Practice6_DA5030

Shivam Verma

```
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

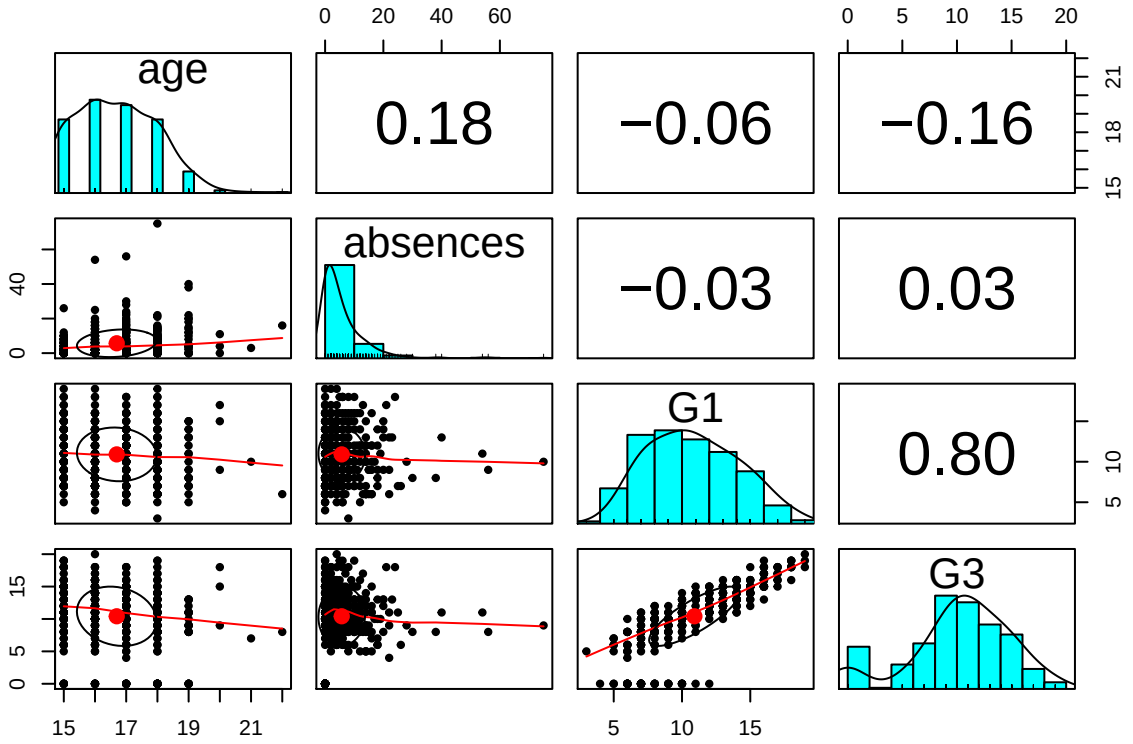
```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(psych)
library(rpart)
library(rpart.plot)
library(RWeka)
```

Problem 1.

Part1.

```
student <- read.csv("student-mat.csv", sep = ";", header = TRUE, stringsAsFactors = TRUE)
pairs.panels(student[, c(3, 30, 31, 33)])
```



Part 2.

```
m <- lm(G3 ~ studytime+ traveltime+ freetime+ goout+ activities+ schoolsup+ famsup+ internet+ health+ G
summary(m)
```

```
##
## Call:
## lm(formula = G3 ~ studytime + traveltime + freetime + goout +
##     activities + schoolsup + famsup + internet + health + G1 +
##     G2, data = student)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -9.1741 -0.4081  0.2502  0.9977  3.4432
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)   -2.74620    0.72785  -3.773 0.000187 ***
## studytime     -0.15363    0.12184  -1.261 0.208119
## traveltime     0.10547    0.14267   0.739 0.460212
## freetime       0.07145    0.10373   0.689 0.491342
## goout          0.06650    0.09310   0.714 0.475488
## activitiesyes -0.31486    0.19695  -1.599 0.110705
## schoolsupyes   0.59683    0.30182   1.977 0.048714 *
## famsupyes      0.18245    0.20495   0.890 0.373902
## internetyes   -0.05353    0.26767  -0.200 0.841592
```

```
## health         0.08514    0.07099   1.199 0.231111
## G1             0.18416    0.05816   3.166 0.001667 **
## G2             0.98823    0.05076  19.467  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.93 on 383 degrees of freedom
## Multiple R-squared:  0.8276, Adjusted R-squared:  0.8226
## F-statistic: 167.1 on 11 and 383 DF,  p-value: < 2.2e-16
```

The lm function treats factors appropriately, so there is no need for additional column generation.

Part 3. Here, using backward elimination for model improvement using AIC measure.

```
step(m, direction = "backward")
```

```
## Start:  AIC=531.1
## G3 ~ studytime + traveltime + freetime + goout + activities +
##     schoolsup + famsup + internet + health + G1 + G2
##
##              Df Sum of Sq    RSS    AIC
## - internet    1      0.15 1426.2 529.14
## - freetime    1      1.77 1427.8 529.59
## - goout       1      1.90 1428.0 529.62
## - traveltime  1      2.03 1428.1 529.66
## - famsup      1      2.95 1429.0 529.92
## - health      1      5.36 1431.4 530.58
## - studytime   1      5.92 1432.0 530.74
## <none>                    1426.1 531.10
## - activities  1      9.52 1435.6 531.73
## - schoolsup   1     14.56 1440.6 533.11
## - G1          1     37.33 1463.4 539.31
## - G2          1   1411.04 2837.1 800.80
##
## Step:  AIC=529.14
## G3 ~ studytime + traveltime + freetime + goout + activities +
##     schoolsup + famsup + health + G1 + G2
##
##              Df Sum of Sq    RSS    AIC
## - freetime    1      1.74 1428.0 527.62
## - goout       1      1.83 1428.0 527.65
## - traveltime  1      2.15 1428.4 527.74
## - famsup      1      2.84 1429.1 527.93
## - health      1      5.52 1431.7 528.67
## - studytime   1      5.97 1432.2 528.79
## <none>                    1426.2 529.14
## - activities  1      9.62 1435.8 529.80
## - schoolsup   1     14.62 1440.8 531.17
## - G1          1     37.66 1463.9 537.43
## - G2          1   1422.67 2848.9 800.44
##
## Step:  AIC=527.62
## G3 ~ studytime + traveltime + goout + activities + schoolsup +
##     famsup + health + G1 + G2
```

```
##
##              Df Sum of Sq    RSS    AIC
## - traveltime  1      2.01 1430.0 526.18
## - famsup      1      3.05 1431.0 526.46
## - goout       1      3.23 1431.2 526.51
## - health      1      5.99 1434.0 527.27
## - studytime   1      7.15 1435.1 527.59
## <none>                    1428.0 527.62
## - activities  1      8.98 1436.9 528.10
## - schoolsup   1     14.46 1442.4 529.60
## - G1          1     38.89 1466.8 536.23
## - G2          1   1420.97 2848.9 798.45
##
## Step:  AIC=526.18
## G3 ~ studytime + goout + activities + schoolsup + famsup + health +
##     G1 + G2
##
##              Df Sum of Sq    RSS    AIC
## - famsup      1      3.09 1433.1 525.03
## - goout       1      3.24 1433.2 525.07
## - health      1      5.89 1435.8 525.80
## <none>                    1430.0 526.18
## - studytime   1      7.90 1437.9 526.35
## - activities  1      8.92 1438.9 526.63
## - schoolsup   1     14.38 1444.3 528.13
## - G1          1     40.50 1470.5 535.21
## - G2          1   1434.55 2864.5 798.60
##
## Step:  AIC=525.03
## G3 ~ studytime + goout + activities + schoolsup + health + G1 +
##     G2
##
##              Df Sum of Sq    RSS    AIC
## - goout       1      3.15 1436.2 523.90
## - health      1      6.24 1439.3 524.74
## - studytime   1      6.58 1439.6 524.84
## <none>                    1433.1 525.03
## - activities  1      9.08 1442.1 525.52
## - schoolsup   1     15.52 1448.6 527.28
## - G1          1     39.28 1472.3 533.71
## - G2          1   1437.28 2870.3 797.40
##
## Step:  AIC=523.9
## G3 ~ studytime + activities + schoolsup + health + G1 + G2
##
##              Df Sum of Sq    RSS    AIC
## - health      1      5.95 1442.2 523.53
## - studytime   1      6.99 1443.2 523.81
## <none>                    1436.2 523.90
## - activities  1      8.45 1444.7 524.21
## - schoolsup   1     14.68 1450.9 525.91
## - G1          1     38.61 1474.8 532.37
## - G2          1   1434.46 2870.7 795.45
##
```

```
## Step:  AIC=523.53
## G3 ~ studytime + activities + schoolsup + G1 + G2
##
##              Df Sum of Sq    RSS    AIC
## <none>                    1442.2 523.53
## - studytime   1      7.89 1450.0 523.68
## - activities  1      7.95 1450.1 523.70
## - schoolsup   1     13.96 1456.1 525.33
## - G1          1     39.06 1481.2 532.09
## - G2          1   1428.52 2870.7 793.45
```

```
##
## Call:
## lm(formula = G3 ~ studytime + activities + schoolsup + G1 + G2,
##     data = student)
##
## Coefficients:
##   (Intercept)      studytime  activitiesyes   schoolsupyes             G1
##       -1.6469        -0.1718        -0.2856         0.5807         0.1867
##            G2
##        0.9749
```

```
# New model with selected features
new_m <- lm(G3 ~ studytime+ activities+ G1+ G2+ schoolsup, data = student)
summary(new_m)
```

```
##
## Call:
## lm(formula = G3 ~ studytime + activities + G1 + G2 + schoolsup,
##     data = student)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -9.3403 -0.3352  0.2532  0.9873  3.1446
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)   -1.64692    0.39786  -4.140 4.27e-05 ***
## studytime     -0.17182    0.11780  -1.459  0.14548
## activitiesyes -0.28562    0.19504  -1.464  0.14389
## G1             0.18671    0.05752   3.246  0.00127 **
## G2             0.97493    0.04967  19.630  < 2e-16 ***
## schoolsupyes   0.58071    0.29928   1.940  0.05306 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.925 on 389 degrees of freedom
## Multiple R-squared:  0.8256, Adjusted R-squared:  0.8234
## F-statistic: 368.3 on 5 and 389 DF,  p-value: < 2.2e-16
```

Part 4.

```r
# selecting 127th student to predict using multiple linear regression
stu <- student[127,]
student_pred<- predict(new_m, stu)
se <- 1.925
upper <- unname(student_pred + 1.96*(se))
lower <- unname(student_pred - 1.96*(se))
cat(sprintf("Predicted G3: %f \n95%% Confidence interval: [%f, %f]", student_pred, lower, upper))
```

```
## Predicted G3: 9.360862
## 95% Confidence interval: [5.587862, 13.133862]
```

Part 5.

```r
RMSE <- sqrt(mean(new_m$residuals^2))
RMSE
```

```
## [1] 1.91077
```

Problem 2.

Part 1.

```r
student$PF <- ifelse(student$G3 < 10, "F", "P")
student$PF_dummy <- ifelse(student$PF=="P", 1, 0)
```

Part 2.

```r
model <- glm(PF_dummy ~ studytime+ traveltime+ freetime+ goout+ activities+ schoolsup+ famsup+ internet
summary(model)
```

```
##
## Call:
## glm(formula = PF_dummy ~ studytime + traveltime + freetime +
##     goout + activities + schoolsup + famsup + internet + health +
##     G1 + G2, family = "binomial", data = student)
##
## Deviance Residuals:
##      Min        1Q    Median        3Q       Max
## -2.62469  -0.03606   0.00332   0.08991   2.07981
##
## Coefficients:
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept)   -19.0459     3.1976  -5.956 2.58e-09 ***
## studytime      -0.5248     0.2872  -1.828   0.0676 .
## traveltime      0.7489     0.3132   2.391   0.0168 *
## freetime        0.2324     0.2441   0.952   0.3411
## goout          -0.3234     0.2127  -1.520   0.1284
## activitiesyes  -0.6948     0.4704  -1.477   0.1396
## schoolsupyes    0.1826     0.5661   0.323   0.7471
## famsupyes      -0.3250     0.4660  -0.698   0.4855
## internetyes    -0.3787     0.5811  -0.652   0.5146
```

```
## health         -0.1836     0.1724  -1.065   0.2867
## G1              0.2041     0.1623   1.257   0.2086
## G2              2.0717     0.3309   6.261 3.82e-10 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 500.50  on 394  degrees of freedom
## Residual deviance: 131.28  on 383  degrees of freedom
## AIC: 155.28
##
## Number of Fisher Scoring iterations: 8
```

```
# eliminating features using AIC
step(model, direction = "backward")
```

```
## Start:  AIC=155.28
## PF_dummy ~ studytime + traveltime + freetime + goout + activities +
##     schoolsup + famsup + internet + health + G1 + G2
##
##              Df Deviance    AIC
## - schoolsup   1   131.38 153.38
## - internet    1   131.71 153.71
## - famsup      1   131.77 153.77
## - freetime    1   132.19 154.19
## - health      1   132.42 154.42
## - G1          1   132.90 154.90
## <none>            131.28 155.28
## - activities  1   133.53 155.53
## - goout       1   133.63 155.63
## - studytime   1   134.73 156.73
## - traveltime  1   137.16 159.16
## - G2          1   245.22 267.22
##
## Step:  AIC=153.38
## PF_dummy ~ studytime + traveltime + freetime + goout + activities +
##     famsup + internet + health + G1 + G2
##
##              Df Deviance    AIC
## - internet    1   131.78 151.78
## - famsup      1   131.82 151.82
## - freetime    1   132.37 152.37
## - health      1   132.63 152.63
## - G1          1   132.91 152.91
## <none>            131.38 153.38
## - activities  1   133.55 153.55
## - goout       1   133.90 153.90
## - studytime   1   134.75 154.75
## - traveltime  1   137.51 157.51
## - G2          1   246.57 266.57
##
## Step:  AIC=151.78
## PF_dummy ~ studytime + traveltime + freetime + goout + activities +
```

```
##     famsup + health + G1 + G2
##
##              Df Deviance    AIC
## - famsup      1   132.28 150.28
## - freetime    1   132.70 150.70
## - health      1   132.97 150.97
## - G1          1   133.42 151.42
## <none>            131.78 151.78
## - goout       1   134.28 152.28
## - activities  1   134.31 152.31
## - studytime   1   135.15 153.15
## - traveltime  1   137.72 155.72
## - G2          1   247.02 265.02
##
## Step:  AIC=150.28
## PF_dummy ~ studytime + traveltime + freetime + goout + activities +
##     health + G1 + G2
##
##              Df Deviance    AIC
## - freetime    1   133.11 149.11
## - health      1   133.46 149.46
## - G1          1   134.03 150.03
## <none>            132.28 150.28
## - activities  1   134.71 150.71
## - goout       1   134.76 150.76
## - studytime   1   135.66 151.66
## - traveltime  1   138.30 154.30
## - G2          1   247.18 263.18
##
## Step:  AIC=149.11
## PF_dummy ~ studytime + traveltime + goout + activities + health +
##     G1 + G2
##
##              Df Deviance    AIC
## - health      1   134.34 148.34
## - goout       1   134.99 148.99
## <none>            133.11 149.11
## - activities  1   135.37 149.37
## - G1          1   135.45 149.45
## - studytime   1   136.80 150.80
## - traveltime  1   139.01 153.01
## - G2          1   247.55 261.55
##
## Step:  AIC=148.34
## PF_dummy ~ studytime + traveltime + goout + activities + G1 +
##     G2
##
##              Df Deviance    AIC
## - activities  1   136.20 148.20
## <none>            134.34 148.34
## - G1          1   136.75 148.75
## - goout       1   136.80 148.80
## - studytime   1   137.81 149.81
## - traveltime  1   139.90 151.90
```

```
## - G2          1   248.63 260.63
##
## Step:  AIC=148.2
## PF_dummy ~ studytime + traveltime + goout + G1 + G2
##
##              Df Deviance    AIC
## <none>            136.20 148.20
## - G1          1   138.24 148.24
## - goout       1   138.66 148.66
## - studytime   1   140.08 150.08
## - traveltime  1   141.28 151.28
## - G2          1   249.18 259.18

##
## Call:  glm(formula = PF_dummy ~ studytime + traveltime + goout + G1 +
##     G2, family = "binomial", data = student)
##
## Coefficients:
## (Intercept)    studytime   traveltime        goout           G1           G2
##    -18.3691      -0.5403       0.6596      -0.3088       0.2189       1.9138
##
## Degrees of Freedom: 394 Total (i.e. Null);  389 Residual
## Null Deviance:       500.5
## Residual Deviance: 136.2     AIC: 148.2
```

Part 3. Regression equation is G3 = -18.3691 -0.5403(studytime) + 0.6596(traveltime) -0.3088(goout) + 2.189(G1) + 1.9138(G2)

Part4.

```
new_model <- glm(PF_dummy ~ studytime+ traveltime +goout + G1 + G2, data= student, family = "binomial")
summary(new_model)
```

```
##
## Call:
## glm(formula = PF_dummy ~ studytime + traveltime + goout + G1 +
##     G2, family = "binomial", data = student)
##
## Deviance Residuals:
##      Min        1Q    Median        3Q       Max
## -2.68132  -0.04287   0.00543   0.10614   2.29729
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept) -18.3691     2.8213  -6.511 7.47e-11 ***
## studytime    -0.5403     0.2792  -1.935   0.0530 .
## traveltime    0.6596     0.2944   2.241   0.0251 *
## goout        -0.3088     0.1984  -1.556   0.1196
## G1            0.2189     0.1556   1.407   0.1593
## G2            1.9138     0.2943   6.503 7.88e-11 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
```

```
##
##     Null deviance: 500.5  on 394  degrees of freedom
## Residual deviance: 136.2  on 389  degrees of freedom
## AIC: 148.2
##
## Number of Fisher Scoring iterations: 8
```

```
stu_pred<- predict(new_model, student, type = "response")
table(round(stu_pred), student$PF_dummy)
```

```
##
##       0   1
##   0 113  18
##   1  17 247
```

Part 4.

```
accuracy <- (113 + 247)/ length(stu_pred)
accuracy*100
```

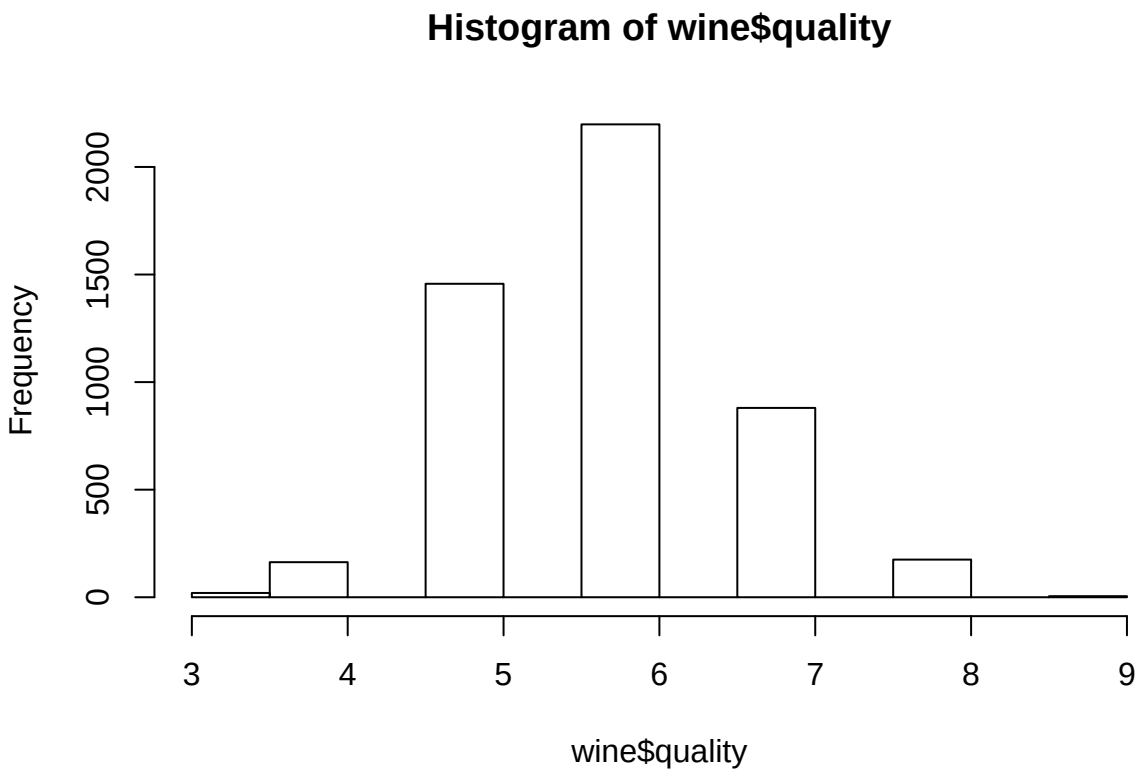
```
## [1] 91.13924
```

Problem 3. Part 1. Step 2- Exploring the data

```
wine <- read.csv("whitewines.csv")
str (wine)
```

```
## 'data.frame':    4898 obs. of  12 variables:
##  $ fixed.acidity       : num  7 6.3 8.1 7.2 7.2 8.1 6.2 7 6.3 8.1 ...
##  $ volatile.acidity    : num  0.27 0.3 0.28 0.23 0.23 0.28 0.32 0.27 0.3 0.22 ...
##  $ citric.acid         : num  0.36 0.34 0.4 0.32 0.32 0.4 0.16 0.36 0.34 0.43 ...
##  $ residual.sugar      : num  20.7 1.6 6.9 8.5 8.5 6.9 7 20.7 1.6 1.5 ...
##  $ chlorides           : num  0.045 0.049 0.05 0.058 0.058 0.05 0.045 0.045 0.049 0.044 ...
##  $ free.sulfur.dioxide : num  45 14 30 47 47 30 30 45 14 28 ...
##  $ total.sulfur.dioxide: num  170 132 97 186 186 97 136 170 132 129 ...
##  $ density             : num  1.001 0.994 0.995 0.996 0.996 ...
##  $ pH                  : num  3 3.3 3.26 3.19 3.19 3.26 3.18 3 3.3 3.22 ...
##  $ sulphates           : num  0.45 0.49 0.44 0.4 0.4 0.44 0.47 0.45 0.49 0.45 ...
##  $ alcohol             : num  8.8 9.5 10.1 9.9 9.9 10.1 9.6 8.8 9.5 11 ...
##  $ quality             : int  6 6 6 6 6 6 6 6 6 6 ...
```

```
hist(wine$quality)
```




```
# wine quality is fairly normal
```

Splitting data into test and training data

```
wine_train <- wine[1:3750, ]
wine_test <- wine[3751:4898, ]
```

Step 3- training a modle on the data

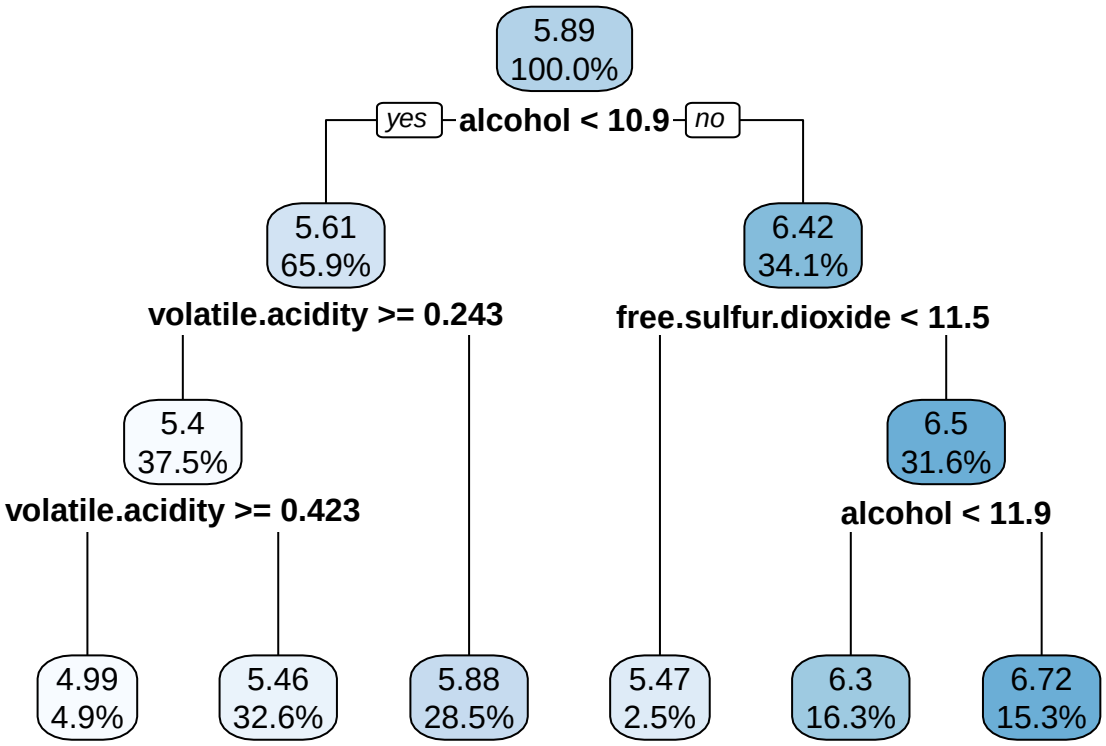
```
m.rpart <- rpart(quality ~ . , data= wine_train)
m.rpart
```

```
## n= 3750
##
## node), split, n, deviance, yval
##       * denotes terminal node
##
##  1) root 3750 3140.06000 5.886933
##    2) alcohol< 10.85 2473 1510.66200 5.609381
##      4) volatile.acidity>=0.2425 1406  740.15080 5.402560
##        8) volatile.acidity>=0.4225 182   92.99451 4.994505 *
##        9) volatile.acidity< 0.4225 1224  612.34560 5.463235 *
##      5) volatile.acidity< 0.2425 1067  631.12090 5.881912 *
##    3) alcohol>=10.85 1277 1069.95800 6.424432
```

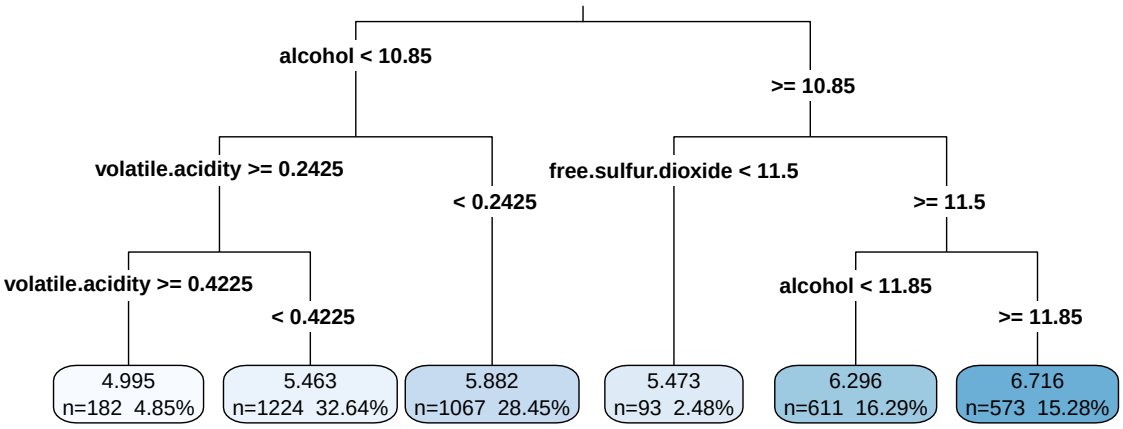
```
##       6) free.sulfur.dioxide< 11.5 93   99.18280 5.473118 *
##       7) free.sulfur.dioxide>=11.5 1184  879.99920 6.499155
##        14) alcohol< 11.85 611  447.38130 6.296236 *
##        15) alcohol>=11.85 573  380.63180 6.715532 *
```

Visualizing the decision trees

```
rpart.plot(m.rpart, digits =  3)
```




```
# adding additional parameters to adjust the visualization
rpart.plot(m.rpart, digits = 4, fallen.leaves = TRUE, type = 3, extra = 101)
```



Step 4- Evaluating model performance

```
p.rpart <- predict(m.rpart, wine_test)
summary(p.rpart)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   4.995   5.463   5.882   5.999   6.296   6.716
```

```
summary(wine_test$quality)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   3.000   5.000   6.000   5.848   6.000   8.000
```

```
# finding correlation to measure relationship
cor(p.rpart, wine_test$quality)
```

```
## [1] 0.4931608
```

Performance evaluation using mean absolute error

```
MAE <- function(actual, predicted) { mean(abs(actual - predicted))
}
# Assessing quality score of model and prediction by mean
MAE(p.rpart, wine_test$quality)
```

```
## [1] 0.5732104
```

```
mean(wine_train$quality)
```

```
## [1] 5.886933
```

```
MAE(5.88, wine_test$quality)
```

```
## [1] 0.5778397
```

Step 5- improving model performance

```
# using M5P algorithm
m.m5p <- M5P(quality ~ . , data= wine_train)
m.m5p
```

```
## M5 pruned model tree:
## (using smoothed linear models)
##
## alcohol <= 10.85 :
## |   volatile.acidity <= 0.282 :
## |   |   volatile.acidity <= 0.207 :
## |   |   |   residual.sugar <= 10.1 :
## |   |   |   |   alcohol <= 10.15 :
## |   |   |   |   |   citric.acid <= 0.275 : LM1 (66/46.178%)
## |   |   |   |   |   citric.acid >  0.275 :
## |   |   |   |   |   |   fixed.acidity <= 7.45 :
## |   |   |   |   |   |   |   alcohol <= 9.85 : LM2 (89/64.134%)
## |   |   |   |   |   |   |   alcohol >  9.85 :
## |   |   |   |   |   |   |   |   density <= 0.993 :
## |   |   |   |   |   |   |   |   |   fixed.acidity <= 6.6 : LM3 (7/0%)
## |   |   |   |   |   |   |   |   |   fixed.acidity >  6.6 : LM4 (13/49.88%)
## |   |   |   |   |   |   |   |   density >  0.993 :
## |   |   |   |   |   |   |   |   |   residual.sugar <= 1.85 : LM5 (5/0%)
## |   |   |   |   |   |   |   |   |   residual.sugar >  1.85 : LM6 (7/15.602%)
## |   |   |   |   |   |   fixed.acidity >  7.45 : LM7 (59/74.093%)
## |   |   |   |   alcohol >  10.15 : LM8 (214/81.981%)
## |   |   |   residual.sugar >  10.1 :
## |   |   |   |   citric.acid <= 0.305 :
## |   |   |   |   |   citric.acid <= 0.275 : LM9 (15/50.102%)
## |   |   |   |   |   citric.acid >  0.275 :
## |   |   |   |   |   |   free.sulfur.dioxide <= 30.5 : LM10 (14/0%)
## |   |   |   |   |   |   free.sulfur.dioxide >  30.5 :
## |   |   |   |   |   |   |   chlorides <= 0.055 :
## |   |   |   |   |   |   |   |   free.sulfur.dioxide <= 51.25 :
## |   |   |   |   |   |   |   |   |   density <= 0.997 :
## |   |   |   |   |   |   |   |   |   |   residual.sugar <= 10.35 : LM11 (3/0%)
## |   |   |   |   |   |   |   |   |   |   residual.sugar >  10.35 : LM12 (3/0%)
## |   |   |   |   |   |   |   |   |   density >  0.997 : LM13 (8/0%)
## |   |   |   |   |   |   |   |   free.sulfur.dioxide >  51.25 : LM14 (6/0%)
## |   |   |   |   |   |   |   chlorides >  0.055 : LM15 (6/0%)
## |   |   |   |   citric.acid >  0.305 :
```

```
## |   |   |   |   |   citric.acid <= 0.435 :
## |   |   |   |   |   |   chlorides <= 0.052 :
## |   |   |   |   |   |   |   density <= 0.997 :
## |   |   |   |   |   |   |   |   sulphates <= 0.57 : LM16 (11/18.751%)
## |   |   |   |   |   |   |   |   sulphates >  0.57 : LM17 (6/0%)
## |   |   |   |   |   |   |   density >  0.997 :
## |   |   |   |   |   |   |   |   density <= 0.999 : LM18 (22/0%)
## |   |   |   |   |   |   |   |   density >  0.999 : LM19 (6/28.153%)
## |   |   |   |   |   |   chlorides >  0.052 : LM20 (13/0%)
## |   |   |   |   |   citric.acid >  0.435 :
## |   |   |   |   |   |   citric.acid <= 0.495 :
## |   |   |   |   |   |   |   pH <= 3.205 : LM21 (10/38.853%)
## |   |   |   |   |   |   |   pH >  3.205 :
## |   |   |   |   |   |   |   |   fixed.acidity <= 7.55 : LM22 (3/0%)
## |   |   |   |   |   |   |   |   fixed.acidity >  7.55 : LM23 (3/0%)
## |   |   |   |   |   |   citric.acid >  0.495 :
## |   |   |   |   |   |   |   free.sulfur.dioxide <= 51.5 : LM24 (12/0%)
## |   |   |   |   |   |   |   free.sulfur.dioxide >  51.5 :
## |   |   |   |   |   |   |   |   citric.acid <= 0.67 : LM25 (2/0%)
## |   |   |   |   |   |   |   |   citric.acid >  0.67 : LM26 (5/0%)
## |   |   volatile.acidity >  0.207 :
## |   |   |   alcohol <= 9.95 :
## |   |   |   |   citric.acid <= 0.265 :
## |   |   |   |   |   chlorides <= 0.046 :
## |   |   |   |   |   |   residual.sugar <= 6.25 :
## |   |   |   |   |   |   |   chlorides <= 0.038 : LM27 (5/0%)
## |   |   |   |   |   |   |   chlorides >  0.038 :
## |   |   |   |   |   |   |   |   density <= 0.994 : LM28 (5/0%)
## |   |   |   |   |   |   |   |   density >  0.994 :
## |   |   |   |   |   |   |   |   |   volatile.acidity <= 0.253 : LM29 (2/0%)
## |   |   |   |   |   |   |   |   |   volatile.acidity >  0.253 : LM30 (2/0%)
## |   |   |   |   |   |   residual.sugar >  6.25 : LM31 (51/40.682%)
## |   |   |   |   |   chlorides >  0.046 :
## |   |   |   |   |   |   chlorides <= 0.057 :
## |   |   |   |   |   |   |   pH <= 3.18 : LM32 (24/0%)
## |   |   |   |   |   |   |   pH >  3.18 : LM33 (24/48.999%)
## |   |   |   |   |   |   chlorides >  0.057 : LM34 (27/78.724%)
## |   |   |   |   citric.acid >  0.265 :
## |   |   |   |   |   citric.acid <= 0.425 :
## |   |   |   |   |   |   total.sulfur.dioxide <= 146.5 :
## |   |   |   |   |   |   |   density <= 1 :
## |   |   |   |   |   |   |   |   total.sulfur.dioxide <= 115.5 :
## |   |   |   |   |   |   |   |   |   pH <= 3.175 :
## |   |   |   |   |   |   |   |   |   |   density <= 0.996 : LM35 (14/0%)
## |   |   |   |   |   |   |   |   |   |   density >  0.996 :
## |   |   |   |   |   |   |   |   |   |   |   citric.acid <= 0.305 : LM36 (2/0%)
## |   |   |   |   |   |   |   |   |   |   |   citric.acid >  0.305 : LM37 (3/0%)
## |   |   |   |   |   |   |   |   |   pH >  3.175 :
## |   |   |   |   |   |   |   |   |   |   residual.sugar <= 1.1 : LM38 (2/0%)
## |   |   |   |   |   |   |   |   |   |   residual.sugar >  1.1 : LM39 (6/0%)
## |   |   |   |   |   |   |   |   total.sulfur.dioxide >  115.5 :
## |   |   |   |   |   |   |   |   |   free.sulfur.dioxide <= 24.5 : LM40 (12/30.204%)
## |   |   |   |   |   |   |   |   |   free.sulfur.dioxide >  24.5 :
## |   |   |   |   |   |   |   |   |   |   volatile.acidity <= 0.235 :
```

```
## |   |   |   |   |   |   |   |   |   |   pH <= 3.085 : LM41 (9/0%)
## |   |   |   |   |   |   |   |   |   |   pH >  3.085 :
## |   |   |   |   |   |   |   |   |   |   |   residual.sugar <= 16.75 :
## |   |   |   |   |   |   |   |   |   |   |   |   residual.sugar <= 9.65 : LM42 (4/0%)
## |   |   |   |   |   |   |   |   |   |   |   |   residual.sugar >  9.65 : LM43 (7/0%)
## |   |   |   |   |   |   |   |   |   |   |   residual.sugar >  16.75 : LM44 (5/0%)
## |   |   |   |   |   |   |   |   |   |   volatile.acidity >  0.235 :
## |   |   |   |   |   |   |   |   |   |   |   citric.acid <= 0.35 : LM45 (9/0%)
## |   |   |   |   |   |   |   |   |   |   |   citric.acid >  0.35 : LM46 (5/43.713%)
## |   |   |   |   |   |   |   density >  1 :
## |   |   |   |   |   |   |   |   residual.sugar <= 15.05 : LM47 (5/58.835%)
## |   |   |   |   |   |   |   |   residual.sugar >  15.05 : LM48 (16/0%)
## |   |   |   |   |   |   total.sulfur.dioxide >  146.5 :
## |   |   |   |   |   |   |   fixed.acidity <= 6.65 : LM49 (74/60.126%)
## |   |   |   |   |   |   |   fixed.acidity >  6.65 :
## |   |   |   |   |   |   |   |   pH <= 3.145 : LM50 (102/68.399%)
## |   |   |   |   |   |   |   |   pH >  3.145 : LM51 (77/61.812%)
## |   |   |   |   |   citric.acid >  0.425 : LM52 (135/57.831%)
## |   |   |   alcohol >  9.95 :
## |   |   |   |   free.sulfur.dioxide <= 27.5 :
## |   |   |   |   |   free.sulfur.dioxide <= 13.5 : LM53 (33/98.682%)
## |   |   |   |   |   free.sulfur.dioxide >  13.5 : LM54 (86/62.63%)
## |   |   |   |   free.sulfur.dioxide >  27.5 :
## |   |   |   |   |   pH <= 3.325 :
## |   |   |   |   |   |   volatile.acidity <= 0.263 :
## |   |   |   |   |   |   |   free.sulfur.dioxide <= 55.5 : LM55 (103/57.077%)
## |   |   |   |   |   |   |   free.sulfur.dioxide >  55.5 :
## |   |   |   |   |   |   |   |   residual.sugar <= 8 : LM56 (15/40.324%)
## |   |   |   |   |   |   |   |   residual.sugar >  8 :
## |   |   |   |   |   |   |   |   |   total.sulfur.dioxide <= 155 :
## |   |   |   |   |   |   |   |   |   |   chlorides <= 0.039 : LM57 (2/0%)
## |   |   |   |   |   |   |   |   |   |   chlorides >  0.039 : LM58 (4/0%)
## |   |   |   |   |   |   |   |   |   total.sulfur.dioxide >  155 : LM59 (8/0%)
## |   |   |   |   |   |   volatile.acidity >  0.263 :
## |   |   |   |   |   |   |   chlorides <= 0.044 :
## |   |   |   |   |   |   |   |   total.sulfur.dioxide <= 130.5 : LM60 (5/30.588%)
## |   |   |   |   |   |   |   |   total.sulfur.dioxide >  130.5 :
## |   |   |   |   |   |   |   |   |   density <= 0.992 : LM61 (3/0%)
## |   |   |   |   |   |   |   |   |   density >  0.992 :
## |   |   |   |   |   |   |   |   |   |   fixed.acidity <= 6.85 : LM62 (4/0%)
## |   |   |   |   |   |   |   |   |   |   fixed.acidity >  6.85 :
## |   |   |   |   |   |   |   |   |   |   |   free.sulfur.dioxide <= 30.5 : LM63 (2/0%)
## |   |   |   |   |   |   |   |   |   |   |   free.sulfur.dioxide >  30.5 : LM64 (4/22.369%)
## |   |   |   |   |   |   |   chlorides >  0.044 :
## |   |   |   |   |   |   |   |   density <= 0.995 : LM65 (9/57.073%)
## |   |   |   |   |   |   |   |   density >  0.995 : LM66 (7/0%)
## |   |   |   |   pH >  3.325 : LM67 (72/73.853%)
## |   volatile.acidity >  0.282 :
## |   |   volatile.acidity <= 0.422 :
## |   |   |   free.sulfur.dioxide <= 21.5 : LM68 (143/70.071%)
## |   |   |   free.sulfur.dioxide >  21.5 :
## |   |   |   |   alcohol <= 9.25 : LM69 (188/55.598%)
## |   |   |   |   alcohol >  9.25 :
## |   |   |   |   |   chlorides <= 0.04 : LM70 (94/71.599%)
```

```
## |   |   |   |   |   chlorides >  0.04 :
## |   |   |   |   |   |   volatile.acidity <= 0.305 : LM71 (70/66.297%)
## |   |   |   |   |   |   volatile.acidity >  0.305 :
## |   |   |   |   |   |   |   citric.acid <= 0.345 : LM72 (132/54.604%)
## |   |   |   |   |   |   |   citric.acid >  0.345 :
## |   |   |   |   |   |   |   |   volatile.acidity <= 0.335 :
## |   |   |   |   |   |   |   |   |   chlorides <= 0.044 : LM73 (7/37.561%)
## |   |   |   |   |   |   |   |   |   chlorides >  0.044 : LM74 (20/0%)
## |   |   |   |   |   |   |   |   volatile.acidity >  0.335 :
## |   |   |   |   |   |   |   |   |   pH <= 3.15 :
## |   |   |   |   |   |   |   |   |   |   volatile.acidity <= 0.375 :
## |   |   |   |   |   |   |   |   |   |   |   pH <= 3.055 : LM75 (6/0%)
## |   |   |   |   |   |   |   |   |   |   |   pH >  3.055 :
## |   |   |   |   |   |   |   |   |   |   |   |   sulphates <= 0.42 : LM76 (5/0%)
## |   |   |   |   |   |   |   |   |   |   |   |   sulphates >  0.42 :
## |   |   |   |   |   |   |   |   |   |   |   |   |   pH <= 3.105 : LM77 (5/0%)
## |   |   |   |   |   |   |   |   |   |   |   |   |   pH >  3.105 :
## |   |   |   |   |   |   |   |   |   |   |   |   |   |   volatile.acidity <= 0.355 : LM78 (2/0%)
## |   |   |   |   |   |   |   |   |   |   |   |   |   |   volatile.acidity >  0.355 : LM79 (2/0%)
## |   |   |   |   |   |   |   |   |   |   volatile.acidity >  0.375 : LM80 (10/0%)
## |   |   |   |   |   |   |   |   |   pH >  3.15 :
## |   |   |   |   |   |   |   |   |   |   residual.sugar <= 9.45 :
## |   |   |   |   |   |   |   |   |   |   |   density <= 0.996 : LM81 (4/0%)
## |   |   |   |   |   |   |   |   |   |   |   density >  0.996 : LM82 (4/0%)
## |   |   |   |   |   |   |   |   |   |   residual.sugar >  9.45 : LM83 (7/0%)
## |   |   volatile.acidity >  0.422 :
## |   |   |   volatile.acidity <= 0.587 :
## |   |   |   |   chlorides <= 0.049 :
## |   |   |   |   |   residual.sugar <= 10.65 : LM84 (49/74.502%)
## |   |   |   |   |   residual.sugar >  10.65 : LM85 (17/56.041%)
## |   |   |   |   chlorides >  0.049 : LM86 (71/54.436%)
## |   |   |   volatile.acidity >  0.587 : LM87 (45/63.658%)
## alcohol >  10.85 :
## |   free.sulfur.dioxide <= 20.5 :
## |   |   free.sulfur.dioxide <= 10.5 : LM88 (81/104.574%)
## |   |   free.sulfur.dioxide >  10.5 : LM89 (224/87.002%)
## |   free.sulfur.dioxide >  20.5 :
## |   |   alcohol <= 12.05 :
## |   |   |   fixed.acidity <= 7.35 :
## |   |   |   |   sulphates <= 0.565 :
## |   |   |   |   |   residual.sugar <= 2.05 :
## |   |   |   |   |   |   density <= 0.991 : LM90 (76/70.139%)
## |   |   |   |   |   |   density >  0.991 : LM91 (53/88.647%)
## |   |   |   |   |   residual.sugar >  2.05 :
## |   |   |   |   |   |   free.sulfur.dioxide <= 38.5 :
## |   |   |   |   |   |   |   total.sulfur.dioxide <= 125 : LM92 (66/68.756%)
## |   |   |   |   |   |   |   total.sulfur.dioxide >  125 : LM93 (39/85.617%)
## |   |   |   |   |   |   free.sulfur.dioxide >  38.5 : LM94 (77/74.028%)
## |   |   |   |   sulphates >  0.565 : LM95 (99/67.429%)
## |   |   |   fixed.acidity >  7.35 :
## |   |   |   |   density <= 0.994 : LM96 (123/81.196%)
## |   |   |   |   density >  0.994 : LM97 (53/63.304%)
## |   |   alcohol >  12.05 :
## |   |   |   sulphates <= 0.475 :
```

```
## |   |   |   |   total.sulfur.dioxide <= 112.5 :
## |   |   |   |   |   alcohol <= 12.55 : LM98 (56/55.393%)
## |   |   |   |   |   alcohol >  12.55 :
## |   |   |   |   |   |   citric.acid <= 0.285 :
## |   |   |   |   |   |   |   citric.acid <= 0.245 : LM99 (5/36.972%)
## |   |   |   |   |   |   |   citric.acid >  0.245 : LM100 (5/0%)
## |   |   |   |   |   |   citric.acid >  0.285 :
## |   |   |   |   |   |   |   sulphates <= 0.415 :
## |   |   |   |   |   |   |   |   free.sulfur.dioxide <= 34.5 :
## |   |   |   |   |   |   |   |   |   alcohol <= 13.3 :
## |   |   |   |   |   |   |   |   |   |   total.sulfur.dioxide <= 77.5 : LM101 (5/0%)
## |   |   |   |   |   |   |   |   |   |   total.sulfur.dioxide >  77.5 : LM102 (9/27.113%)
## |   |   |   |   |   |   |   |   |   alcohol >  13.3 : LM103 (4/47.32%)
## |   |   |   |   |   |   |   |   free.sulfur.dioxide >  34.5 : LM104 (5/0%)
## |   |   |   |   |   |   |   sulphates >  0.415 :
## |   |   |   |   |   |   |   |   pH <= 3.225 : LM105 (4/9.044%)
## |   |   |   |   |   |   |   |   pH >  3.225 : LM106 (4/0%)
## |   |   |   |   total.sulfur.dioxide >  112.5 :
## |   |   |   |   |   free.sulfur.dioxide <= 35.5 : LM107 (56/78.811%)
## |   |   |   |   |   free.sulfur.dioxide >  35.5 : LM108 (79/66.147%)
## |   |   |   sulphates >  0.475 :
## |   |   |   |   citric.acid <= 0.345 :
## |   |   |   |   |   pH <= 3.155 : LM109 (22/28.736%)
## |   |   |   |   |   pH >  3.155 :
## |   |   |   |   |   |   residual.sugar <= 1.85 : LM110 (15/69.709%)
## |   |   |   |   |   |   residual.sugar >  1.85 : LM111 (59/58.202%)
## |   |   |   |   citric.acid >  0.345 : LM112 (58/78.288%)
##
## LM num: 1
## quality =
##  0.0496 * volatile.acidity
##  - 0.1195 * citric.acid
##  + 0.0803 * residual.sugar
##  + 0.0388 * chlorides
##  + 1.0289 * free.sulfur.dioxide
##  + 0.0017 * total.sulfur.dioxide
##  - 117.4688 * density
##  - 87.6934 * pH
##  + 1.2306 * sulphates
##  + 0.4379 * alcohol
##  + 207.4502
##
## LM num: 2
## quality =
##  0.0649 * volatile.acidity
##  - 0.1195 * citric.acid
##  - 0.0156 * residual.sugar
##  + 0.0337 * chlorides
##  + 0.6633 * free.sulfur.dioxide
##  + 0.0038 * total.sulfur.dioxide
##  - 0.0009 * density
##  - 82.3489 * pH
##  + 1.3566 * sulphates
##  + 0.5559 * alcohol
```

```
##  + 84.3863
##
## LM num: 3
## quality =
##  0.152 * fixed.acidity
##  + 0.1047 * volatile.acidity
##  - 0.1195 * citric.acid
##  - 0.0156 * residual.sugar
##  + 0.0391 * chlorides
##  + 0.6633 * free.sulfur.dioxide
##  + 0.0054 * total.sulfur.dioxide
##  - 85.756 * density
##  - 103.5429 * pH
##  + 0.5226 * sulphates
##  + 0.757 * alcohol
##  + 191.2577
##
## LM num: 4
## quality =
##  0.1397 * fixed.acidity
##  + 0.1047 * volatile.acidity
##  - 0.1195 * citric.acid
##  - 0.0156 * residual.sugar
##  + 5.2812 * chlorides
##  + 0.6633 * free.sulfur.dioxide
##  + 0.0054 * total.sulfur.dioxide
##  - 85.756 * density
##  - 103.5429 * pH
##  + 0.5226 * sulphates
##  + 0.757 * alcohol
##  + 191.1871
##
## LM num: 5
## quality =
##  0.1227 * fixed.acidity
##  + 0.1047 * volatile.acidity
##  - 0.1195 * citric.acid
##  - 0.0156 * residual.sugar
##  + 0.0391 * chlorides
##  + 0.6633 * free.sulfur.dioxide
##  + 0.0054 * total.sulfur.dioxide
##  - 111.1648 * density
##  - 103.5429 * pH
##  + 0.5226 * sulphates
##  + 0.757 * alcohol
##  + 216.4052
##
## LM num: 6
## quality =
##  0.1227 * fixed.acidity
##  + 0.1047 * volatile.acidity
##  - 4.9064 * citric.acid
##  - 0.0156 * residual.sugar
##  + 0.0391 * chlorides
```

```
##  + 0.6633 * free.sulfur.dioxide
##  + 0.0043 * total.sulfur.dioxide
##  - 111.1648 * density
##  - 103.5429 * pH
##  + 0.5226 * sulphates
##  + 0.757 * alcohol
##  + 218.1117
##
## LM num: 7
## quality =
##  -0.2034 * fixed.acidity
##  + 0.032 * volatile.acidity
##  - 0.1195 * citric.acid
##  - 0.0156 * residual.sugar
##  + 0.0335 * chlorides
##  + 0.6727 * free.sulfur.dioxide
##  + 0.0039 * total.sulfur.dioxide
##  - 0.0008 * density
##  - 77.0631 * pH
##  + 0.4009 * sulphates
##  + 0.4942 * alcohol
##  + 81.8479
##
## LM num: 8
## quality =
##  0.0209 * volatile.acidity
##  - 0.1195 * citric.acid
##  - 0.0156 * residual.sugar
##  + 0.0146 * chlorides
##  + 0.4346 * free.sulfur.dioxide
##  + 0.0006 * total.sulfur.dioxide
##  - 0.0001 * density
##  - 29.7968 * pH
##  + 0.1267 * sulphates
##  + 0.1532 * alcohol
##  + 34.9695
##
## LM num: 9
## quality =
##  0.5123 * fixed.acidity
##  + 6.1308 * volatile.acidity
##  + 2.6439 * citric.acid
##  - 0.0455 * residual.sugar
##  + 0.0145 * chlorides
##  + 0.4099 * free.sulfur.dioxide
##  + 0 * total.sulfur.dioxide
##  + 0 * density
##  - 27.6843 * pH
##  + 0.1008 * sulphates
##  + 0.1372 * alcohol
##  + 28.2284
##
## LM num: 10
## quality =
```

```
##  0.2052 * fixed.acidity
##  + 0.0196 * volatile.acidity
##  + 1.2384 * citric.acid
##  - 0.1119 * residual.sugar
##  - 8.7167 * chlorides
##  + 0.4088 * free.sulfur.dioxide
##  + 0 * total.sulfur.dioxide
##  + 127.8654 * density
##  - 27.6843 * pH
##  + 0.1008 * sulphates
##  + 0.1372 * alcohol
##  - 93.9949
##
## LM num: 11
## quality =
##  0.2052 * fixed.acidity
##  + 0.0196 * volatile.acidity
##  + 1.2384 * citric.acid
##  - 0.1617 * residual.sugar
##  - 6.1612 * chlorides
##  + 0.4026 * free.sulfur.dioxide
##  + 0 * total.sulfur.dioxide
##  + 164.9383 * density
##  - 27.6843 * pH
##  + 0.1008 * sulphates
##  + 0.1372 * alcohol
##  - 130.1995
##
## LM num: 12
## quality =
##  0.2052 * fixed.acidity
##  + 0.0196 * volatile.acidity
##  + 1.2384 * citric.acid
##  - 0.1617 * residual.sugar
##  - 6.1612 * chlorides
##  + 0.4026 * free.sulfur.dioxide
##  + 0 * total.sulfur.dioxide
##  + 164.9383 * density
##  - 27.6843 * pH
##  + 0.1008 * sulphates
##  + 0.1372 * alcohol
##  - 130.2078
##
## LM num: 13
## quality =
##  0.2052 * fixed.acidity
##  + 0.0196 * volatile.acidity
##  + 1.2384 * citric.acid
##  - 0.1487 * residual.sugar
##  - 6.1612 * chlorides
##  + 0.4026 * free.sulfur.dioxide
##  + 0 * total.sulfur.dioxide
##  + 164.9383 * density
##  - 27.6843 * pH
```

```
##  + 0.1008 * sulphates
##  + 0.1372 * alcohol
##  - 130.3516
##
## LM num: 14
## quality =
##  0.2052 * fixed.acidity
##  + 0.0196 * volatile.acidity
##  + 1.2384 * citric.acid
##  - 0.1374 * residual.sugar
##  - 6.1612 * chlorides
##  + 0.4015 * free.sulfur.dioxide
##  + 0 * total.sulfur.dioxide
##  + 172.5486 * density
##  - 27.6843 * pH
##  + 0.1008 * sulphates
##  + 0.1372 * alcohol
##  - 138.0831
##
## LM num: 15
## quality =
##  0.2052 * fixed.acidity
##  + 0.0196 * volatile.acidity
##  + 1.2384 * citric.acid
##  - 0.135 * residual.sugar
##  - 6.1612 * chlorides
##  + 0.4025 * free.sulfur.dioxide
##  + 0 * total.sulfur.dioxide
##  + 181.3076 * density
##  - 27.6843 * pH
##  + 0.1008 * sulphates
##  + 0.1372 * alcohol
##  - 146.7274
##
## LM num: 16
## quality =
##  0.4254 * fixed.acidity
##  + 1.0239 * volatile.acidity
##  - 0.3325 * citric.acid
##  - 0.0308 * residual.sugar
##  + 0.0145 * chlorides
##  + 0.416 * free.sulfur.dioxide
##  + 0 * total.sulfur.dioxide
##  - 58.9145 * density
##  - 27.6843 * pH
##  + 1.2124 * sulphates
##  + 0.1372 * alcohol
##  + 88.0625
##
## LM num: 17
## quality =
##  0.3275 * fixed.acidity
##  + 1.0239 * volatile.acidity
##  - 0.3325 * citric.acid
```

```
##   - 0.0308 * residual.sugar
##   + 0.0145 * chlorides
##   + 0.416 * free.sulfur.dioxide
##   + 0 * total.sulfur.dioxide
##   - 58.9145 * density
##   - 27.6843 * pH
##   + 1.3728 * sulphates
##   + 0.1372 * alcohol
##   + 88.7343
##
## LM num: 18
## quality =
##   0.1428 * fixed.acidity
##   + 0.767 * volatile.acidity
##   - 0.3325 * citric.acid
##   - 0.0204 * residual.sugar
##   + 0.0145 * chlorides
##   + 0.416 * free.sulfur.dioxide
##   + 0 * total.sulfur.dioxide
##   - 66.5438 * density
##   - 27.6843 * pH
##   + 0.456 * sulphates
##   + 0.1372 * alcohol
##   + 97.9113
##
## LM num: 19
## quality =
##   0.1428 * fixed.acidity
##   + 0.767 * volatile.acidity
##   - 0.3325 * citric.acid
##   + 0.0247 * residual.sugar
##   + 0.0145 * chlorides
##   + 0.416 * free.sulfur.dioxide
##   + 0 * total.sulfur.dioxide
##   - 83.8395 * density
##   - 27.6843 * pH
##   + 0.456 * sulphates
##   + 0.1372 * alcohol
##   + 114.4554
##
## LM num: 20
## quality =
##   0.0305 * fixed.acidity
##   + 0.0196 * volatile.acidity
##   - 0.3325 * citric.acid
##   - 0.0455 * residual.sugar
##   + 0.0145 * chlorides
##   + 0.416 * free.sulfur.dioxide
##   + 0 * total.sulfur.dioxide
##   + 0 * density
##   - 27.6843 * pH
##   + 0.2148 * sulphates
##   + 0.1372 * alcohol
##   + 32.9088
```

```
##
## LM num: 21
## quality =
##  0.0305 * fixed.acidity
##  + 0.8924 * volatile.acidity
##  + 1.8355 * citric.acid
##  - 0.0455 * residual.sugar
##  + 0.0145 * chlorides
##  + 0.416 * free.sulfur.dioxide
##  + 0 * total.sulfur.dioxide
##  + 0 * density
##  - 26.8063 * pH
##  + 0.2673 * sulphates
##  + 0.4283 * alcohol
##  + 26.2329
##
## LM num: 22
## quality =
##  0.0801 * fixed.acidity
##  + 0.0196 * volatile.acidity
##  - 1.1333 * citric.acid
##  - 0.0455 * residual.sugar
##  + 0.0145 * chlorides
##  + 0.416 * free.sulfur.dioxide
##  + 0 * total.sulfur.dioxide
##  + 0 * density
##  - 26.6391 * pH
##  + 0.2673 * sulphates
##  + 0.1372 * alcohol
##  + 29.8621
##
## LM num: 23
## quality =
##  0.0801 * fixed.acidity
##  + 0.0196 * volatile.acidity
##  - 1.1333 * citric.acid
##  - 0.0455 * residual.sugar
##  + 0.0145 * chlorides
##  + 0.416 * free.sulfur.dioxide
##  + 0 * total.sulfur.dioxide
##  + 0 * density
##  - 26.6391 * pH
##  + 0.2673 * sulphates
##  + 0.1372 * alcohol
##  + 29.875
##
## LM num: 24
## quality =
##  0.0305 * fixed.acidity
##  + 0.0196 * volatile.acidity
##  - 1.601 * citric.acid
##  - 0.0455 * residual.sugar
##  + 0.0145 * chlorides
##  + 0.416 * free.sulfur.dioxide
```

```
##  + 0 * total.sulfur.dioxide
##  + 0 * density
##  - 27.6843 * pH
##  + 0.2673 * sulphates
##  + 0.1372 * alcohol
##  + 33.6464
##
## LM num: 25
## quality =
##  0.0305 * fixed.acidity
##  + 0.0196 * volatile.acidity
##  - 3.3422 * citric.acid
##  - 0.0455 * residual.sugar
##  + 0.0145 * chlorides
##  + 0.416 * free.sulfur.dioxide
##  + 0 * total.sulfur.dioxide
##  + 0 * density
##  - 27.6843 * pH
##  + 0.2673 * sulphates
##  + 0.1372 * alcohol
##  + 34.8327
##
## LM num: 26
## quality =
##  0.0305 * fixed.acidity
##  + 0.0196 * volatile.acidity
##  - 3.0994 * citric.acid
##  - 0.0455 * residual.sugar
##  + 0.0145 * chlorides
##  + 0.416 * free.sulfur.dioxide
##  + 0 * total.sulfur.dioxide
##  + 0 * density
##  - 27.6843 * pH
##  + 0.2673 * sulphates
##  + 0.1372 * alcohol
##  + 34.6333
##
## LM num: 27
## quality =
##  0.0703 * fixed.acidity
##  + 0.0156 * volatile.acidity
##  - 0.6574 * citric.acid
##  + 0.0243 * residual.sugar
##  - 67.0175 * chlorides
##  + 0.0315 * free.sulfur.dioxide
##  - 0.0012 * total.sulfur.dioxide
##  - 119.9591 * density
##  - 30.6011 * pH
##  + 0.919 * sulphates
##  + 0.1648 * alcohol
##  + 156.9039
##
## LM num: 28
## quality =
```

```
##  0.0703 * fixed.acidity
##  + 0.0156 * volatile.acidity
##  - 0.6574 * citric.acid
##  + 0.0243 * residual.sugar
##  - 58.9969 * chlorides
##  + 0.0315 * free.sulfur.dioxide
##  - 0.0012 * total.sulfur.dioxide
##  - 150.9471 * density
##  - 30.6011 * pH
##  + 0.919 * sulphates
##  + 0.1648 * alcohol
##  + 187.2329
##
## LM num: 29
## quality =
##  0.0703 * fixed.acidity
##  + 0.4472 * volatile.acidity
##  - 0.6574 * citric.acid
##  + 0.0243 * residual.sugar
##  - 58.9969 * chlorides
##  + 0.0315 * free.sulfur.dioxide
##  - 0.0012 * total.sulfur.dioxide
##  - 153.3651 * density
##  - 30.6011 * pH
##  + 0.919 * sulphates
##  + 0.1648 * alcohol
##  + 189.4848
##
## LM num: 30
## quality =
##  0.0703 * fixed.acidity
##  + 0.4472 * volatile.acidity
##  - 0.6574 * citric.acid
##  + 0.0243 * residual.sugar
##  - 58.9969 * chlorides
##  + 0.0315 * free.sulfur.dioxide
##  - 0.0012 * total.sulfur.dioxide
##  - 153.3651 * density
##  - 30.6011 * pH
##  + 0.919 * sulphates
##  + 0.1648 * alcohol
##  + 189.4879
##
## LM num: 31
## quality =
##  -0.1508 * fixed.acidity
##  + 0.0156 * volatile.acidity
##  - 0.6574 * citric.acid
##  + 0.0243 * residual.sugar
##  - 9.3904 * chlorides
##  + 0.0214 * free.sulfur.dioxide
##  - 0.0005 * total.sulfur.dioxide
##  - 46.7687 * density
##  - 31.5322 * pH
```

```
##  + 2.6091 * sulphates
##  + 0.1648 * alcohol
##  + 85.973
##
## LM num: 32
## quality =
##  0.0156 * volatile.acidity
##  - 0.6574 * citric.acid
##  + 0.0344 * residual.sugar
##  - 1.7245 * chlorides
##  + 0.0356 * free.sulfur.dioxide
##  + 0 * total.sulfur.dioxide
##  - 93.0156 * density
##  - 30.2048 * pH
##  + 0.5967 * sulphates
##  + 0.1648 * alcohol
##  + 126.2803
##
## LM num: 33
## quality =
##  0.0156 * volatile.acidity
##  - 0.6574 * citric.acid
##  + 0.0344 * residual.sugar
##  - 1.7245 * chlorides
##  + 0.0356 * free.sulfur.dioxide
##  + 0 * total.sulfur.dioxide
##  - 93.0156 * density
##  - 30.2048 * pH
##  + 1.711 * sulphates
##  + 0.1648 * alcohol
##  + 125.8596
##
## LM num: 34
## quality =
##  -0.2318 * fixed.acidity
##  + 0.0156 * volatile.acidity
##  - 0.6574 * citric.acid
##  + 0.0409 * residual.sugar
##  - 1.7245 * chlorides
##  + 0.0518 * free.sulfur.dioxide
##  + 0 * total.sulfur.dioxide
##  - 112.9779 * density
##  - 30.3269 * pH
##  + 0.3189 * sulphates
##  + 0.1648 * alcohol
##  + 147.7215
##
## LM num: 35
## quality =
##  -0.0373 * fixed.acidity
##  + 0.0097 * volatile.acidity
##  - 1.1116 * citric.acid
##  - 0.0206 * residual.sugar
##  + 0.0089 * chlorides
```

```
##  + 0.1432 * free.sulfur.dioxide
##  + 0.0012 * total.sulfur.dioxide
##  + 5.3167 * density
##  - 20.8994 * pH
##  - 0.0294 * sulphates
##  + 0.2675 * alcohol
##  + 20.4697
##
## LM num: 36
## quality =
##  -0.0373 * fixed.acidity
##  + 0.0097 * volatile.acidity
##  - 0.6856 * citric.acid
##  - 0.0206 * residual.sugar
##  + 0.0089 * chlorides
##  + 0.1432 * free.sulfur.dioxide
##  + 0.0012 * total.sulfur.dioxide
##  + 16.0734 * density
##  - 20.8994 * pH
##  - 0.0294 * sulphates
##  + 0.2675 * alcohol
##  + 9.6669
##
## LM num: 37
## quality =
##  -0.0373 * fixed.acidity
##  + 0.0097 * volatile.acidity
##  - 0.7093 * citric.acid
##  - 0.0206 * residual.sugar
##  + 0.0089 * chlorides
##  + 0.1432 * free.sulfur.dioxide
##  + 0.0012 * total.sulfur.dioxide
##  + 16.0734 * density
##  - 20.8994 * pH
##  - 0.0294 * sulphates
##  + 0.2675 * alcohol
##  + 9.6825
##
## LM num: 38
## quality =
##  -0.0373 * fixed.acidity
##  + 0.0097 * volatile.acidity
##  - 1.1116 * citric.acid
##  - 0.0206 * residual.sugar
##  + 0.0089 * chlorides
##  + 0.1432 * free.sulfur.dioxide
##  + 0.0012 * total.sulfur.dioxide
##  - 7.6551 * density
##  - 20.8068 * pH
##  - 0.0294 * sulphates
##  + 0.2675 * alcohol
##  + 33.198
##
## LM num: 39
```

```
## quality =
##  -0.0373 * fixed.acidity
##  + 0.0097 * volatile.acidity
##  - 1.1116 * citric.acid
##  - 0.0206 * residual.sugar
##  + 0.0089 * chlorides
##  + 0.1432 * free.sulfur.dioxide
##  + 0.0012 * total.sulfur.dioxide
##  - 7.6551 * density
##  - 20.8068 * pH
##  - 0.0294 * sulphates
##  + 0.2675 * alcohol
##  + 33.2209
##
## LM num: 40
## quality =
##  -0.0373 * fixed.acidity
##  - 1.338 * volatile.acidity
##  - 1.1116 * citric.acid
##  - 0.0274 * residual.sugar
##  + 0.0089 * chlorides
##  + 0.1405 * free.sulfur.dioxide
##  + 0.0008 * total.sulfur.dioxide
##  - 26.3738 * density
##  - 21.3441 * pH
##  - 0.0294 * sulphates
##  + 0.2675 * alcohol
##  + 54.1599
##
## LM num: 41
## quality =
##  -0.0373 * fixed.acidity
##  - 1.4177 * volatile.acidity
##  - 1.1116 * citric.acid
##  - 0.0274 * residual.sugar
##  + 0.0089 * chlorides
##  + 0.1419 * free.sulfur.dioxide
##  + 0.0008 * total.sulfur.dioxide
##  - 26.3738 * density
##  - 21.4879 * pH
##  - 0.0294 * sulphates
##  + 0.2675 * alcohol
##  + 54.5573
##
## LM num: 42
## quality =
##  -0.0373 * fixed.acidity
##  - 1.4177 * volatile.acidity
##  - 1.1116 * citric.acid
##  - 0.0307 * residual.sugar
##  + 0.0089 * chlorides
##  + 0.1419 * free.sulfur.dioxide
##  + 0.0008 * total.sulfur.dioxide
##  - 26.3738 * density
```

```
##  - 21.4271 * pH
##  - 0.0294 * sulphates
##  + 0.2675 * alcohol
##  + 54.3559
##
## LM num: 43
## quality =
##  -0.0373 * fixed.acidity
##  - 1.4177 * volatile.acidity
##  - 1.1116 * citric.acid
##  - 0.0302 * residual.sugar
##  + 0.0089 * chlorides
##  + 0.1419 * free.sulfur.dioxide
##  + 0.0008 * total.sulfur.dioxide
##  - 26.3738 * density
##  - 21.4271 * pH
##  - 0.0294 * sulphates
##  + 0.2675 * alcohol
##  + 54.3387
##
## LM num: 44
## quality =
##  -0.0373 * fixed.acidity
##  - 1.4177 * volatile.acidity
##  - 1.1116 * citric.acid
##  - 0.0274 * residual.sugar
##  + 0.0089 * chlorides
##  + 0.1419 * free.sulfur.dioxide
##  + 0.0008 * total.sulfur.dioxide
##  - 26.3738 * density
##  - 21.4271 * pH
##  - 0.0294 * sulphates
##  + 0.2675 * alcohol
##  + 54.3353
##
## LM num: 45
## quality =
##  -0.0373 * fixed.acidity
##  - 1.7035 * volatile.acidity
##  - 0.2688 * citric.acid
##  - 0.0274 * residual.sugar
##  + 0.0089 * chlorides
##  + 0.1419 * free.sulfur.dioxide
##  + 0.0008 * total.sulfur.dioxide
##  - 26.3738 * density
##  - 21.2186 * pH
##  - 0.0294 * sulphates
##  + 0.2675 * alcohol
##  + 53.3604
##
## LM num: 46
## quality =
##  -0.0373 * fixed.acidity
##  - 1.7035 * volatile.acidity
```

```
##   - 0.1002 * citric.acid
##   - 0.0274 * residual.sugar
##   + 0.0089 * chlorides
##   + 0.1419 * free.sulfur.dioxide
##   + 0.0008 * total.sulfur.dioxide
##   - 26.3738 * density
##   - 21.2186 * pH
##   - 0.0294 * sulphates
##   + 0.2675 * alcohol
##   + 53.3441
##
## LM num: 47
## quality =
##   -0.1902 * fixed.acidity
##   + 0.0097 * volatile.acidity
##   - 0.6172 * citric.acid
##   - 0.0453 * residual.sugar
##   + 0.0089 * chlorides
##   + 0.1451 * free.sulfur.dioxide
##   + 0 * total.sulfur.dioxide
##   + 0.0008 * density
##   - 21.0931 * pH
##   - 0.0294 * sulphates
##   + 0.2675 * alcohol
##   + 27.6418
##
## LM num: 48
## quality =
##   -0.0964 * fixed.acidity
##   + 0.0097 * volatile.acidity
##   - 0.6172 * citric.acid
##   - 0.0453 * residual.sugar
##   + 0.0089 * chlorides
##   + 0.1451 * free.sulfur.dioxide
##   + 0 * total.sulfur.dioxide
##   + 0.0008 * density
##   - 21.0931 * pH
##   - 0.0294 * sulphates
##   + 0.2675 * alcohol
##   + 26.779
##
## LM num: 49
## quality =
##   -6.8807 * volatile.acidity
##   - 2.2888 * citric.acid
##   + 0.0028 * residual.sugar
##   + 0.0116 * chlorides
##   + 0.5173 * free.sulfur.dioxide
##   - 0.0007 * total.sulfur.dioxide
##   - 151.6726 * density
##   - 20.0671 * pH
##   - 0.1039 * sulphates
##   + 0.4164 * alcohol
##   + 176.1433
```

```
##
## LM num: 50
## quality =
##  -0.1254 * fixed.acidity
##  - 5.7221 * volatile.acidity
##  - 3.728 * citric.acid
##  - 0.0355 * residual.sugar
##  + 0.0049 * chlorides
##  + 0.3076 * free.sulfur.dioxide
##  + 0.0045 * total.sulfur.dioxide
##  + 0.0007 * density
##  - 5.6339 * pH
##  - 0.2195 * sulphates
##  + 0.4467 * alcohol
##  + 14.807
##
## LM num: 51
## quality =
##  -0.2414 * fixed.acidity
##  - 0.0174 * volatile.acidity
##  + 1.47 * citric.acid
##  - 0.0355 * residual.sugar
##  + 0.0034 * chlorides
##  + 0.3142 * free.sulfur.dioxide
##  - 0.0003 * total.sulfur.dioxide
##  + 0.0007 * density
##  - 1.4331 * pH
##  + 1.2034 * sulphates
##  + 0.4884 * alcohol
##  + 7.8975
##
## LM num: 52
## quality =
##  0.0097 * volatile.acidity
##  - 0.8681 * citric.acid
##  - 0.0868 * residual.sugar
##  + 2.4897 * chlorides
##  + 0.2947 * free.sulfur.dioxide
##  + 0 * total.sulfur.dioxide
##  + 0.0004 * density
##  - 25.9035 * pH
##  + 0.0418 * sulphates
##  + 0.5273 * alcohol
##  + 27.7486
##
## LM num: 53
## quality =
##  0.0378 * volatile.acidity
##  - 0.2385 * citric.acid
##  + 0.3919 * residual.sugar
##  + 0.0374 * chlorides
##  + 0.0364 * free.sulfur.dioxide
##  + 0.0006 * total.sulfur.dioxide
##  + 0.0015 * density
```

```
##   - 113.0943 * pH
##   + 0.4485 * sulphates
##   + 0.177 * alcohol
##   + 115.5411
##
## LM num: 54
## quality =
##   0.0378 * volatile.acidity
##   + 0.5557 * citric.acid
##   + 0.1863 * residual.sugar
##   + 0.0277 * chlorides
##   + 0.0177 * free.sulfur.dioxide
##   + 0.0006 * total.sulfur.dioxide
##   + 0.0008 * density
##   - 79.6938 * pH
##   + 0.3522 * sulphates
##   + 0.5283 * alcohol
##   + 77.6072
##
## LM num: 55
## quality =
##   0.0558 * volatile.acidity
##   - 0.5883 * citric.acid
##   - 0.0908 * residual.sugar
##   + 0.0194 * chlorides
##   - 1.141 * free.sulfur.dioxide
##   - 0.0002 * total.sulfur.dioxide
##   - 0.0004 * density
##   - 52.8732 * pH
##   + 1.4656 * sulphates
##   + 0.3038 * alcohol
##   + 56.6676
##
## LM num: 56
## quality =
##   0.0558 * volatile.acidity
##   - 0.5883 * citric.acid
##   - 0.0908 * residual.sugar
##   + 0.0194 * chlorides
##   - 1.1427 * free.sulfur.dioxide
##   - 0.0062 * total.sulfur.dioxide
##   - 0.0004 * density
##   - 52.8732 * pH
##   + 0.2938 * sulphates
##   + 0.3038 * alcohol
##   + 58.0593
##
## LM num: 57
## quality =
##   0.0558 * volatile.acidity
##   - 0.5883 * citric.acid
##   - 0.0908 * residual.sugar
##   - 22.5962 * chlorides
##   - 1.1427 * free.sulfur.dioxide
```

```
##  + 0.001 * total.sulfur.dioxide
##  - 0.0004 * density
##  - 52.8732 * pH
##  + 0.2938 * sulphates
##  + 0.3038 * alcohol
##  + 57.8996
##
## LM num: 58
## quality =
##  0.0558 * volatile.acidity
##  - 0.5883 * citric.acid
##  - 0.0908 * residual.sugar
##  - 21.7687 * chlorides
##  - 1.1427 * free.sulfur.dioxide
##  + 0.001 * total.sulfur.dioxide
##  - 0.0004 * density
##  - 52.8732 * pH
##  + 0.2938 * sulphates
##  + 0.3038 * alcohol
##  + 57.8455
##
## LM num: 59
## quality =
##  0.0558 * volatile.acidity
##  - 0.5883 * citric.acid
##  - 0.0908 * residual.sugar
##  - 13.4527 * chlorides
##  - 1.1427 * free.sulfur.dioxide
##  + 0.0009 * total.sulfur.dioxide
##  - 0.0004 * density
##  - 52.8732 * pH
##  + 0.2938 * sulphates
##  + 0.3038 * alcohol
##  + 57.549
##
## LM num: 60
## quality =
##  0.1669 * fixed.acidity
##  + 0.0798 * volatile.acidity
##  - 1.2879 * citric.acid
##  - 0.2725 * residual.sugar
##  + 0.0194 * chlorides
##  - 2.2249 * free.sulfur.dioxide
##  - 0.0063 * total.sulfur.dioxide
##  + 44.5851 * density
##  - 52.8732 * pH
##  + 0.2938 * sulphates
##  + 0.5177 * alcohol
##  + 12.5094
##
## LM num: 61
## quality =
##  0.0295 * fixed.acidity
##  + 0.0798 * volatile.acidity
```

```
##  - 1.2879 * citric.acid
##  - 0.2725 * residual.sugar
##  + 0.0194 * chlorides
##  - 2.2249 * free.sulfur.dioxide
##  - 0.0054 * total.sulfur.dioxide
##  + 61.713 * density
##  - 52.8732 * pH
##  + 0.2938 * sulphates
##  + 0.5177 * alcohol
##  - 3.8043
##
## LM num: 62
## quality =
##  0.0465 * fixed.acidity
##  + 0.0798 * volatile.acidity
##  - 1.2879 * citric.acid
##  - 0.2725 * residual.sugar
##  + 0.0194 * chlorides
##  - 2.2231 * free.sulfur.dioxide
##  - 0.0054 * total.sulfur.dioxide
##  + 53.3503 * density
##  - 52.8732 * pH
##  + 0.2938 * sulphates
##  + 0.5177 * alcohol
##  + 4.3304
##
## LM num: 63
## quality =
##  0.0465 * fixed.acidity
##  + 0.0798 * volatile.acidity
##  - 1.2879 * citric.acid
##  - 0.2725 * residual.sugar
##  + 0.0194 * chlorides
##  - 2.2219 * free.sulfur.dioxide
##  - 0.0054 * total.sulfur.dioxide
##  + 53.3503 * density
##  - 52.8732 * pH
##  + 0.2938 * sulphates
##  + 0.5177 * alcohol
##  + 4.2756
##
## LM num: 64
## quality =
##  0.0451 * fixed.acidity
##  + 0.0798 * volatile.acidity
##  - 1.2879 * citric.acid
##  - 0.2725 * residual.sugar
##  + 0.0194 * chlorides
##  - 2.2221 * free.sulfur.dioxide
##  - 0.0054 * total.sulfur.dioxide
##  + 53.3503 * density
##  - 52.8732 * pH
##  + 0.2938 * sulphates
##  + 0.5177 * alcohol
```

```
##  + 4.2979
##
## LM num: 65
## quality =
##  0.2279 * fixed.acidity
##  + 0.0798 * volatile.acidity
##  - 1.2879 * citric.acid
##  - 0.2725 * residual.sugar
##  + 0.0194 * chlorides
##  - 2.2249 * free.sulfur.dioxide
##  - 0.0033 * total.sulfur.dioxide
##  - 23.573 * density
##  - 52.8732 * pH
##  + 0.2938 * sulphates
##  + 0.5177 * alcohol
##  + 79.1277
##
## LM num: 66
## quality =
##  0.1818 * fixed.acidity
##  + 0.0798 * volatile.acidity
##  - 1.2879 * citric.acid
##  - 0.2725 * residual.sugar
##  + 0.0194 * chlorides
##  - 2.2249 * free.sulfur.dioxide
##  - 0.0033 * total.sulfur.dioxide
##  - 25.7159 * density
##  - 52.8732 * pH
##  + 0.2938 * sulphates
##  + 0.5177 * alcohol
##  + 81.5402
##
## LM num: 67
## quality =
##  0.2367 * fixed.acidity
##  + 0.0644 * volatile.acidity
##  - 0.2385 * citric.acid
##  + 0.079 * residual.sugar
##  + 0.0261 * chlorides
##  - 1.2827 * free.sulfur.dioxide
##  + 0.0003 * total.sulfur.dioxide
##  - 345.5155 * density
##  - 72.342 * pH
##  + 0.4309 * sulphates
##  + 0.271 * alcohol
##  + 417.898
##
## LM num: 68
## quality =
##  -0.1693 * fixed.acidity
##  + 0.0005 * volatile.acidity
##  - 0.0778 * citric.acid
##  - 4.7237 * chlorides
##  - 0.0053 * free.sulfur.dioxide
```

```
##  + 0.0004 * total.sulfur.dioxide
##  + 0 * density
##  - 13.0236 * pH
##  + 1.1874 * sulphates
##  + 0.0177 * alcohol
##  + 18.283
##
## LM num: 69
## quality =
##  0.1278 * fixed.acidity
##  + 0.0005 * volatile.acidity
##  - 0.0778 * citric.acid
##  + 0.0054 * chlorides
##  - 0.0269 * free.sulfur.dioxide
##  + 0.0002 * total.sulfur.dioxide
##  + 0 * density
##  - 9.7325 * pH
##  - 1.0363 * sulphates
##  + 0.0177 * alcohol
##  + 14.2795
##
## LM num: 70
## quality =
##  0.011 * volatile.acidity
##  - 0.0778 * citric.acid
##  + 0.0605 * residual.sugar
##  + 0.0157 * chlorides
##  - 0.0301 * free.sulfur.dioxide
##  + 0.0002 * total.sulfur.dioxide
##  - 102.0986 * density
##  - 32.8676 * pH
##  + 0.2018 * sulphates
##  + 0.0177 * alcohol
##  + 136.6965
##
## LM num: 71
## quality =
##  0.1926 * fixed.acidity
##  + 0.0238 * volatile.acidity
##  - 0.0778 * citric.acid
##  + 0.0215 * chlorides
##  - 0.0041 * free.sulfur.dioxide
##  - 0.0048 * total.sulfur.dioxide
##  + 0 * density
##  - 48.3519 * pH
##  + 0.2599 * sulphates
##  + 0.0177 * alcohol
##  + 51.0641
##
## LM num: 72
## quality =
##  0.0209 * volatile.acidity
##  + 1.0973 * citric.acid
##  + 0.0587 * residual.sugar
```

```
##  + 0.022 * chlorides
##  - 0.0224 * free.sulfur.dioxide
##  - 0.0002 * total.sulfur.dioxide
##  - 142.8597 * density
##  - 50.4643 * pH
##  + 0.25 * sulphates
##  + 0.0177 * alcohol
##  + 195.9329
##
## LM num: 73
## quality =
##  0.027 * volatile.acidity
##  - 0.8363 * citric.acid
##  - 1.0441 * chlorides
##  - 0.0224 * free.sulfur.dioxide
##  - 0.0005 * total.sulfur.dioxide
##  + 0.0003 * density
##  - 64.4052 * pH
##  + 0.3045 * sulphates
##  + 0.0177 * alcohol
##  + 67.6152
##
## LM num: 74
## quality =
##  0.027 * volatile.acidity
##  - 0.2941 * citric.acid
##  - 0.646 * chlorides
##  - 0.0224 * free.sulfur.dioxide
##  - 0.0005 * total.sulfur.dioxide
##  + 0.0003 * density
##  - 64.4052 * pH
##  + 0.3045 * sulphates
##  + 0.0177 * alcohol
##  + 67.294
##
## LM num: 75
## quality =
##  -1.4942 * volatile.acidity
##  - 0.0778 * citric.acid
##  + 0.0063 * residual.sugar
##  + 0.0278 * chlorides
##  - 0.0224 * free.sulfur.dioxide
##  - 0.0005 * total.sulfur.dioxide
##  - 16.3185 * density
##  - 63.1123 * pH
##  + 0.5305 * sulphates
##  + 0.0177 * alcohol
##  + 79.9383
##
## LM num: 76
## quality =
##  0.1213 * volatile.acidity
##  - 0.0778 * citric.acid
##  + 0.0063 * residual.sugar
```

```
##  + 0.0278 * chlorides
##  - 0.0224 * free.sulfur.dioxide
##  - 0.0005 * total.sulfur.dioxide
##  - 16.3185 * density
##  - 63.3098 * pH
##  + 0.8489 * sulphates
##  + 0.0177 * alcohol
##  + 79.8492
##
## LM num: 77
## quality =
##  0.5923 * volatile.acidity
##  - 0.0778 * citric.acid
##  + 0.0063 * residual.sugar
##  + 0.0278 * chlorides
##  - 0.0224 * free.sulfur.dioxide
##  - 0.0005 * total.sulfur.dioxide
##  - 16.3185 * density
##  - 63.627 * pH
##  + 0.7854 * sulphates
##  + 0.0177 * alcohol
##  + 80.7193
##
## LM num: 78
## quality =
##  0.8827 * volatile.acidity
##  - 0.0778 * citric.acid
##  + 0.0063 * residual.sugar
##  + 0.0278 * chlorides
##  - 0.0224 * free.sulfur.dioxide
##  - 0.0005 * total.sulfur.dioxide
##  - 16.3185 * density
##  - 63.6437 * pH
##  + 0.7854 * sulphates
##  + 0.0177 * alcohol
##  + 80.6638
##
## LM num: 79
## quality =
##  0.8827 * volatile.acidity
##  - 0.0778 * citric.acid
##  + 0.0063 * residual.sugar
##  + 0.0278 * chlorides
##  - 0.0224 * free.sulfur.dioxide
##  - 0.0005 * total.sulfur.dioxide
##  - 16.3185 * density
##  - 63.6437 * pH
##  + 0.7854 * sulphates
##  + 0.0177 * alcohol
##  + 80.6646
##
## LM num: 80
## quality =
##  -1.8044 * volatile.acidity
```

```
##   - 0.0778 * citric.acid
##   + 0.0063 * residual.sugar
##   + 0.0278 * chlorides
##   - 0.0224 * free.sulfur.dioxide
##   - 0.0005 * total.sulfur.dioxide
##   - 16.3185 * density
##   - 63.6906 * pH
##   + 0.3045 * sulphates
##   + 0.0177 * alcohol
##   + 81.9045
##
## LM num: 81
## quality =
##   -1.0917 * volatile.acidity
##   - 0.0778 * citric.acid
##   + 0.0094 * residual.sugar
##   + 0.0278 * chlorides
##   - 0.0224 * free.sulfur.dioxide
##   - 0.0005 * total.sulfur.dioxide
##   - 37.3197 * density
##   - 64.0122 * pH
##   + 0.3045 * sulphates
##   + 0.0177 * alcohol
##   + 103.6611
##
## LM num: 82
## quality =
##   -1.0917 * volatile.acidity
##   - 0.0778 * citric.acid
##   + 0.0094 * residual.sugar
##   + 0.0278 * chlorides
##   - 0.0224 * free.sulfur.dioxide
##   - 0.0005 * total.sulfur.dioxide
##   - 37.3197 * density
##   - 64.0122 * pH
##   + 0.3045 * sulphates
##   + 0.0177 * alcohol
##   + 103.6431
##
## LM num: 83
## quality =
##   -1.0917 * volatile.acidity
##   - 0.0778 * citric.acid
##   + 0.0094 * residual.sugar
##   + 0.0278 * chlorides
##   - 0.0224 * free.sulfur.dioxide
##   - 0.0005 * total.sulfur.dioxide
##   - 24.4779 * density
##   - 64.0122 * pH
##   + 0.3045 * sulphates
##   + 0.0177 * alcohol
##   + 90.9105
##
## LM num: 84
```

```
## quality =
##  -0.0442 * fixed.acidity
##  - 0.0021 * volatile.acidity
##  - 0.2639 * citric.acid
##  + 0.0064 * residual.sugar
##  + 0.0127 * chlorides
##  - 0.3027 * free.sulfur.dioxide
##  + 0.004 * total.sulfur.dioxide
##  + 10.4465 * density
##  - 19.2592 * pH
##  + 0.051 * sulphates
##  + 0.0959 * alcohol
##  + 10.4627
##
## LM num: 85
## quality =
##  -0.0697 * fixed.acidity
##  - 0.0021 * volatile.acidity
##  - 0.2639 * citric.acid
##  + 0.0127 * residual.sugar
##  + 0.0127 * chlorides
##  - 0.3027 * free.sulfur.dioxide
##  + 0.002 * total.sulfur.dioxide
##  + 10.4465 * density
##  - 20.2244 * pH
##  + 0.051 * sulphates
##  + 0.1262 * alcohol
##  + 13.934
##
## LM num: 86
## quality =
##  -0.0177 * fixed.acidity
##  - 0.0021 * volatile.acidity
##  - 0.2639 * citric.acid
##  + 0.0127 * chlorides
##  - 0.2991 * free.sulfur.dioxide
##  + 0.0002 * total.sulfur.dioxide
##  + 9.8391 * density
##  - 20.2244 * pH
##  + 0.051 * sulphates
##  + 0.2593 * alcohol
##  + 12.7934
##
## LM num: 87
## quality =
##  1.1384 * volatile.acidity
##  - 0.4332 * citric.acid
##  + 0.1153 * residual.sugar
##  + 0.0247 * chlorides
##  - 0.6445 * free.sulfur.dioxide
##  + 0.0002 * total.sulfur.dioxide
##  - 218.6066 * density
##  - 37.5179 * pH
##  - 0.896 * sulphates
```

```
##  + 0.0177 * alcohol
##  + 258.5079
##
## LM num: 88
## quality =
##  -0.0318 * fixed.acidity
##  - 0.2828 * volatile.acidity
##  + 1.7345 * citric.acid
##  + 0.1261 * residual.sugar
##  + 0.0055 * chlorides
##  - 0.1249 * free.sulfur.dioxide
##  + 0.0005 * total.sulfur.dioxide
##  - 169.7648 * density
##  - 8.8633 * pH
##  + 0.1416 * sulphates
##  + 0.0516 * alcohol
##  + 180.6069
##
## LM num: 89
## quality =
##  -0.2023 * fixed.acidity
##  - 2.3216 * volatile.acidity
##  - 1.1434 * citric.acid
##  + 0.085 * residual.sugar
##  + 0.0055 * chlorides
##  - 0.242 * free.sulfur.dioxide
##  + 0.0005 * total.sulfur.dioxide
##  - 168.2147 * density
##  - 8.8633 * pH
##  + 0.0892 * sulphates
##  + 0.0516 * alcohol
##  + 183.5076
##
## LM num: 90
## quality =
##  -0.9811 * volatile.acidity
##  - 0.4977 * citric.acid
##  + 0.2969 * residual.sugar
##  + 0.1228 * chlorides
##  - 0.4223 * free.sulfur.dioxide
##  - 0.0025 * total.sulfur.dioxide
##  - 91.1749 * pH
##  + 0.2995 * sulphates
##  + 0.1593 * alcohol
##  + 95.8184
##
## LM num: 91
## quality =
##  0.281 * fixed.acidity
##  + 0.0497 * volatile.acidity
##  - 0.5876 * citric.acid
##  + 0.5856 * residual.sugar
##  + 0.1536 * chlorides
##  - 0.4365 * free.sulfur.dioxide
```

```
##  - 0.0031 * total.sulfur.dioxide
##  - 101.1551 * pH
##  + 0.2995 * sulphates
##  + 0.1593 * alcohol
##  + 103.6026
##
## LM num: 92
## quality =
##  0.0481 * fixed.acidity
##  + 0.1018 * volatile.acidity
##  - 3.1227 * citric.acid
##  + 0.019 * residual.sugar
##  + 0.0504 * chlorides
##  - 0.4223 * free.sulfur.dioxide
##  + 0.005 * total.sulfur.dioxide
##  - 134.7439 * density
##  - 113.0235 * pH
##  + 0.5211 * sulphates
##  + 0.1593 * alcohol
##  + 249.4849
##
## LM num: 93
## quality =
##  0.0721 * fixed.acidity
##  + 0.1018 * volatile.acidity
##  + 2.133 * citric.acid
##  + 0.0286 * residual.sugar
##  + 0.0504 * chlorides
##  - 0.4223 * free.sulfur.dioxide
##  - 0.0005 * total.sulfur.dioxide
##  - 75.3967 * density
##  - 112.9138 * pH
##  + 0.5211 * sulphates
##  + 0.1593 * alcohol
##  + 189.1576
##
## LM num: 94
## quality =
##  -1.5419 * volatile.acidity
##  - 0.3565 * citric.acid
##  + 0.0571 * residual.sugar
##  - 14.5588 * chlorides
##  - 0.4223 * free.sulfur.dioxide
##  - 0.0026 * total.sulfur.dioxide
##  - 114.9384 * density
##  - 131.5293 * pH
##  + 1.9599 * sulphates
##  + 0.1593 * alcohol
##  + 248.6708
##
## LM num: 95
## quality =
##  0.0484 * volatile.acidity
##  - 0.2028 * citric.acid
```

```
##  - 10.4768 * chlorides
##  - 0.4105 * free.sulfur.dioxide
##  + 0.0001 * total.sulfur.dioxide
##  + 71.8209 * density
##  - 59.8368 * pH
##  + 0.2884 * sulphates
##  + 0.2842 * alcohol
##  - 6.4802
##
## LM num: 96
## quality =
##  0.0004 * volatile.acidity
##  - 0.1102 * citric.acid
##  + 0.0077 * residual.sugar
##  + 0.0124 * chlorides
##  - 0.6704 * free.sulfur.dioxide
##  - 0.0001 * total.sulfur.dioxide
##  - 15.8573 * density
##  - 20.9433 * pH
##  + 0.1255 * sulphates
##  + 0.6133 * alcohol
##  + 36.4891
##
## LM num: 97
## quality =
##  -0.2327 * fixed.acidity
##  + 0.0004 * volatile.acidity
##  - 0.1102 * citric.acid
##  + 0.0157 * residual.sugar
##  - 10.1688 * chlorides
##  - 0.6639 * free.sulfur.dioxide
##  - 0.0001 * total.sulfur.dioxide
##  - 292.089 * density
##  - 19.6906 * pH
##  + 0.1255 * sulphates
##  + 0.1425 * alcohol
##  + 315.2155
##
## LM num: 98
## quality =
##  0.0051 * volatile.acidity
##  + 0.005 * citric.acid
##  + 0.2304 * residual.sugar
##  + 0.0177 * chlorides
##  - 3.5522 * free.sulfur.dioxide
##  + 0.0066 * total.sulfur.dioxide
##  + 69.2071 * density
##  - 21.4691 * pH
##  + 3.2589 * sulphates
##  - 0.0759 * alcohol
##  - 44.6207
##
## LM num: 99
## quality =
```

```
##   0.0051 * volatile.acidity
##   - 1.0607 * citric.acid
##   + 0.2921 * residual.sugar
##   - 4.5739 * chlorides
##   - 3.9879 * free.sulfur.dioxide
##   - 0.0024 * total.sulfur.dioxide
##   - 21.4691 * pH
##   - 1.2175 * sulphates
##   - 0.0759 * alcohol
##   + 26.2419
##
## LM num: 100
## quality =
##   0.0051 * volatile.acidity
##   + 0.3848 * citric.acid
##   + 0.2921 * residual.sugar
##   - 4.5739 * chlorides
##   - 3.9879 * free.sulfur.dioxide
##   - 0.0024 * total.sulfur.dioxide
##   - 21.4691 * pH
##   - 1.2175 * sulphates
##   - 0.0759 * alcohol
##   + 25.9185
##
## LM num: 101
## quality =
##   0.0051 * volatile.acidity
##   + 1.1585 * citric.acid
##   + 0.2921 * residual.sugar
##   - 3.8969 * chlorides
##   - 3.9875 * free.sulfur.dioxide
##   - 0.0024 * total.sulfur.dioxide
##   - 21.4691 * pH
##   - 1.7496 * sulphates
##   - 0.1438 * alcohol
##   + 27.1715
##
## LM num: 102
## quality =
##   -0.0787 * volatile.acidity
##   + 1.1585 * citric.acid
##   + 0.2921 * residual.sugar
##   - 3.8969 * chlorides
##   - 3.9875 * free.sulfur.dioxide
##   - 0.0011 * total.sulfur.dioxide
##   - 21.4691 * pH
##   - 1.7496 * sulphates
##   - 0.1438 * alcohol
##   + 27.0506
##
## LM num: 103
## quality =
##   0.0051 * volatile.acidity
##   + 1.1585 * citric.acid
```

```
##  + 0.2921 * residual.sugar
##  - 3.8969 * chlorides
##  - 3.9875 * free.sulfur.dioxide
##  - 0.0024 * total.sulfur.dioxide
##  - 21.4691 * pH
##  - 1.7496 * sulphates
##  - 0.1438 * alcohol
##  + 27.1387
##
## LM num: 104
## quality =
##  0.0051 * volatile.acidity
##  + 1.1585 * citric.acid
##  + 0.2921 * residual.sugar
##  - 3.8969 * chlorides
##  - 3.9903 * free.sulfur.dioxide
##  - 0.0024 * total.sulfur.dioxide
##  - 21.4691 * pH
##  - 1.7496 * sulphates
##  - 0.1879 * alcohol
##  + 27.788
##
## LM num: 105
## quality =
##  0.0051 * volatile.acidity
##  + 1.1585 * citric.acid
##  + 0.2921 * residual.sugar
##  + 13.0163 * chlorides
##  - 3.9832 * free.sulfur.dioxide
##  - 0.0024 * total.sulfur.dioxide
##  - 22.2668 * pH
##  - 2.5266 * sulphates
##  - 0.0759 * alcohol
##  + 28.2301
##
## LM num: 106
## quality =
##  0.0051 * volatile.acidity
##  + 1.1585 * citric.acid
##  + 0.2921 * residual.sugar
##  + 4.7171 * chlorides
##  - 3.9832 * free.sulfur.dioxide
##  - 0.0024 * total.sulfur.dioxide
##  - 22.2668 * pH
##  - 2.5266 * sulphates
##  - 0.0759 * alcohol
##  + 28.5047
##
## LM num: 107
## quality =
##  -0.0215 * volatile.acidity
##  + 0.2131 * citric.acid
##  + 0.0163 * chlorides
##  - 4.8929 * free.sulfur.dioxide
```

```
##   + 0.0059 * total.sulfur.dioxide
##   - 0.0009 * density
##   + 3.6137 * pH
##   + 0.2004 * sulphates
##   - 0.3518 * alcohol
##   + 2.2656
##
## LM num: 108
## quality =
##   -0.1376 * fixed.acidity
##   - 0.015 * volatile.acidity
##   - 0.6288 * citric.acid
##   + 0.0472 * residual.sugar
##   - 25.5055 * chlorides
##   - 4.0634 * free.sulfur.dioxide
##   + 0.0049 * total.sulfur.dioxide
##   + 93.5166 * density
##   - 2.5236 * pH
##   + 0.2004 * sulphates
##   - 0.2717 * alcohol
##   - 82.8348
##
## LM num: 109
## quality =
##   0.0073 * volatile.acidity
##   + 0.0223 * citric.acid
##   - 0.0896 * residual.sugar
##   + 0.0491 * chlorides
##   + 2.7673 * free.sulfur.dioxide
##   + 0.0027 * total.sulfur.dioxide
##   - 0.0004 * density
##   - 105.913 * pH
##   - 0.0516 * sulphates
##   + 0.4989 * alcohol
##   + 109.828
##
## LM num: 110
## quality =
##   0.0073 * volatile.acidity
##   + 0.0223 * citric.acid
##   - 0.6267 * residual.sugar
##   + 0.0683 * chlorides
##   + 5.5425 * free.sulfur.dioxide
##   + 0.0027 * total.sulfur.dioxide
##   - 0.0004 * density
##   - 143.589 * pH
##   + 2.2909 * sulphates
##   + 1.0975 * alcohol
##   + 142.3524
##
## LM num: 111
## quality =
##   -0.0775 * fixed.acidity
##   + 0.0073 * volatile.acidity
```

```
##  + 0.0223 * citric.acid
##  - 0.0896 * residual.sugar
##  + 7.5482 * chlorides
##  + 2.6838 * free.sulfur.dioxide
##  + 0.0027 * total.sulfur.dioxide
##  - 0.0004 * density
##  - 101.1158 * pH
##  + 0.523 * sulphates
##  + 0.6223 * alcohol
##  + 104.6966
##
## LM num: 112
## quality =
##  0.0073 * volatile.acidity
##  + 0.0223 * citric.acid
##  - 0.1362 * residual.sugar
##  - 7.0049 * chlorides
##  - 0.7231 * free.sulfur.dioxide
##  - 0.0038 * total.sulfur.dioxide
##  - 0.0006 * density
##  - 56.9685 * pH
##  - 1.0182 * sulphates
##  + 0.1557 * alcohol
##  + 63.228
##
## Number of Rules : 112
```

```
summary(m.m5p)
```

```
##
## === Summary ===
##
## Correlation coefficient                -0.2414
## Mean absolute error                  102.3629
## Root mean squared error              129.5719
## Relative absolute error            14704.2234 %
## Root relative squared error        14159.8116 %
## Total Number of Instances           3750
```

```
p.m5p <- predict(m.m5p, wine_test)
summary(p.m5p)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## -539.90 -165.65 -107.07 -112.27  -33.70   32.49
```

```
cor(p.m5p, wine_test$quality)
```

```
## [1] -0.2036594
```

```
MAE(wine_test$quality, p.m5p)
```

```
## [1] 118.6835
```

Part 2.

```
RMSE <- (sqrt(sum(wine_test$quality-p.m5p)^2/length(wine_test$quality)))
RMSE
```

```
## [1] 4002.081
```