

Dimensionality reduction

Ran command `install.packages("ggplot2") install.packages("lattice") install.packages("caret")`

```
library(ggplot2)
library(lattice)
library(caret)
library(tidyverse)
```

```
## Warning: package 'tidyverse' was built under R version 4.2.3
```

```
## Warning: package 'readr' was built under R version 4.2.3
```

```
## Warning: package 'forcats' was built under R version 4.2.3
```

```
## — Attaching core tidyverse packages — tidyverse 2.0.0 —
## ✓ dplyr      1.1.0      ✓ readr      2.1.4
## ✓ forcats    1.0.0      ✓ stringr    1.5.0
## ✓ lubridate  1.9.2      ✓ tibble     3.1.8
## ✓ purrr      1.0.1      ✓ tidyr      1.3.0
## — Conflicts — tidyverse_conflicts() —
## ✗ dplyr::filter() masks stats::filter()
## ✗ dplyr::lag()     masks stats::lag()
## ✗ purrr::lift()    masks caret::lift()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to be
come errors
```

- Data exploration
- Converted make into factor
- Since we are prediction emissions based on other variable I had converted emissions with a cutoff point 250 , greater than 200 to be 1, otherwise to be 0 also converted enngine sie ad factor for logistic regression

```
fuelData<- read.csv("Fuel_Consumption_2000-2022.csv")
str(fuelData)
```

```
## 'data.frame':    22556 obs. of  13 variables:
## $ YEAR          : int  2000 2000 2000 2000 2000 2000 2000 2000 2000 2000 2000 ...
## $ MAKE          : chr  "ACURA" "ACURA" "ACURA" "ACURA" ...
## $ MODEL         : chr  "1.6EL" "1.6EL" "3.2TL" "3.5RL" ...
## $ VEHICLE.CLASS : chr  "COMPACT" "COMPACT" "MID-SIZE" "MID-SIZE" ...
## $ ENGINE.SIZE   : num  1.6 1.6 3.2 3.5 1.8 1.8 1.8 3 3.2 1.8 ...
## $ CYLINDERS     : int  4 4 6 6 4 4 4 6 6 4 ...
## $ TRANSMISSION  : chr  "A4" "M5" "AS5" "A4" ...
## $ FUEL          : chr  "X" "X" "Z" "Z" ...
## $ FUEL.CONSUMPTION: num  9.2 8.5 12.2 13.4 10 9.3 9.4 13.6 13.8 11.4 ...
## $ HWY..L.100.km. : num  6.7 6.5 7.4 9.2 7 6.8 7 9.2 9.1 7.2 ...
## $ COMB..L.100.km. : num  8.1 7.6 10 11.5 8.6 8.2 8.3 11.6 11.7 9.5 ...
## $ COMB..mpg.     : int  35 37 28 25 33 34 34 24 24 30 ...
## $ EMISSIONS      : int  186 175 230 264 198 189 191 267 269 218 ...
```

```
summary((fuelData$YEAR))
```

```
##      Min. 1st Qu.  Median      Mean 3rd Qu.      Max.
##      2000    2006    2012    2012    2017    2022
```

```
fuelData$MAKE <- as.factor(fuelData$MAKE)
fuelData$EMISSIONS <- as.factor (ifelse (fuelData$EMISSIONS>250,1,0))
#fuelData$ENGINE.SIZE <- as.factor(fuelData$ENGINE.SIZE)
#fuelData$CYLINDERS<-as.factor(fuelData$CYLINDERS)
fuelData$EMISSIONS
```

```
##      [1] 0 0 0 1 0 0 0 1 1 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1 0 0 0 0
##     [37] 0 0 0 0 0 1 0 1 0 1 1 1 1 1 1 1 0 0 1 1 0 0 0 0 1 0 0 0 1 0 1 1 1 1 1 1
##     [73] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0 0 0 0 0 0 1 0 1 1 1 1 1 1 0 0 1 1
##    [109] 1 1 1 0 0 0 0 0 0 1 1 1 1 1 1 0 0 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
##    [145] 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
##    [181] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
##    [217] 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
##    [253] 0 0 0 0 1 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1
##    [289] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 0 0 0 0 0 0
##    [325] 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 1 1 1 1 1 1 1 1
##    [361] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 0
##    [397] 0 0 1 1 1 1 1 1 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 1 1 0 0 0 0 1 1 1 1 1
##    [433] 1 1 0 0 0 0 0 0 1 1 1 1 1 0 0 1 1 1 1 1 1 1 0 0 0 0 0 1 0 1 0 0 1 1 0
##    [469] 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0
##    [505] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0
##    [541] 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 1 1 1
##    [577] 1 1 1 1 1 1 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
##    [613] 1 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 1 1 0 0 1 0 0 0 1 0 0 0 0 1 0 0
##    [649] 1 1 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0
##    [685] 0 0 0 1 0 0 1 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1 0
##    [721] 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0 0 0 0 0 0 1 0 1
##    [757] 1 1 1 1 0 0 1 1 1 1 1 1 1 1 0 0 0 1 1 1 1 0 0 0 0 0 0 0 0 0 0 1 0 0
##    [793] 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 1 1 1
##    [829] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
##    [865] 1 1 1 1 1 0 0 1 0 1 1 1 1 1 1 1 1 1 0 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1
##    [901] 1 1 1 1 1 0 0 0 0 0 0 0 0 1 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0 1 1
##    [937] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
##    [973] 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 1 1
##   [1009] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 1 1 0 1 1 1
##   [1045] 1 1 1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1 1 0 0 1 0 0 0 0 0 0 0 1 0 1 0
##   [1081] 1 0 0 1 1 1 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 1 1 1 1
##   [1117] 1 0 0 1 1 1 0 0 0 0 1 1 0 0 0 1 1 0 0 1 0 1 0 0 0 0 1 0 0 0 0 0 0 0
##   [1153] 0 0 0 1 1 1 1 1 1 1 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
##   [1189] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 1 1 1
##   [1225] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 1 1 1 1 1 1 1 0
##   [1261] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 0 0 1
##   [1297] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 1 1 1 0 0 0
##   [1333] 0 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1 0 0 0 0 0 0 0
##   [1369] 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0
##   [1405] 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0
##   [1441] 0 0 0 0 0 0 0 1 0 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0
##   [1477] 1 1 0 0 0 0 0 0 0 0 0 1 1 1 0 1 1 1 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0
##   [1513] 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1
##   [1549] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0 1
##   [1585] 1 1 0 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0
##   [1621] 1 0 0 1 1 0 0 1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
##   [1657] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
##   [1693] 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 1 1 1 1 1
##   [1729] 1 1 1 1 1 1 1 1 0 0 1 0 1 1 1 1 1 1 0 1 0 0 1 0 0 1 1 1 1 0 1 1 1
##   [1765] 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1 0 1 0 0 0 0 0 0 0 1 0
##   [1801] 0 0 0 1 0 0 1 1 1 0 0 1 1 1 1 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0
```

```
## [1837] 0 0 0 1 1 1 1 1 1 1 1 0 0 1 1 0 0 0 0 0 1 1 1 1 0 0 0 0 1 1 0 0 0 1 1 0 0 1 0 1 0
## [1873] 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1
## [1909] 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## [1945] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0
## [1981] 0 0 0 0 0 0 0 1 0 0 0 1 0 0 1 1 1 1 1 1 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
## [2017] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0
## [2053] 0 0 0 0 0 1 0 0 0 0 0 1 1 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 1 1 0
## [2089] 1 1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## [2125] 1 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1 0 0 0 0 0 0 0 1
## [2161] 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 0 1 1 1 1
## [2197] 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 1 1 1 1 0 0 0 0 1 1
## [2233] 1 1 1 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 1 0 1 1 1
## [2269] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
## [2305] 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1
## [2341] 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 1 1 0 0 1 1 1 1 1 0 0 1 1 1 1 1 1 1
## [2377] 1 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [2413] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 0 0 0 0 0 0
## [2449] 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 1 1 0 0 0 0
## [2485] 0 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 0 0 1 0 1 1 0 1 1 1 1 1 1 1 0 0 0 0 0
## [2521] 0 1 1 1 0 0 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 0 1 0 1 1 1 1 1 1 0 0 1 1 1
## [2557] 1 1 1 1 1 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 1 0 1 0 0 0 0 0 0 1 1
## [2593] 0 1 1 1 1 1 1 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 1 0 0
## [2629] 0 0 0 0 0 1 1 1 1 1 0 0 0 1 1 0 0 0 0 0 1 1 1 1 0 0 0 1 1 0 1 0 1 0 0 0
## [2665] 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 0 1 1 0 0 0
## [2701] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## [2737] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 1 1 0
## [2773] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 1 1 1 1 1
## [2809] 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## [2845] 0 0 0 1 1 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 1 1 1 0 0
## [2881] 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 1 1 0 1 1 1 1 1 1 1 1 1
## [2917] 1 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0
## [2953] 1 0 0 0 0 0 0 0 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0
## [2989] 0 1 1 1 1 1 0 1 0 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1
## [3025] 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 0 0 1
## [3061] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1 0 0 1 1
## [3097] 1 1 1 1 1 1 0 1 0 0 0 0 1 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 1 1
## [3133] 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [3169] 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0
## [3205] 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 1 0 0 1 1 1 1 1 0 0 1 0 1 1 1 1 1 1 1 1 1 1
## [3241] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [3277] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0
## [3313] 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 1 1 1 0 0 0 0 0 1 1
## [3349] 0 1 1 1 0 0 1 1 1 1 1 0 0 1 0 1 1 0 1 1 1 1 1 1 1 0 0 0 0 1 1 1 0 0 1 1
## [3385] 1 1 0 1 1 1 1 1 1 1 1 0 0 1 1 1 1 0 1 0 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 0 0
## [3421] 0 0 0 0 0 0 1 0 0 0 1 1 0 0 0 1 0 0 0 0 0 1 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0
## [3457] 1 1 1 0 0 1 1 1 1 0 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1
## [3493] 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 1 1 0 0 1 0 1 0 0 0
## [3529] 0 0 0 0 1 1 1 1 1 0 0 0 0 0 0 1 1 1 0 1 0 0 0 0 1 1 1 1 1 1 0 0 0 1 0 1
## [3565] 0 1 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## [3601] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0
## [3637] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 0 0 1 1 1 1 0 0 0 0 0 0 0 0
```

##	[3673]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
##	[3709]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
##	[3745]	0	0	0	1	1	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
##	[3781]	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
##	[3817]	1	1	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
##	[3853]	0	0	1	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
##	[3889]	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	1	1	1	1	0	1	1	1	1	1
##	[3925]	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
##	[3961]	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1
##	[3997]	1	1	1	1	1	1	1	1	0	0	0	0	0	1	0	0	0	0	1	1	1	1	1	1	1	1	1
##	[4033]	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
##	[4069]	1	1	1	1	1	1	1	1	0	0	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1
##	[4105]	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	1	0	0	1	1	1	1	1	1	1
##	[4141]	0	0	0	0	0	0	0	1	1	0	1	1	0	0	1	1	0	0	1	1	1	1	1	1	0	0	0
##	[4177]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
##	[4213]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
##	[4249]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
##	[4285]	1	1	0	1	1	1	1	1	0	1	1	1	1	1	0	0	1	1	1	1	1	0	0	1	0	0	0
##	[4321]	1	1	1	1	1	0	0	0	0	1	1	1	0	0	0	0	0	0	1	1	1	1	0	1	1	1	1
##	[4357]	1	0	1	0	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0
##	[4393]	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	1	1	1	1	1	1	0	0	1	1
##	[4429]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0
##	[4465]	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0											

```
## [5509] 1 1 0 0 0 0 1 0 1 0 0 0 0 1 1 1 1 0 0 0 0 0 0 1 0 0 1 0 0 0 0 1 1 1 0 0
## [5545] 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 1 1 1 1 1 1 1 1 1 1
## [5581] 1 1 1 0 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 1 0 1 1 0 0 0 0 0 1 1 1 0 0 0 0 0
## [5617] 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0
## [5653] 0 0 0 0 0 1 1 1 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 1
## [5689] 0 0 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1
## [5725] 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0
## [5761] 1 1 1 0 0 0 1 1 0 0 0 0 0 0 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0
## [5797] 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## [5833] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
## [5869] 0 0 0 1 1 0 0 0 0 0 0 0 1 1 1 0 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [5905] 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 1 0 1 1 1 1 1 1 0 1 1 1 0 1 0 0 1 1 1
## [5941] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0
## [5977] 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [6013] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 0 1 0 1 1 1 1 0 0 0
## [6049] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 1 0 0 1 1 1 1 1 1
## [6085] 1 1 1 1 1 1 1 1 1 1 1 0 1 1 0 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [6121] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1
## [6157] 1 1 0 0 0 0 0 0 0 1 1 0 1 0 0 0 0 1 1 1 1 0 1 1 1 0 0 1 1 1 1 1 1 0 1 1
## [6193] 1 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [6229] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [6265] 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 1 1 0 0 0
## [6301] 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 1 0 0 1 1 1 1 0 1 1 1 0
## [6337] 0 1 0 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 1 1 1 0
## [6373] 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 0
## [6409] 1 0 0 0 0 0 0 1 1 1 0 1 1 1 1 0 1 1 1 0 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0
## [6445] 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 1 0 0 1 1 0 0 1 1 1 1 1 1 0 1 1 1
## [6481] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0
## [6517] 0 0 0 1 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 1 1 0 0 0 1 1 0 0 1 1
## [6553] 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1
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[illegible]

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##	[11701]	0	0	0																														

[illegible]

[illegible]

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##	[18901]	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1	
##	[18937]	1	1	0	1	1	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
##	[18973]	1	1	1	1	1	1	1	1	0	0	0	0	0	1	0	0	0	0	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0
##	[19009]	0	0	0	0	1																															

```
## [20197] 1 0 0 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 1 1 1 1 1 1 0 0 0 0
## [20233] 0 0 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 1 0 1 1 1 1 1
## [20269] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1 1 1 0 0 0 1 1 1 0 1 1
## [20305] 1 0 1 0 1 0 0 0 1 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1
## [20341] 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1
## [20377] 1 1 1 1 1 1 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0
## [20413] 0 0 0 0 0 1 1 1 1 0 0 0 0 0 1 1 1 1 1 0 0 1 1 1 1 1 1 0 1 0 0 0 0 0 0 0
## [20449] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 0 1 1 1 1 0 0 0 0 0 0 0 0 1
## [20485] 1 0 0 0 0 0 1 1 0 0 0 0 1 1 0 0 0 0 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1
## [20521] 1 1 1 1 1 1 1 1 1 1 0 1 1 0 1 1 1 1 1 1 1 1 0 1 0 1 1 1 1 1 1 1 1 1 0
## [20557] 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 1 0 0 0 0
## [20593] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1
## [20629] 1 1 1 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0
## [20665] 0 0 1 1 0 0 1 0 0 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 1 1
## [20701] 1 1 1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1 1 1 1 0 0 0 0
## [20737] 0 0 1 1 1 1 1 1 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1 1 0 0 1 1
## [20773] 0 0 1 1 1 0 1 1 1 1 1 0 0 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1
## [20809] 1 1 1 1 0 0 0 0 1 0 1 0 0 0 0 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0
## [20845] 0 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1
## [20881] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 1 0 0 0 0 0 1 1 0 0 1 0 1 1 1 1 1
## [20917] 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 1 0 0
## [20953] 0 0 0 1 1 0 0 1 1 0 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0
## [20989] 1 0 0 0 0 0 1 1 0 0 1 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 1 1 0 1 0 1
## [21025] 1 0 1 0 0 0 0 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [21061] 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0
## [21097] 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0
## [21133] 0 0 0 0 0 0 1 1 1 1 0 1 0 0 1 1 1 1 0 0 0 0 0 0 0 0 0 1 1 0 0 1 1 1 1 1
## [21169] 1 1 1 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0
## [21205] 0 0 0 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1 0 1 1 1 1 0 1 0 1 0 0 0
## [21241] 1 1 1 1 1 0 0 0 0 0 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0
## [21277] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 1 1 1 0 0
## [21313] 0 0 0 0 1 1 1 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0
## [21349] 0 0 0 1 0 0 0 0 1 0 1 1 1 1 1 1 1 1 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## [21385] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0
## [21421] 1 1 1 1 0 0 0 0 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [21457] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0 1 1 1 1
## [21493] 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 0 0
## [21529] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
## [21565] 0 0 1 1 1 1 1 0 0 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## [21601] 0 0 1 0 0 0 0 1 1 0 0 1 0 0 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## [21637] 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 1 1
## [21673] 0 0 0 0 0 1 1 1 1 1 0 0 1 1 1 0 0 1 1 1 1 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1
## [21709] 1 0 0 0 0 1 1 0 0 1 1 0 0 1 1 1 0 1 1 1 1 1 0 0 1 1 1 1 1 0 0 0 0 0 0 0
## [21745] 0 0 0 0 0 0 1 1 0 1 0 1 1 1 1 1 1 1 0 0 0 0 1 0 1 0 1 0 1 0 1 0 0 1 1 1
## [21781] 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [21817] 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 1 0 0 0
## [21853] 1 0 0 1 0 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1
## [21889] 1 1 0 0 0 0 0 1 0 0 0 0 0 1 1 1 1 0 1 1 1 1 0 1 1 1 0 1 1 1 1 1 1 1 1 1
## [21925] 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0 0 0 0 0 0 0 0 1 1 0 0 1 0 1 1 1 1 1 1 1
## [21961] 0 0 0 0 0 0 0 0 0 1 0 1 1 0 1 0 1 0 1 0 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1
## [21997] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
```

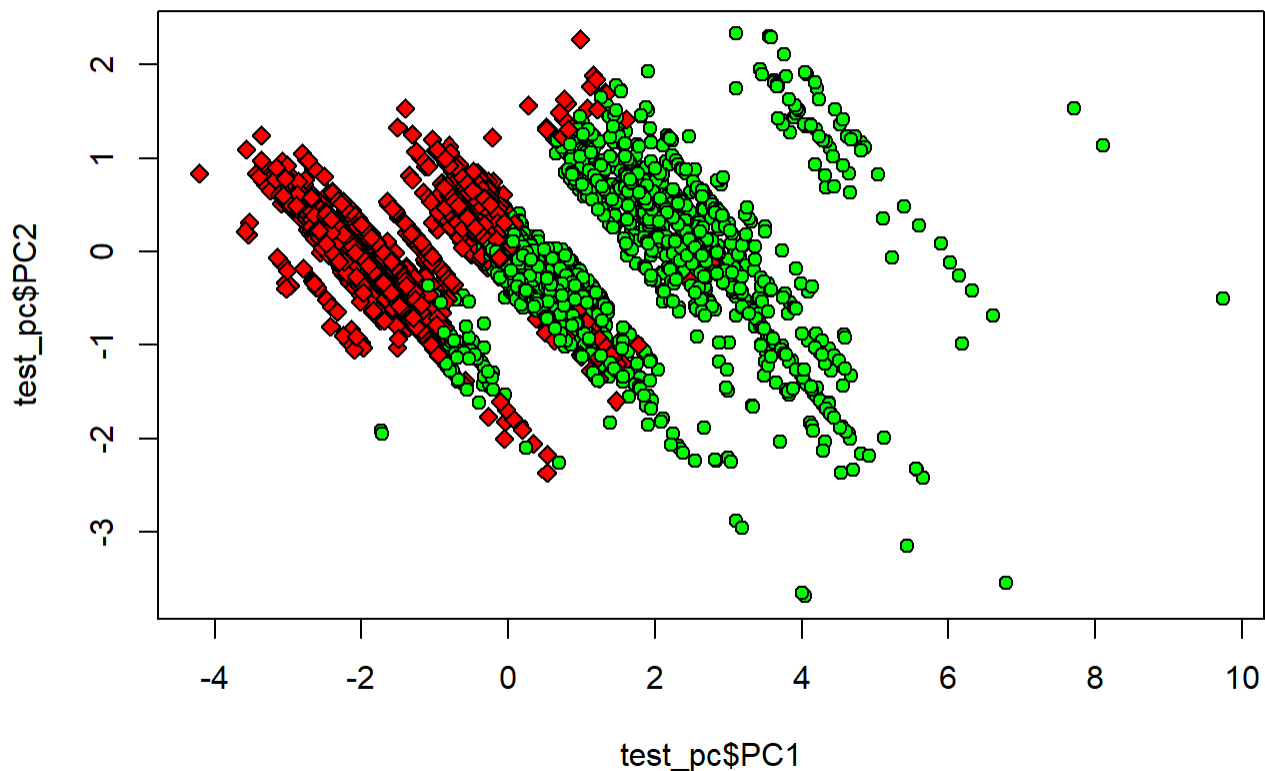
- Count NA
- We have 22556 observations with 13 variables
- Train 18000, test is the test 4556

##	YEAR	MAKE	MODEL	VEHICLE.CLASS
##	0	0	0	0
##	ENGINE.SIZE	CYLINDERS	TRANSMISSION	FUEL
##	0	0	0	0
##	FUEL.CONSUMPTION	HWY..L.100.km.	COMB..L.100.km.	COMB..mpg.
##	0	0	0	0
##	EMISSIONS			
##	0			

```
## Created from 17995 samples and 4 variables
##
## Pre-processing:
##   - centered (4)
##   - ignored (0)
##   - principal component signal extraction (4)
##   - scaled (4)
##
## PCA needed 2 components to capture 95 percent of the variance
```

- PCA suggested only 2 components as Variables
- Now plot the PCA
- build GLM using logistic regression and pca components

```
train_pc <- predict(pca_out, train[, c(5,6,10,11)])
test_pc <- predict(pca_out, test[,])
plot(test_pc$PC1, test_pc$PC2, pch=c(23,21,22)[unclass(test_pc$EMISSIONS)],bg=c("red","green","blue")[unclass(test_pc$EMISSIONS)])
```



```
train_df <- data.frame(train_pc$PC1, train_pc$PC2, train$EMISSIONS)
test_df <- data.frame(test_pc$PC1, test_pc$PC2, test$EMISSIONS)
library(class)
set.seed(1234)

glm1 = glm(EMISSIONS~train_pc$PC1+train_pc$PC2, data = train, family = binomial)
```

```
## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred
```

```
probs <- predict(glm1, newdata = test , type = "response")
```

```
## Warning: 'newdata' had 4561 rows but variables found have 18000 rows
```



```
pred<-ifelse(probs> 0.5, 1,0)
acc1<- mean(pred == as.integer(test$EMISSIONS))
```

```
## Warning in pred == as.integer(test$EMISSIONS): longer object length is not a
## multiple of shorter object length
```

```
summary(glm1)
```

```
##
## Call:
## glm(formula = EMISSIONS ~ train_pc$PC1 + train_pc$PC2, family = binomial,
##      data = train)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -4.3647  -0.2243  -0.0206   0.0945   2.6506
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)   0.28792    0.03262   8.825  <2e-16 ***
## train_pc$PC1   3.33643    0.05932  56.249  <2e-16 ***
## train_pc$PC2  -2.02351    0.06386 -31.687  <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 24794.7  on 17994  degrees of freedom
## Residual deviance:  6971.4  on 17992  degrees of freedom
## (5 observations deleted due to missingness)
## AIC: 6977.4
##
## Number of Fisher Scoring iterations: 8
```

```
print(paste("glm1 has accuracy = ",acc1))
```

```
## [1] "glm1 has accuracy = NA"
```

- Try logistic regression on the non-reduced data
- set ground truth

```
library(class)
set.seed(1234)
glm2 = glm(EMISSIONS~ HWY..L.100.km.+COMB..L.100.km.+ENGINE.SIZE+CYLINDERS, data = train, fam
ily = binomial)
```

```
## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred
```

```
probs <- predict(glm2, newdata = test , type = "response")
pred<-ifelse(probs> 0.5, 1,0)
acc2<- mean(pred == as.integer(test$EMISSIONS))
summary(glm2)
```

```
##
## Call:
## glm(formula = EMISSIONS ~ HWY..L.100.km. + COMB..L.100.km. +
##     ENGINE.SIZE + CYLINDERS, family = binomial, data = train)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -4.3705  -0.2223  -0.0204   0.0957   2.7281
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -24.34460    0.44416  -54.81  < 2e-16 ***
## HWY..L.100.km.   1.25252    0.07430   16.86  < 2e-16 ***
## COMB..L.100.km.   0.87795    0.06927   12.68  < 2e-16 ***
## ENGINE.SIZE      0.34976    0.07123    4.91 9.10e-07 ***
## CYLINDERS        0.44284    0.05401    8.20 2.41e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 24794.7  on 17994  degrees of freedom
## Residual deviance:  6959.5  on 17990  degrees of freedom
## (5 observations deleted due to missingness)
## AIC: 6969.5
##
## Number of Fisher Scoring iterations: 8
```

```
print(paste("glm2 has accuracy = ",acc2))
```

```
## [1] "glm2 has accuracy = 0.0208287656215742"
```

```
table(pred, as.integer(test$EMISSIONS))
```

```
##
## pred    1    2
##    0 2392  161
##    1   95 1913
```

Accuracy from model is around 2% Confusion matrix shows the distribution of prediction where correct and

incorrect being around 0.50 margin.

LDA

```
library(MASS)
```

```
##  
## Attaching package: 'MASS'
```

```
## The following object is masked from 'package:dplyr':  
##  
##      select
```

```
lda1<-lda(EMISSIONS~ HWY..L.100.km.+COMB..L.100.km.+ENGINE.SIZE+CYLINDERS,data =train)  
lda1$means
```

```
##      HWY..L.100.km. COMB..L.100.km. ENGINE.SIZE CYLINDERS  
## 0          7.384536          9.05311    2.491968  4.729614  
## 1          10.756694          13.41678    4.400551  7.216471
```

Above data shows a clear positive relativity between EMISSION and the rest of the predictors 0 classified vehicles with emission less than 250, and 1 is more than 250

```
lda_pred<- predict(lda1, newdata = test,type = "class")  
lda_pred$class
```

```
## [1] 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 1 1 1 1 1 1 1 1 0 1 0 0 0 0 0 0 0 0 0 0 1
## [38] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 1 0
## [75] 1 1 1 1 0 1 1 0 0 0 1 1 1 1 1 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## [112] 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 1 0
## [149] 0 1 1 1 1 1 0 1 1 1 1 0 1 0 0 0 0 0 0 0 0 1 1 1 1 0 1 1 1 0 1 1 1 0 1 1 1
## [186] 1 1 1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 0 0 0 0 1 0 1 1 0 0 0 0 0 0 0 1 1 1 0 0
## [223] 1 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## [260] 1 1 1 0 0 1 0 1 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 1 1 0 0 0 0 0 0 0 1 1
## [297] 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0
## [334] 1 1 1 1 1 1 0 1 1 0 0 0 0 0 1 0 1 1 0 0 0 0 0 1 1 0 0 0 1 1 1 1 1 0 0 1 0
## [371] 1 0 0 0 0 1 0 1 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
## [408] 1 0 0 0 0 0 0 0 0 1 1 1 1 0 0 0 0 0 1 1 1 1 1 0 0 1 1 1 1 1 0 0 0 0 0 0
## [445] 0 0 0 0 0 0 1 1 1 1 1 1 0 1 1 1 0 0 1 0 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [482] 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 1 1 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0
## [519] 0 0 1 0 0 1 1 0 1 0 1 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0
## [556] 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0
## [593] 1 0 0 0 0 0 0 1 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 1 0 1 1 1 1 1 1 1 0 1 1
## [630] 0 0 0 0 1 0 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 0 1 1 1 1 0 1 1 1 1 1 1 1 1 1
## [667] 1 1 0 0 0 1 0 0 1 1 1 1 0 1 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1
## [704] 0 0 0 0 0 0 0 1 0 1 0 0 1 0 1 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## [741] 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 1 1
## [778] 0 0 0 0 0 0 1 1 0 0 1 1 0 0 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1 0 0 1
## [815] 0 0 0 1 0 1 1 1 1 0 0 0 0 1 1 1 0 1 1 1 0 1 1 1 1 1 0 1 1 1 1 0 1 1 1 1
## [852] 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 1 1 0 0 1 1 0 0 0 1 1 1 0 0 0 1 1 0
## [889] 0 0 0 0 0 0 0 0 1 1 1 1 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 1 0 0 0 0 1
## [926] 0 0 0 0 0 0 1 1 1 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0
## [963] 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1
## [1000] 0 1 0 0 0 0 0 0 0 0 1 1 1 0 1 1 1 0 0 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 0 0
## [1037] 0 1 1 1 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0 0 1 1 1 1 1 1 1 1 0 0 1
## [1074] 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 1 0 0 1 0 0 0 0 0 0 0 0 1 1 1 0
## [1111] 1 1 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 0 1 1 1 1 0 0 0 0 1 0 0 0 0 0 1 0 0 1
## [1148] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
## [1185] 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 1 1 1 0 0 0
## [1222] 1 1 0 1 1 1 0 1 0 0 1 1 1 1 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 1 1 1 1 1
## [1259] 1 1 1 1 1 0 0 0 0 0 0 0 1 1 1 0 0 0 1 0 1 1 1 0 0 1 1 1 0 1 0 0 1 0 1 0 1
## [1296] 0 0 0 1 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 1 0 0 0 0 1 1 1 1 1 1 0 1 0 0 0
## [1333] 1 1 1 1 0 1 1 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0
## [1370] 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 1 0 0 0
## [1407] 0 0 0 0 0 0 0 0 0 1 0 0 1 1 0 0 0 0 0 0 0 0 1 1 1 0 1 0 0 0 0 0 1 1 0 1 0 1
## [1444] 0 0 1 0 0 0 1 1 1 1 0 1 1 1 1 1 1 1 1 0 1 0 0 1 0 0 0 0 1 1 1 0 0 1 1 1 1
## [1481] 1 1 1 1 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 1 1
## [1518] 1 1 0 0 1 0 0 0 0 0 1 0 0 0 1 1 0 0 0 1 1 1 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1
## [1555] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## [1592] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1
## [1629] 1 0 0 0 0 0 0 1 0 0 1 1 1 0 0 0 0 0 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0
## [1666] 0 0 1 1 0 1 0 1 0 1 0 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
## [1703] 1 0 1 1 0 1 0 1 1 1 1 0 0 1 1 1 0 1 1 1 0 0 0 0 0 0 1 0 1 1 1 1 1 1 1 1 1
## [1740] 1 1 1 1 1 1 0 0 0 0 1 0 0 1 1 1 0 0 1 1 0 0 1 1 1 1 0 0 1 0 0 0 0 0 0 0 0
## [1777] 0 1 0 1 1 0 1 1 1 0 0 0 0 0 0 0 1 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0
## [1814] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
## [1851] 1 1 0 1 0 1 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 0 0 0 0 1 1 0 0 0 0 1 0 1 1 0 0 1
```

```
## [1888] 0 0 0 0 1 1 1 1 1 1 1 1 1 0 1 1 0 0 1 0 0 1 0 0 1 1 1 1 0 0 0 0 0 1 0 1 0
## [1925] 0 0 0 1 1 1 1 1 1 1 1 0 1 1 1 1 1 0 0 0 0 0 0 0 1 0 0 0 0 1 1 0 1 0 0 0
## [1962] 1 1 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0
## [1999] 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0
## [2036] 1 1 0 0 0 0 0 0 0 0 0 1 1 1 1 0 1 1 0 0 0 0 1 0 0 1 0 0 0 0 0 1 1 0 1 1 1
## [2073] 1 0 0 0 1 1 1 0 1 0 1 1 1 1 1 1 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 0 0 1 0 1 1
## [2110] 1 1 1 1 0 1 1 1 1 0 1 1 1 1 0 0 0 1 1 0 0 0 1 0 1 0 0 1 1 1 1 1 1 1 1 1 1
## [2147] 1 1 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 0 0 1 0 0 0 0 0 0 1 0 0 0 0
## [2184] 0 1 1 1 1 0 1 1 0 0 0 0 0 0 0 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## [2221] 0 1 0 0 1 1 0 0 1 0 0 0 0 0 1 0 0 1 1 1 1 0 0 0 0 0 0 0 0 0 0 1 0 1 1 0 0 0
## [2258] 0 0 0 0 0 0 0 0 1 1 1 1 0 0 1 0 0 0 0 0 0 0 0 1 1 1 1 0 0 0 0 0 1 0 1 0 0
## [2295] 0 0 0 0 1 1 1 1 0 0 1 1 1 1 1 1 0 1 0 1 0 1 0 0 0 1 0 0 1 1 1 1 0 0 0 0
## [2332] 0 0 0 0 0 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 0 0 0 0 1 0 0 0 0 1 1 1 0 0 1
## [2369] 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 1 1 0 0 0 0
## [2406] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 1 0 0 0 0 0 0
## [2443] 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 1 1 0 0 0 0 1 0 0 1 1 1 0 0 0 0
## [2480] 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 1 1 1 0 1 1 1 1 1 1 0 0 0 1 1 1 1 0 1 0
## [2517] 0 1 1 0 0 0 0 0 1 0 1 0 0 0 1 1 0 0 1 1 0 1 1 1 0 0 0 0 0 0 0 0 0 0 1 1 1
## [2554] 1 1 1 0 0 1 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 1 0 1 0 0 0 1 0 0 0
## [2591] 1 1 0 1 1 0 1 0 1 0 0 0 0 0 0 1 1 1 1 1 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0
## [2628] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 1 0 1 0 0 0 0 0 1 0 0 0 0 0
## [2665] 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 1 1
## [2702] 0 0 1 1 1 1 0 0 0 1 1 1 1 0 0 1 0 1 1 1 1 1 0 0 0 0 1 0 0 1 1 0 0 0 0
## [2739] 1 0 0 0 0 0 0 1 1 1 1 0 0 0 0 0 0 0 0 1 1 1 0 0 1 1 0 0 1 0 0 0 0 0 0
## [2776] 0 0 1 0 1 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 1 0 0 0 0
## [2813] 0 1 0 0 1 1 0 0 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0
## [2850] 0 0 0 0 1 0 1 1 0 1 1 1 1 0 0 0 0 0 1 1 0 0 1 0 1 1 0 0 0 0 0 0 0 0 0
## [2887] 0 0 0 1 0 0 0 0 0 0 0 1 1 1 1 0 1 1 0 0 0 0 0 0 0 1 1 1 0 0 0 0 1 1 1 0
## [2924] 0 1 0 1 0 0 0 0 1 0 1 0 1 1 0 0 0 0 1 1 0 0 0 1 0 0 0 0 1 1 1 0 0 1 1 1 0
## [2961] 1 0 0 0 0 0 0 0 0 0 0 1 0 1 1 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1
## [2998] 0 0 0 0 0 0 1 1 1 1 1 0 0 0 0 0 0 1 0 0 1 0 0 0 1 0 0 1 0 0 1 0 0 1 0 1 1
## [3035] 0 0 0 0 1 0 1 1 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0
## [3072] 0 0 1 0 0 1 0 1 1 0 0 0 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0
## [3109] 0 0 1 0 0 0 1 1 0 0 0 0 0 1 0 0 0 0 0 1 1 0 0 0 0 0 0 1 1 1 1 1 1 0 0 1 0
## [3146] 0 0 1 1 1 1 1 1 0 1 0 0 1 1 1 1 0 0 0 0 1 1 1 0 0 1 1 1 1 1 0 1 1 0 0 1 1
## [3183] 0 0 0 0 1 0 1 1 1 0 1 0 0 1 1 0 0 0 0 1 1 0 1 1 0 0 0 0 0 0 1 1 0 0 1 0 0
## [3220] 0 0 0 0 0 1 0 0 0 0 0 0 0 1 1 0 0 1 0 0 0 1 0 0 0 0 0 0 1 1 1 1 1 0 1 1
## [3257] 0 0 1 0 1 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 1 1 0 0 0 0 0 1 0 0 1 1 1 1 0 1 1
## [3294] 0 0 0 0 0 0 1 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 1 1 1 0
## [3331] 0 0 0 0 0 0 1 0 1 1 0 1 0 1 0 0 0 0 1 0 1 1 1 0 0 0 0 1 1 0 1 1 1 1 1 1 0
## [3368] 0 1 1 1 0 1 1 1 0 0 0 0 0 1 0 0 1 1 1 1 1 1 1 0 0 0 0 1 1 1 1 0 0 1 1 1
## [3405] 1 0 0 1 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 1 1 0 1 0 1 1 0 0 0 1 0 0 0
## [3442] 0 1 1 0 0 0 1 0 1 0 1 1 1 1 0 0 0 0 0 0 0 0 0 1 1 1 1 0 0 1 0 0 1 0 0 0
## [3479] 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 1 1 0 0 0 0 0 0 0 0 1 0 0
## [3516] 1 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 1 0 0 0 0 1 1 1 0 1 0 0 1 1 0 0 1 0 0
## [3553] 1 1 0 0 1 1 1 1 0 0 1 1 1 1 0 1 1 0 1 1 0 0 0 0 0 0 0 1 0 1 1 1 1 1 0 0
## [3590] 0 1 1 1 0 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 1 0 0 0 0 0 1 1 0 0 0 0 1 0 0 1
## [3627] 0 0 0 0 0 0 1 0 0 0 0 1 1 1 0 0 0 1 0 0 1 0 1 1 1 1 1 1 0 0 0 0 0 0 0 0 1
## [3664] 1 1 1 0 1 1 1 1 1 1 1 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 0 0 0 1
## [3701] 0 0 0 0 0 0 0 1 1 1 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 1 0
## [3738] 0 0 1 1 0 0 1 0 0 0 0 0 0 1 1 1 0 0 0 1 1 1 1 1 1 1 0 0 1 1 0 0 0 0 0 1 1
```

```
## [3775] 0 0 0 1 0 0 0 0 0 1 1 1 1 1 1 1 0 1 0 1 0 0 1 0 0 1 1 1 1 1 1 0 1 1 0 1
## [3812] 0 0 0 1 1 0 0 1 1 0 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0
## [3849] 1 0 0 0 0 0 0 0 0 0 0 1 1 1 0 1 0 0 1 1 1 0 1 0 0 1 1 0 0 0 1 0 0 0 1 1
## [3886] 0 0 0 0 0 0 0 0 0 1 1 1 1 1 0 0 0 0 1 0 1 1 0 1 0 0 0 0 0 0 0 1 0 0 0 0
## [3923] 0 1 0 0 0 0 0 0 0 0 0 0 1 1 0 0 1 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0
## [3960] 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 1 0 0 1 1 1 0 0 0 1 1
## [3997] 1 1 0 1 1 1 1 0 0 0 0 0 0 0 0 1 0 0 0 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 0 0
## [4034] 0 0 1 1 1 1 0 1 1 1 0 0 0 1 0 1 1 1 1 1 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0
## [4071] 0 0 1 0 0 0 0 0 1 1 1 0 0 0 1 0 0 0 1 0 0 1 1 0 1 0 0 1 0 0 0 1 1 0 0 1
## [4108] 0 1 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 0 0 1 0 0 0 1 0 0 0 0 0 1 0 0 0 0 1 1
## [4145] 1 1 1 1 1 1 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0
## [4182] 0 0 0 1 1 0 0 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 0 0 0 0 0 0 0 1 0 0 1 1 0 1
## [4219] 1 0 0 0 0 1 1 1 0 0 0 0 1 1 0 1 1 1 0 1 1 1 1 1 1 1 1 0 0 1 1 0 1 1 1 1
## [4256] 0 1 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 1 0 0 1 1 0 0 1 0 0 0 0 0 0 1 1 1
## [4293] 1 0 0 0 0 0 1 0 0 1 1 1 1 1 1 1 0 1 1 0 0 0 0 0 0 0 1 0 0 1 0 0 1 0 1
## [4330] 0 1 1 1 1 0 1 1 1 1 1 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0
## [4367] 0 0 0 1 1 1 1 1 0 1 1 1 1 0 1 1 1 1 0 0 1 1 0 1 0 0 0 0 0 0 0 1 1 0 0
## [4404] 0 1 1 0 1 1 1 1 1 1 1 1 0 0 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 0
## [4441] 0 0 1 1 1 1 1 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 1 1 0 1 0 0 0
## [4478] 1 1 1 1 1 1 1 1 0 0 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 1 0 0 0
## [4515] 0 0 0 0 0 0 0 1 0 1 1 1 1 1 1 1 1 1 1 1 0 1 0 0 0 0 0 0 1 0 0 0 0 0
## [4552] 0 0 0 1 1 0 0 0 0
## Levels: 0 1
```

Summary: Predicted result shows an accuracy around 89% on the unreduced data. The LCA has not has as high as an accuracy rate comparing to PDA. where it was 95% accuracy using two predictors. Logistic regression wasn't able to predict anything practically using the reduced data

```
mean(lda_pred$class == test$EMISSIONS)
```

```
## [1] 0.8916904
```