  1  1  1  1  1  1  1  1  1  1
##  [385]  1  1  1  1  1  1  1  1  1 10 10 10 10 10 10 10 10 10 10  8  8  8  8  8  8
##  [409]  8  8  8  8  8  8  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3
##  [433]  3  3  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
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##  [457] 10 10 10 10 10 10 10 10 10  8  8  8  8  8  8  8  8  8  8  8  3  3  3  3
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##  [553] 10 10 10 10  8  8  8  8  8  8  8  3  3  3  3  3  3  3  3  3  3  3  1  1
##  [577]  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1 10 10 10 10 10  5  8  8  8
##  [601]  8  8  8  8  8  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  1  1  1  1
##  [625]  1  1  1  1  1  1  1  1  1  1  1  1 10 10 10 10 10  5  5  5  5  8  8  8
##  [649]  8  8  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  1  1  1  1  1  1  1  1
##  [673]  1  1  1  1  1  1 10 10  5  5  5  5  5  5  5  5  8  8  8  8  3  3  3  3
##  [697]  3  3  3  3  3  3  3  3  3  3  1  1  1  1  1  1  1  1  1  1  1  1  1  1
##  [721]  1  1  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  3  3  3  3  3  3  3
##  [745]  3  3  3  3  3  3  3  3  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
##  [769]  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  3  3  3  3  3  3  3  3  3  3
##  [793]  3  3  3  3  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  5  5  5  5
##  [817]  5  5  5  5  5  5  5  5  5  5  3  3  3  3  3  3  3  3  3  3  3  3  3  3
##  [841]  3  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  5  5  5  5  5  5  5
##  [865]  5  5  5  5  5  5  5  5  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  1
##  [889]  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  5  5  5  5  5  5
##  [913]  5  5  5  5  5  5  5  5  5  5  5  5  5  3  3  3  3  3  3  3  3  3  3  3  3
##  [937]  3  3  3  3  3  3  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
##  [961]  1  1  1 10  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  3
##  [985]  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  1  1  1  1  1
## [1009]  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  5  5  5  5  5  5  5  5  5
## [1033]  5  5  5  5  5  5  5  5  5  5  3  3  3  3  3  3  3  3  3  3  3  3  3  3
## [1057]  3  3  3  3  3  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
## [1081]  1  1  1  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  3  3
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## [1273]  5  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  1  1  1  1  1  1
## [1297]  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  5  5  5  5  5  5  5
## [1321]  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  3  3  3  3  3  3  3  3  3
## [1345]  3  3  3  3  3  3  3  3  3  3  3  3  3  3  1  1  1  1  1  1  1  1  1  1  1
## [1369]  1  1  1  1  1  1  1  1  1  1  1  1  1  5  5  5  5  5  5  5  5  5  5  5  5
## [1393]  5  5  5  5  5  5  5  5  5  5  5  5  3  3  3  3  3  3  3  3  3  3  3  3  3
## [1417]  3  3  3  3  3  3  3  3  3  1  6  6  6  6  6  6  6  6  6  6  6  6  6  6
## [1441]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6
## [1465]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6
## [1489]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6
## [1513]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6
## [1537]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6
## [1561]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6
## [1585]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6
## [1609]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6
## [1633]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6
## [1657]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6
## [1681]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6
## [1705]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6
## [1729]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6
```

```
## [1753]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  2  2  2  2  2  2  2  2  2
## [1777]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [1801]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [1825]  2  2  2  2  2  2  2  2  2  2  2  9  9  9  9  9  9  2  2  2  2  2  2  2
## [1849]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  7  7  7  7  7  7
## [1873]  7  9  9  9  9  9  9  9  9  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [1897]  2  2  2  2  2  2  2  2  2  2  7  7  7  7  9  9  9  9  9  9  9  9  9  9
## [1921]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [1945]  2  2  2  2  7  7  9  9  9  9  9  9  9  9  9  9  9  9  9  2  2  2  2  2
## [1969]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [1993]  7  7  7  7  7  9  9  9  9  9  9  9  9  9  9  9  9  9  9  2  2  2  2  2
## [2017]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  7
## [2041]  7  7  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  2  2  2  2
## [2065]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [2089]  7  7  7  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  2  2  2
## [2113]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [2137]  2  2  7  7  7  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [2161]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [2185]  2  2  2  2  2  2  2  2  2  2  7  7  7  7  9  9  9  9  9  9  9  9  9  9
## [2209]  9  9  9  9  9  9  9  9  9  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [2233]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  7  7  7  7  7
## [2257]  7  7  7  7  7  4  4  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [2281]  9  9  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [2305]  2  2  2  2  2  2  2  2  2  2  2  2  7  7  7  7  7  7  7  7  7  7  7  7
## [2329]  4  4  4  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  2  2
## [2353]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [2377]  2  2  2  2  2  2  2  2  2  2  7  7  7  7  7  7  7  7  7  7  7  7  4  4
## [2401]  4  4  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  2
## [2425]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [2449]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  7  7  7  7  7  7  7  7  7  7
## [2473]  7  7  7  7  4  4  4  4  4  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [2497]  9  9  9  9  9  9  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [2521]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  7  7  7
## [2545]  7  7  7  7  7  7  7  7  7  7  7  4  4  4  4  4  9  9  9  9  9  9  9  9
## [2569]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  2  2  2  2  2  2  2  2
## [2593]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [2617]  2  2  2  2  2  2  2  2  2  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [2641]  7  7  4  4  4  4  4  4  4  4  4  9  9  9  9  9  9  9  9  9  9  9  9  9
## [2665]  9  9  9  9  9  9  9  9  9  9  9  9  9  2  2  2  2  2  2  2  2  2  2  2
## [2689]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [2713]  2  2  2  2  2  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  4  4
## [2737]  4  4  4  4  4  4  4  4  4  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [2761]  9  9  9  9  9  9  9  9  9  9  9  2  2  2  2  2  2  2  2  2  2  2  2  2
## [2785]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [2809]  2  2  2  2  7  7  7  7  7  7  7  7  4  4  4  4  4  4  4  4  4  4  4  9
## [2833]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [2857]  9  9  9  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [2881]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  7  7  7
## [2905]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  4  4  4  4  4  4  4
## [2929]  4  4  4  4  4  4  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [2953]  9  9  9  9  9  9  9  9  9  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [2977]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [3001]  2  2  2  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [3025]  7  4  4  4  4  4  4  4  4  4  4  4  4  4  4  9  9  9  9  9  9  9  9  9
```

```
## [3049]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  2  2  2  2
## [3073]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [3097]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  7  7  7  7  7  7  7  7  7
## [3121]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  4  4  4  4
## [3145]  4  4  4  4  4  4  4  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [3169]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  2  2  2  2  2  2  2  2  2
## [3193]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [3217]  2  2  2  2  2  2  2  2  2  2  2  7  7  7  7  7  7  7  7  7  7  7  7
## [3241]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  4  4  4  4  4  4  4  4  4
## [3265]  4  4  4  4  4  4  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [3289]  9  9  9  9  9  9  9  9  9  9  9  9  9  2  2  2  2  2  2  2  2  2  2
## [3313]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [3337]  2  2  2  2  2  2  2  2  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [3361]  7  7  7  7  7  7  7  7  7  7  4  4  4  4  4  4  4  4  4  4  4  4  4
## [3385]  4  4  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [3409]  9  9  9  9  9  9  9  9  9  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [3433]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [3457]  2  2  2  2  2  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [3481]  7  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  9  9  9  9  9  9
## [3505]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [3529]  9  9  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [3553]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  7
## [3577]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [3601]  7  7  7  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  9
## [3625]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [3649]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  2  2  2  2  2  2  2  2
## [3673]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [3697]  2  2  2  2  2  2  2  2  2  2  2  2  7  7  7  7  7  7  7  7  7  7  7
## [3721]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [3745]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  4  4  4  4  4  4  4  4
## [3769]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [3793]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [3817]  4  4  4  4  4  4  4  4  4  4  4  4  4  9  9  9  9  9  9  9  9  9  9
## [3841]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [3865]  9  9  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [3889]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  7  7  7  7  7  7  7  7  7
## [3913]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [3937]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [3961]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [3985]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [4009]  4  4  4  4  4  4  4  4  4  4  4  4  4  4
##
## Within cluster sum of squares by cluster:
##  [1] 19.525379 65.956422 19.316793 30.950073  4.903574 13.782873 35.170870
##  [8]  4.404013 25.879236  4.039289
##  (between_SS / total_SS =  97.2 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
##
## [[11]]
## K-means clustering with 11 clusters of sizes 241, 244, 504, 341, 237, 332, 516, 559, 328, 441, 279
```

```
##
## Cluster means:
##             x          y
## 1  -1.3539251 -0.6696803
## 2   1.5814256  1.4427949
## 3   0.9240098  1.2768745
## 4  -0.6771679  0.2920086
## 5   1.6378261  1.0865538
## 6   0.1459620 -0.9417097
## 7  -0.3237155 -0.6072366
## 8  -0.5142130 -0.9243509
## 9  -1.2384119 -0.9657591
## 10 -0.7102710  1.2249978
## 11  1.5875561 -0.9750650
##
## Clustering vector:
##    [1] 10 10  3  3  3  3  2  2 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
##   [25] 10 10 10 10 10 10 10  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3
##   [49]  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3
##   [73]  3  3  3  3  3  3  3  3  3  3  3  3  2  2  2  2  2  2  2  2  2  2  2  2
##   [97]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
##  [121]  2  2  2  2  2  2  2  2  2  2  2 10  3  3  3  3  3  3  3  3  3  3  3  3
##  [145]  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  2  2  2
##  [169]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
##  [193] 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10  3
##  [217]  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3
##  [241]  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3
##  [265]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
##  [289]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2 10 10 10 10 10 10 10
##  [313] 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10  3  3  3  3  3  3  3  3
##  [337]  3  3  3  3  3  3  3  3  3  3  3  3  3  3  2  2  2  2  2  2  2  2  2  2
##  [361]  2  2  2  2  2  2  2  2  2  2  2  2 10 10 10 10 10 10 10 10 10 10 10 10
##  [385] 10 10 10 10 10 10 10 10 10  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3
##  [409]  3  3  3  3  3  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
##  [433]  2  2 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
##  [457]  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  2  2  2  2
##  [481]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2 10 10 10 10 10 10 10 10 10
##  [505] 10 10 10 10 10 10  3  3  3  3  3  3  3  3  3  3  3  3  3  3  2  2  2  2
##  [529]  2  2  2  2  2  2  2  2  2  2 10 10 10 10 10 10 10 10 10 10 10 10 10  3
##  [553]  3  3  3  3  3  3  3  3  3  3  3  2  2  2  2  2  2  2  2  2  2  2 10 10
##  [577] 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10  3  3  3  3  3  3  3  3  3
##  [601]  3  3  3  3  3  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2 10 10 10 10
##  [625] 10 10 10 10 10 10 10 10 10 10 10 10  3  3  3  3  3  3  3  3  3  3  3  3
##  [649]  3  3  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2 10 10 10 10 10 10 10 10
##  [673] 10 10 10 10 10 10  3  3  3  3  3  3  3  3  3  3  3  3  3  3  2  2  2  2
##  [697]  2  2  2  2  2  5  5  5  5  5 10 10 10 10 10 10 10 10 10 10 10 10 10 10
##  [721] 10 10  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  2  2  5  5  5  5  5
##  [745]  5  5  5  5  5  5  5  5 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
##  [769]  3  3  3  3  3  3  3  3  3  3  3  3  3  3  5  5  5  5  5  5  5  5  5  5
##  [793]  5  5  5  5 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10  3  3  3  3
##  [817]  3  3  3  3  3  3  3  3  3  3  5  5  5  5  5  5  5  5  5  5  5  5  5  5
##  [841]  5 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10  3  3  3  3  3  3  3
##  [865]  3  3  3  3  3  3  3  3  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5 10
##  [889] 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10  3  3  3  3  3  3
```

```
##  [913]  3  3  3  3  3  3  3  3  3  3  3  3  5  5  5  5  5  5  5  5  5  5  5  5
##  [937]  5  5  5  5  5  5 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
##  [961] 10 10 10  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  5
##  [985]  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5 10 10 10 10 10
## [1009] 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10  3  3  3  3  3  3  3  3  3
## [1033]  3  3  3  3  3  3  3  3  3  3  3  5  5  5  5  5  5  5  5  5  5  5  5  5  5
## [1057]  5  5  5  5  5 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
## [1081] 10 10 10  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  5  5
## [1105]  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5 10 10 10 10 10 10
## [1129] 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10  3  3  3  3  3  3  3  3  3  3
## [1153]  3  3  3  3  3  3  3  3  3  3  3  5  5  5  5  5  5  5  5  5  5  5  5  5  5
## [1177]  5  5  5  5  5 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
## [1201]  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  5  5  5  5  5
## [1225]  5  5  5  5  5  5  5  5  5  5  5  5  5 10 10 10 10 10 10 10 10 10 10 10 10
## [1249] 10 10 10 10 10 10 10 10  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3
## [1273]  3  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5 10 10 10 10 10 10
## [1297] 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10  3  3  3  3  3  3
## [1321]  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  5  5  5  5  5  5  5  5  5
## [1345]  5  5  5  5  5  5  5  5  5  5  5  5  5  5 10 10 10 10 10 10 10 10 10 10 10
## [1369] 10 10 10 10 10 10 10 10 10 10 10 10 10  3  3  3  3  3  3  3  3  3  3  3  3
## [1393]  3  3  3  3  3  3  3  3  3  3  3  3  5  5  5  5  5  5  5  5  5  5  5  5  5
## [1417]  5  5  5  5  5  5  5  5  5 10  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [1441]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [1465]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [1489]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [1513]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [1537]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [1561]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [1585]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [1609]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [1633]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [1657]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [1681]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [1705]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [1729]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [1753]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  7  7  7  7  7  7  7  7  7
## [1777]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [1801]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [1825]  7  7  7  7  7  7  7  7  7  7  7  1  1  1  1  1  1  7  7  7  7  7  7  7
## [1849]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [1873]  7  1  1  1  1  1  1  1  1  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [1897]  7  7  7  7  7  7  7  7  7  7  7  7  6  6  1  1  1  1  1  1  1  1  1  1
## [1921]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [1945]  7  7  7  7  6  6  1  1  1  1  1  1  1  1  1  1  1  1  1  1  7  7  7  7  7
## [1969]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [1993]  7  7  6  6  6  1  1  1  1  1  1  1  1  1  1  1  1  1  1  7  7  7  7  7  7
## [2017]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [2041]  6  6  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  7  7  7  7  7
## [2065]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [2089]  7  6  6  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  7  7  7
## [2113]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [2137]  7  7  7  7  6  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
## [2161]  8  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [2185]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  6  1  1  1  1  1  1  1  1  1  1
```

```
## [2209]  1  1  1  1  1  1  1  1  1  8  8  8  8  8  7  7  7  7  7  7  7  7  7  7
## [2233]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [2257]  7  6  6  6  6 11 11  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
## [2281]  1  1  8  8  8  8  8  8  8  8  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [2305]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  6  6  6  6  6  6
## [2329] 11 11 11  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  8  8
## [2353]  8  8  8  8  8  8  8  8  8  8  8  8  7  7  7  7  7  7  7  7  7  7  7  7
## [2377]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  6  6  6  6  6 11 11
## [2401] 11 11  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  8
## [2425]  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  7  7  7  7  7  7  7  7
## [2449]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  6  6  6
## [2473]  6  6  6  6 11 11 11 11 11  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
## [2497]  1  1  1  1  1  1  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8
## [2521]  8  8  8  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [2545]  7  7  7  6  6  6  6  6  6  6  6 11 11 11 11 11  1  1  1  1  1  1  1  1
## [2569]  1  1  1  1  1  1  1  1  1  9  9  9  9  9  9  9  8  8  8  8  8  8  8  8
## [2593]  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  7  7  7  7  7  7  7
## [2617]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  6  6  6  6  6  6  6  6  6
## [2641]  6  6 11 11 11 11 11 11 11 11 11  1  1  1  1  1  1  1  1  1  1  1  1  9
## [2665]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  8  8  8  8  8  8  8  8  8  8
## [2689]  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  7  7  7  7  7
## [2713]  7  7  7  7  7  7  7  7  7  7  7  6  6  6  6  6  6  6  6  6  6  6  6 11
## [2737] 11 11 11 11 11 11 11 11 11 11  1  1  1  1  1  1  1  9  9  9  9  9  9  9
## [2761]  9  9  9  9  9  9  9  9  9  9  9  9  8  8  8  8  8  8  8  8  8  8  8  8
## [2785]  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  7  7
## [2809]  7  7  7  7  7  7  7  7  6  6  6  6 11 11 11 11 11 11 11 11 11 11 11  1
## [2833]  1  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [2857]  9  9  9  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8
## [2881]  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  7  7  7  7  7
## [2905]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6 11 11 11 11 11 11
## [2929] 11 11 11 11 11 11  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [2953]  9  9  9  9  9  9  9  9  9  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8
## [2977]  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8
## [3001]  8  8  8  7  7  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6
## [3025]  6 11 11 11 11 11 11 11 11 11 11 11 11 11 11  9  9  9  9  9  9  9  9  9
## [3049]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  8  8  8  8
## [3073]  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8
## [3097]  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  6  6  6  6  6  6  6
## [3121]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6 11 11 11 11 11
## [3145] 11 11 11 11 11 11 11  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [3169]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  8  8  8  8  8  8  8  8  8  8
## [3193]  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8
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## [3241]  6  6  6  6  6  6  6  6  6  6  6  6  6  6 11 11 11 11 11 11 11 11 11 11
## [3265] 11 11 11 11 11 11  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [3289]  9  9  9  9  9  9  9  9  9  9  9  9  9  8  8  8  8  8  8  8  8  8  8  8
## [3313]  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8
## [3337]  8  8  8  8  8  8  8  8  8  8  8  6  6  6  6  6  6  6  6  6  6  6  6  6
## [3361]  6  6  6  6  6  6  6  6  6 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11
## [3385] 11 11  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [3409]  9  9  9  9  9  9  9  9  9  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8
## [3433]  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8
## [3457]  8  8  8  8  8  8  8  8  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6
## [3481]  6 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11  9  9  9  9  9  9
```

```
## [3505]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [3529]  9  9  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8
## [3553]  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8
## [3577]  8  8  8  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6
## [3601]  6  6  6 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11  9  9
## [3625]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [3649]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  8  8  8  8  8  8  8  8  8
## [3673]  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8
## [3697]  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  6  6  6  6  6  6  6  6
## [3721]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6
## [3745]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6 11 11 11 11 11
## [3769] 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11
## [3793] 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11
## [3817] 11 11 11 11 11 11 11 11 11 11 11 11  9  9  9  9  9  9  9  9  9  9  9
## [3841]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [3865]  9  9  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8
## [3889]  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  6  6  6  6  6  6
## [3913]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6
## [3937]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6
## [3961]  6  6  6 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11
## [3985] 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11
## [4009] 11 11 11 11 11 11 11 11 11 11 11 11 11 11
##
## Within cluster sum of squares by cluster:
##  [1]  3.755767  7.983527 33.568586 13.782873  4.248952 28.809384 20.108509
##  [8] 21.077980  8.091273 19.525379 27.092500
##  (between_SS / total_SS =  97.7 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
##
## [[12]]
## K-means clustering with 12 clusters of sizes 338, 242, 281, 526, 148, 235, 560, 206, 550, 461, 282,
##
## Cluster means:
##             x          y
## 1   0.1338769 -0.9414023
## 2   0.9663558  1.0880137
## 3   1.5823687 -0.9757179
## 4  -0.3244840 -0.6111989
## 5  -0.7266712  0.1288981
## 6  -0.7131082  1.0725995
## 7  -1.2934898 -0.8367851
## 8  -0.7070343  1.3988502
## 9  -0.5280962 -0.9280690
## 10  1.6243020  1.2565966
## 11  0.9116036  1.4557079
## 12 -0.6392068  0.4170881
##
## Clustering vector:
##    [1]  8  8 11 11 11 11 10 10  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8
##   [25]  8  8  8  8  8  8  8 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11
```

```
##   [49] 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11
##   [73] 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 10 10 10 10
##   [97] 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
##  [121] 10 10 10 10 10 10 10 10 10 10 10 10  8 11 11 11 11 11 11 11 11 11 11 11 11 11
##  [145] 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11
##  [169] 11 11 11 11 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
##  [193]  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8 11
##  [217] 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11
##  [241] 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11
##  [265] 11 11 11 11 11 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
##  [289] 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10  8  8  8  8  8  8  8  8
##  [313]  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8 11 11 11 11 11 11 11 11 11
##  [337] 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 10 10 10 10 10 10 10 10 10 10 10
##  [361] 10 10 10 10 10 10 10 10 10 10 10 10 10  8  8  8  8  8  8  8  8  8  8  8  8  8
##  [385]  8  8  8  8  8  8  8  8  8 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11
##  [409] 11 11 11 11 11 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
##  [433] 10 10  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8
##  [457] 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 10 10 10 10
##  [481] 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10  8  8  8  8  8  8  8  8  8
##  [505]  8  8  8  8  8  8 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 10 10 10 10
##  [529] 10 10 10 10 10 10 10 10 10 10 10  8  8  8  8  8  8  8  8  8  8  8  8  8 11
##  [553] 11 11 11 11 11 11 11 11 11 11 11 11 10 10 10 10 10 10 10 10 10 10 10  8  8
##  [577]  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8 11 11 11 11 11 11 11 11 11 11
##  [601] 11 11 11 11 11 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10  8  8  8  8
##  [625]  8  8  8  8  8  8  8  8  8  8  8  8  8 11 11 11 11 11 11 11 11 11 11 11 11
##  [649] 11 11 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10  8  8  8  8  8  8  8  8
##  [673]  8  8  8  8  8  8 11 11 11 11 11 11 11 11  2  2  2  2  2  2  2 10 10 10 10
##  [697] 10 10 10 10 10 10 10 10 10 10 10  8  8  8  8  8  8  8  8  8  8  8  8  8  8
##  [721]  8  8  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2 10 10 10 10 10 10 10 10
##  [745] 10 10 10 10 10 10 10 10  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6
##  [769]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2 10 10 10 10 10 10 10 10 10 10 10
##  [793] 10 10 10 10  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  2  2  2  2
##  [817]  2  2  2  2  2  2  2  2  2  2 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
##  [841] 10  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  2  2  2  2  2  2  2
##  [865]  2  2  2  2  2  2  2  2 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10  6
##  [889]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  2  2  2  2  2  2
##  [913]  2  2  2  2  2  2  2  2  2  2  2  2  2 10 10 10 10 10 10 10 10 10 10 10 10 10
##  [937] 10 10 10 10 10 10  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6
##  [961]  6  6  6  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2 10
##  [985] 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10  6  6  6  6  6
## [1009]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  2  2  2  2  2  2  2  2  2
## [1033]  2  2  2  2  2  2  2  2  2  2 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
## [1057] 10 10 10 10 10  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6
## [1081]  6  6  6  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2 10 10
## [1105] 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10  6  6  6  6  6  6
## [1129]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  2  2  2  2  2  2  2  2  2  2
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## [1177] 10 10 10 10 10  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6
## [1201]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2 10 10 10 10 10
## [1225] 10 10 10 10 10 10 10 10 10 10 10 10 10 10  6  6  6  6  6  6  6  6  6  6  6
## [1249]  6  6  6  6  6  6  6  6  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
## [1273]  2 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10  6  6  6  6  6  6
## [1297]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  2  2  2  2  2  2  2
## [1321]  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2 10 10 10 10 10 10 10 10 10
```

```
## [1345] 10 10 10 10 10 10 10 10 10 10 10 10 10 10  6  6  6  6  6  6  6  6  6  6  6
## [1369]  6  6  6  6  6  6  6  6  6  6  6  6  2  2  2  2  2  2  2  2  2  2  2  2  2
## [1393]  2  2  2  2  2  2  2  2  2  2  2 10 10 10 10 10 10 10 10 10 10 10 10 10 10
## [1417] 10 10 10 10 10 10 10 10 10  6 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12
## [1441] 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12
## [1465] 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12
## [1489] 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12
## [1513] 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12
## [1537] 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12
## [1561] 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12
## [1585] 12 12 12 12 12 12 12 12 12 12 12 12 12  5 12 12 12 12 12 12 12 12 12 12 12
## [1609] 12 12 12 12 12  5  5  5  5  5  5  5  5  5  5  5 12 12 12 12  5  5  5  5  5
## [1633]  5  5  5  5  5  5  5  5  5 12 12 12  5  5  5  5  5  5  5  5  5  5  5  5  5
## [1657]  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5
## [1681]  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5
## [1705]  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5
## [1729]  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5
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## [1849]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [1873]  4  7  7  7  7  7  7  7  7  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [1897]  4  4  4  4  4  4  4  4  4  4  4  4  4  1  1  7  7  7  7  7  7  7  7  7  7
## [1921]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [1945]  4  4  4  4  1  1  7  7  7  7  7  7  7  7  7  7  7  7  7  7  4  4  4  4  4
## [1969]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [1993]  4  4  1  1  1  7  7  7  7  7  7  7  7  7  7  7  7  7  7  4  4  4  4  4  4
## [2017]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [2041]  1  1  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  4  4  4  4  4
## [2065]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [2089]  4  1  1  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  4  4  4
## [2113]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [2137]  4  4  4  4  1  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [2161]  9  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [2185]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  1  7  7  7  7  7  7  7  7  7  7
## [2209]  7  7  7  7  7  7  7  7  7  9  9  9  9  9  4  4  4  4  4  4  4  4  4  4  4
## [2233]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [2257]  4  1  1  1  1  3  3  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [2281]  7  7  9  9  9  9  9  9  9  9  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [2305]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  1  1  1  1  1  1
## [2329]  3  3  3  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  9  9
## [2353]  9  9  9  9  9  9  9  9  9  9  9  4  4  4  4  4  4  4  4  4  4  4  4  4  4
## [2377]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  1  1  1  1  1  3  3
## [2401]  3  3  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  9
## [2425]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  4  4  4  4  4  4  4  4  4  4
## [2449]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  1  1  1
## [2473]  1  1  1  1  3  3  3  3  3  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [2497]  7  7  7  7  7  7  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [2521]  9  9  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
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## [2569]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  9  9  9  9  9  9  9  9
## [2593]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  4  4  4  4  4  4  4  4
## [2617]  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  1  1  1  1  1  1  1  1  1  1
```

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## [2785]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  4  4  4  4  4
## [2809]  4  4  4  4  4  4  4  1  1  1  1  1  3  3  3  3  3  3  3  3  3  3  3  7
## [2833]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [2857]  7  7  7  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [2881]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  4  4  4  4  4  4  4
## [2905]  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  3  3  3  3  3  3
## [2929]  3  3  3  3  3  3  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [2953]  7  7  7  7  7  7  7  7  7  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [2977]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [3001]  9  4  4  4  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
## [3025]  1  3  3  3  3  3  3  3  3  3  3  3  3  3  3  7  7  7  7  7  7  7  7  7
## [3049]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  9  9  9  9
## [3073]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [3097]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  1  1  1  1  1  1  1  1
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## [3265]  3  3  3  3  3  3  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [3289]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  9  9  9  9  9  9  9  9  9  9
## [3313]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [3337]  9  9  9  9  9  9  9  9  9  9  9  1  1  1  1  1  1  1  1  1  1  1  1  1
## [3361]  1  1  1  1  1  1  1  1  1  1  1  3  3  3  3  3  3  3  3  3  3  3  3  3
## [3385]  3  3  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [3409]  7  7  7  7  7  7  7  7  7  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [3433]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
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## [3505]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
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## [3553]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [3577]  9  9  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
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## [3649]  7  7  7  7  7  7  7  7  7  7  7  9  9  9  9  9  9  9  9  9  9  9  9  9
## [3673]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [3697]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  1  1  1  1  1  1  1  1  1
## [3721]  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
## [3745]  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  3  3  3  3  3  3
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## [3817]  3  3  3  3  3  3  3  3  3  3  3  3  7  7  7  7  7  7  7  7  7  7  7  7
## [3841]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  9  9
## [3865]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [3889]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  1  1  1  1  1  1
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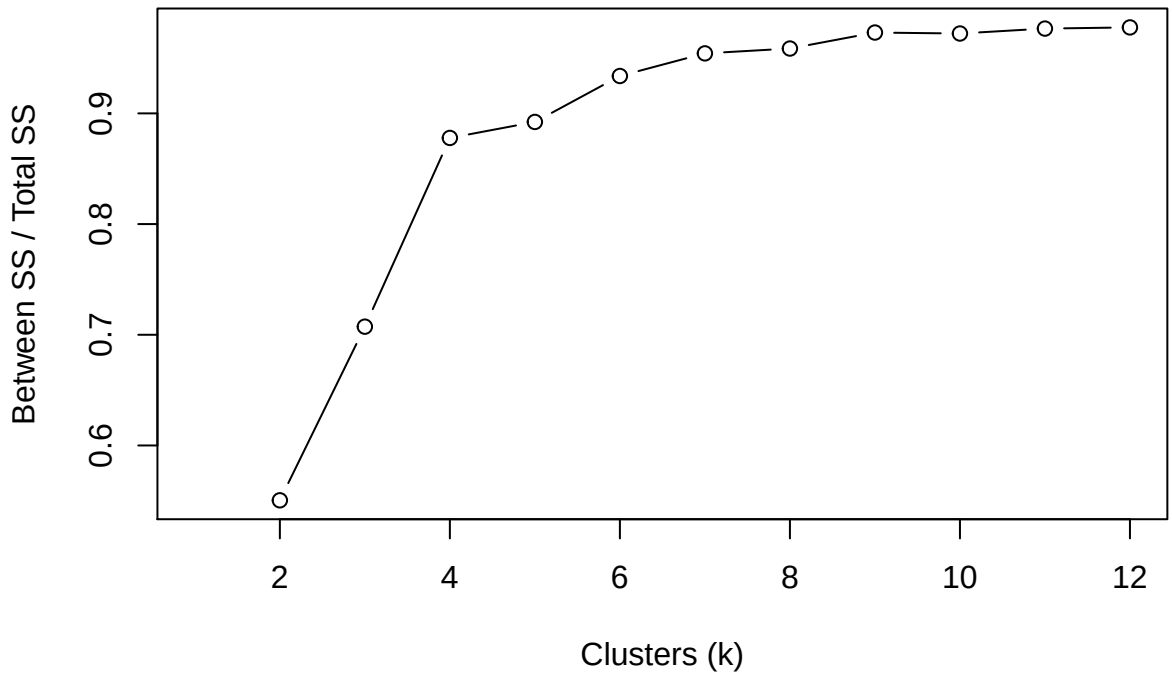
```

```
## [3937]  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
## [3961]  1  1  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3
## [3985]  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3
## [4009]  3  3  3  3  3  3  3  3  3  3  3  3  3  3
##
## Within cluster sum of squares by cluster:
##  [1] 28.634796  4.928350 28.164346 20.611761  3.220997  4.163265 24.082517
##  [8]  3.673850 21.202680 24.063776 13.929891  2.964061
##  (between_SS / total_SS =  97.8 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
```

```r
betweenss_totss <- list()
for (i in 1:12) {
  betweenss_totss[[i]] <- cluster_k[[i]]$betweenss/cluster_k[[i]]$totss
}

plot(1:12, betweenss_totss, type = "b", ylab = "Between SS / Total SS", xlab = "Clusters (k)")
```



Based on the elbow and shoulder plots, it appears that the correct cluster is around 4. Based on the kmeans plot, it looks like 6 makes the most sense.