

DA5030.A6.Parpattedar

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Problem 1

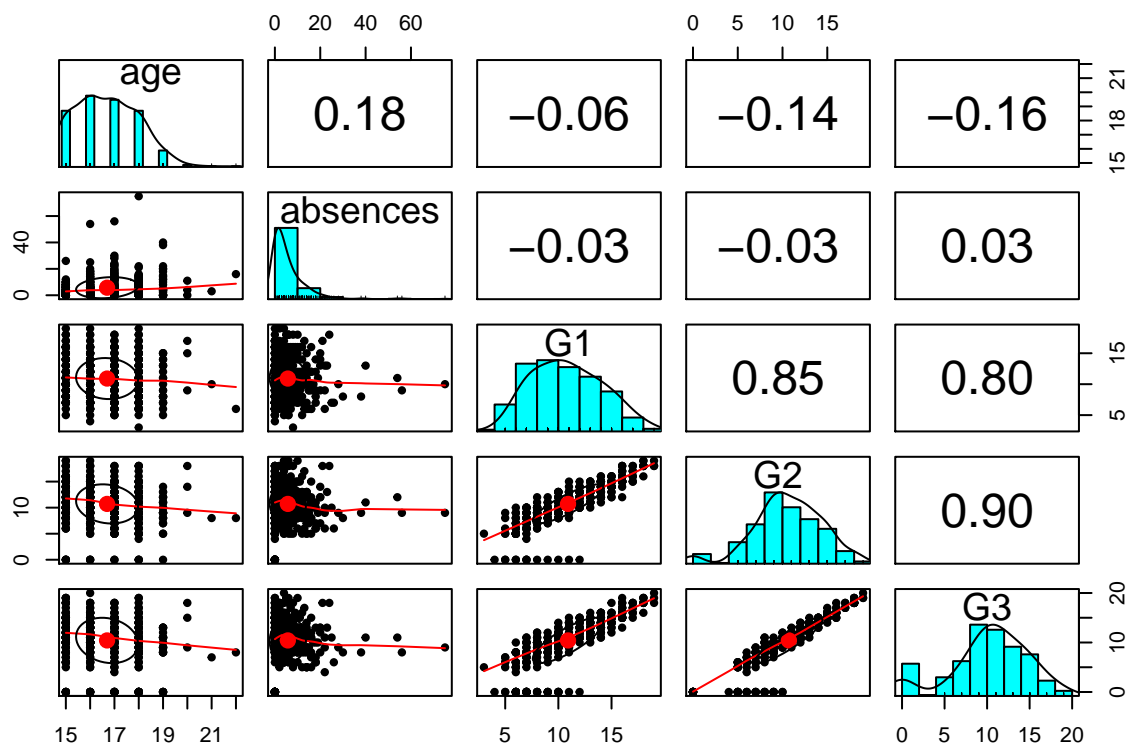
Question 1

Scatterplots and correlations between Age, absences, G1, G2 and G3 using pairs.panel().

```
library(psych)
data <- read.csv("student-mat.csv", sep = ";")
str(data)

## 'data.frame':    395 obs. of  33 variables:
## $ school      : Factor w/ 2 levels "GP","MS": 1 1 1 1 1 1 1 1 1 1 ...
## $ sex         : Factor w/ 2 levels "F","M": 1 1 1 1 1 2 2 1 2 2 ...
## $ age         : int  18 17 15 15 16 16 16 17 15 15 ...
## $ address     : Factor w/ 2 levels "R","U": 2 2 2 2 2 2 2 2 2 2 ...
## $ famsize     : Factor w/ 2 levels "GT3","LE3": 1 1 2 1 1 2 2 1 2 1 ...
## $ Pstatus     : Factor w/ 2 levels "A","T": 1 2 2 2 2 2 2 1 1 2 ...
## $ Medu       : int   4 1 1 4 3 4 2 4 3 3 ...
## $ Fedu       : int   4 1 1 2 3 3 2 4 2 4 ...
## $ Mjob       : Factor w/ 5 levels "at_home","health",...: 1 1 1 2 3 4 3 3 4 3 ...
## $ Fjob       : Factor w/ 5 levels "at_home","health",...: 5 3 3 4 3 3 3 5 3 3 ...
## $ reason     : Factor w/ 4 levels "course","home",...: 1 1 3 2 2 4 2 2 2 2 ...
## $ guardian   : Factor w/ 3 levels "father","mother",...: 2 1 2 2 1 2 2 2 2 2 ...
## $ traveltime : int   2 1 1 1 1 1 1 2 1 1 ...
## $ studytime  : int   2 2 2 3 2 2 2 2 2 2 ...
## $ failures   : int   0 0 3 0 0 0 0 0 0 0 ...
## $ schoolsup  : Factor w/ 2 levels "no","yes": 2 1 2 1 1 1 1 2 1 1 ...
## $ famsup     : Factor w/ 2 levels "no","yes": 1 2 1 2 2 2 1 2 2 2 ...
## $ paid       : Factor w/ 2 levels "no","yes": 1 1 2 2 2 2 1 1 2 2 ...
## $ activities : Factor w/ 2 levels "no","yes": 1 1 1 2 1 2 1 1 1 2 ...
## $ nursery    : Factor w/ 2 levels "no","yes": 2 1 2 2 2 2 2 2 2 2 ...
## $ higher     : Factor w/ 2 levels "no","yes": 2 2 2 2 2 2 2 2 2 2 ...
## $ internet   : Factor w/ 2 levels "no","yes": 1 2 2 2 1 2 2 1 2 2 ...
## $ romantic   : Factor w/ 2 levels "no","yes": 1 1 1 2 1 1 1 1 1 1 ...
## $ famrel     : int   4 5 4 3 4 5 4 4 4 5 ...
## $ freetime   : int   3 3 3 2 3 4 4 1 2 5 ...
## $ goout      : int   4 3 2 2 2 2 4 4 2 1 ...
## $ Dalc       : int   1 1 2 1 1 1 1 1 1 1 ...
## $ Walc       : int   1 1 3 1 2 2 1 1 1 1 ...
## $ health     : int   3 3 3 5 5 5 3 1 1 5 ...
## $ absences   : int   6 4 10 2 4 10 0 6 0 0 ...
## $ G1         : int   5 5 7 15 6 15 12 6 16 14 ...
## $ G2         : int   6 5 8 14 10 15 12 5 18 15 ...
## $ G3         : int   6 6 10 15 10 15 11 6 19 15 ...

pairs.panels(data[,c(3,30:33)])
```



Question 2

Multiple regression model for the final grade, G3 using G2, G1, F0, F1, absences, schoolsup, health1, health2, internet.

The adjusted R-squared value suggests that the model covers approximately 83% of the variance in the data.

```
data$F0 <- ifelse(data$failures == 0, 1, 0)
data$F1 <- ifelse(data$failures == 1, 1, 0)
data$F2 <- ifelse(data$failures == 2, 1, 0)
data$schoolsup <- ifelse(data$schoolsup == 'yes', 1, 0)
data$health1 <- ifelse(data$health == 1, 1, 0)
data$health2 <- ifelse(data$health == 2, 1, 0)
data$health3 <- ifelse(data$health == 3, 1, 0)
data$health4 <- ifelse(data$health == 4, 1, 0)
data$internet <- ifelse(data$internet == 'yes', 1, 0)
m <- lm(G3 ~ G2+G1+F0+F1+absences+schoolsup+health1+health2+internet, data = data)
summary(m)
```

```
##
## Call:
## lm(formula = G3 ~ G2 + G1 + F0 + F1 + absences + schoolsup +
##     health1 + health2 + internet, data = data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -9.3383 -0.5068  0.2649  0.9660  3.6052
```

```
##
## Coefficients:
##           Estimate Std. Error t value Pr(>|t|)
## (Intercept) -2.04156    0.46013  -4.437 1.19e-05 ***
## G2           0.97534    0.04928  19.792 < 2e-16 ***
## G1           0.15831    0.05634   2.810 0.005210 **
## F0           0.40487    0.36635   1.105 0.269784
## F1          -0.63532    0.43029  -1.476 0.140634
## absences     0.04479    0.01212   3.695 0.000252 ***
## schoolsup     0.49064    0.29176   1.682 0.093454 .
## health1     -0.16525    0.29908  -0.553 0.580906
## health2     -0.78521    0.30149  -2.604 0.009560 **
## internet    -0.20318    0.25933  -0.783 0.433832
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.879 on 385 degrees of freedom
## Multiple R-squared:  0.8357, Adjusted R-squared:  0.8318
## F-statistic: 217.5 on 9 and 385 DF, p-value: < 2.2e-16
```

Question 3

Using stepwise backward elimination to remove all non-significant variables from the model used in the previous question.

The final model for the final grade, G3 uses G2, G1, F1, absences, schoolsup, health2 variables.

AIC used as a backward elimination measure.

```
m2 <- step(lm(G3 ~ G2+G1+F0+F1+absences+schoolsup+health1+health2+internet, data = data),
           direction = "backward")
```

```
## Start: AIC=508.07
## G3 ~ G2 + G1 + F0 + F1 + absences + schoolsup + health1 + health2 +
##      internet
##
##           Df Sum of Sq    RSS    AIC
## - health1   1      1.08 1360.1 506.38
## - internet   1      2.17 1361.2 506.70
## - F0         1      4.31 1363.3 507.32
## <none>                1359.0 508.07
## - F1         1      7.69 1366.7 508.30
## - schoolsup   1      9.98 1369.0 508.96
## - health2     1     23.94 1382.9 512.96
## - G1          1     27.87 1386.9 514.08
## - absences    1     48.20 1407.2 519.83
## - G2          1    1382.76 2741.8 783.30
##
## Step: AIC=506.38
## G3 ~ G2 + G1 + F0 + F1 + absences + schoolsup + health2 + internet
##
##           Df Sum of Sq    RSS    AIC
## - internet   1      2.37 1362.4 505.07
## - F0         1      4.18 1364.2 505.59
## <none>                1360.1 506.38
## - F1         1      7.61 1367.7 506.58
```

```
## - schoolsup 1      9.94 1370.0 507.26
## - health2 1      22.98 1383.0 511.00
## - G1 1      28.37 1388.4 512.53
## - absences 1      47.73 1407.8 518.00
## - G2 1      1387.63 2747.7 782.16
##
## Step: AIC=505.07
## G3 ~ G2 + G1 + F0 + F1 + absences + schoolsup + health2
##
##           Df Sum of Sq  RSS   AIC
## - F0      1      4.22 1366.7 504.29
## <none>                    1362.4 505.07
## - F1      1      7.03 1369.5 505.10
## - schoolsup 1      10.08 1372.5 505.98
## - health2 1      23.77 1386.2 509.90
## - G1      1      29.57 1392.0 511.55
## - absences 1      45.85 1408.3 516.14
## - G2      1     1392.29 2754.7 781.16
##
## Step: AIC=504.29
## G3 ~ G2 + G1 + F1 + absences + schoolsup + health2
##
##           Df Sum of Sq  RSS   AIC
## <none>                    1366.7 504.29
## - schoolsup 1      11.01 1377.7 505.46
## - health2 1      23.59 1390.2 509.05
## - G1      1      31.97 1398.6 511.42
## - F1      1      37.14 1403.8 512.88
## - absences 1      45.48 1412.1 515.22
## - G2      1     1424.72 2791.4 784.39
```

```
# Final model
```

```
m2$call[[2]]
```

```
## G3 ~ G2 + G1 + F1 + absences + schoolsup + health2
```

```
# Equation to be used for prediction
```

```
# g3 <- m2$coefficients[[1]] + g2*m2$coefficients[[2]] + g1*m2$coefficients[[3]]
# + f1*m2$coefficients[[4]] + abs*m2$coefficients[[5]] + schsup*m2$coefficients[[6]]
# + h2*m2$coefficients[[7]]
```

Question 4

Predicting the final grade for a new student with the following data and then calculating the 95% Confidence Interval for the prediction.

```
g2 <- 13
g1 <- 14
f1 <- 0
abs <- 3
schsup <- 0
h2 <- 0
new <- c(g2,g1,f1,abs,schsup,h2)
g3 <- m2$coefficients[[1]] + g2*m2$coefficients[[2]] + g1*m2$coefficients[[3]] +
  f1*m2$coefficients[[4]] + abs*m2$coefficients[[5]] + schsup*m2$coefficients[[6]] +
  h2*m2$coefficients[[7]]
```

```

# Prediction for new student
g3

## [1] 13.18661

# Confidence interval for prediction
CI <- c(g3 - 1.96*1.877, g3 + 1.96*1.877)
CI

## [1] 9.507693 16.865533

```

Question 5

Calculating the RMSE for the multiple regression model

```

finalmodel <- lm(m2$call[[2]], data)
pred <- predict(finalmodel, data)
rmse1_lm <- sqrt(mean((data$G3 - pred)^2))
rmse2_lm <- sqrt(mean((finalmodel$residuals)^2))
paste("RMSE for Multiple Regression -", rmse2_lm)

## [1] "RMSE for Multiple Regression - 1.86008063369796"

```

Problem 2

Question 1

Adding a Pass/Fail column based on the G3 column.

Next, converting the new column into dummy codes.

```

data$PF <- ifelse(data$G3<10, 'F', 'P')
data$PF10 <- ifelse(data$PF == 'P', 1, 0)

```

Question 2

Generating a logistic regression model for the Pass/fail dummy codes column using age, Medu, goout1, goout2, goout3, goout4, G1, G2, G3, F0, F1, absences, schoolsup.

Next, using stepwise backward elimination to remove all non-significant variables from the model.

```

data$goout1 <- ifelse(data$goout == 1, 1, 0)
data$goout2 <- ifelse(data$goout == 2, 1, 0)
data$goout3 <- ifelse(data$goout == 3, 1, 0)
data$goout4 <- ifelse(data$goout == 4, 1, 0)

model_logreg <- glm(PF10 ~ age + Medu + goout1 + goout2 + goout3 + goout4 +
                    G1 + G2 + G3 + F0 + F1 + absences + schoolsup, data = data)
model_logreg2 <- step(model_logreg, direction = "backward")

## Start:  AIC=163.48
## PF10 ~ age + Medu + goout1 + goout2 + goout3 + goout4 + G1 +
##      G2 + G3 + F0 + F1 + absences + schoolsup
##
##           Df Deviance    AIC
## - goout3    1   32.425 161.48
## - G2        1   32.434 161.59

```

```

## - goout2      1    32.455 161.85
## - goout4      1    32.473 162.07
## - schoolsup    1    32.546 162.95
## - G1          1    32.585 163.43
## <none>         1    32.425 163.47
## - age         1    32.595 163.54
## - goout1      1    32.646 164.16
## - Medu        1    32.677 164.53
## - F1          1    32.737 165.26
## - F0          1    32.794 165.95
## - absences    1    33.147 170.18
## - G3          1    38.605 230.39
##
## Step:  AIC=161.48
## PF10 ~ age + Medu + goout1 + goout2 + goout4 + G1 + G2 + G3 +
##       F0 + F1 + absences + schoolsup
##
##           Df Deviance    AIC
## - G2        1    32.434 159.59
## - goout2     1    32.474 160.07
## - goout4     1    32.526 160.70
## - schoolsup   1    32.547 160.96
## - G1         1    32.587 161.44
## <none>        1    32.425 161.48
## - age        1    32.595 161.54
## - Medu        1    32.679 162.56
## - goout1     1    32.696 162.77
## - F1         1    32.747 163.38
## - F0         1    32.808 164.11
## - absences   1    33.151 168.22
## - G3         1    38.613 228.47
##
## Step:  AIC=159.59
## PF10 ~ age + Medu + goout1 + goout2 + goout4 + G1 + G3 + F0 +
##       F1 + absences + schoolsup
##
##           Df Deviance    AIC
## - goout2     1    32.486 158.22
## - goout4     1    32.535 158.82
## - schoolsup   1    32.555 159.06
## <none>        1    32.434 159.59
## - age        1    32.606 159.68
## - Medu        1    32.684 160.62
## - G1         1    32.693 160.73
## - goout1     1    32.712 160.96
## - F1         1    32.770 161.66
## - F0         1    32.821 162.27
## - absences   1    33.193 166.73
## - G3         1    45.334 289.85
##
## Step:  AIC=158.22
## PF10 ~ age + Medu + goout1 + goout4 + G1 + G3 + F0 + F1 + absences +
##       schoolsup
##

```

```
##           Df Deviance    AIC
## - schoolsup  1   32.601 157.62
## <none>           32.486 158.22
## - goout4     1   32.657 158.29
## - age        1   32.683 158.61
## - goout1     1   32.727 159.14
## - G1         1   32.755 159.48
## - Medu       1   32.769 159.64
## - F1         1   32.819 160.25
## - F0         1   32.864 160.79
## - absences   1   33.251 165.41
## - G3         1   45.426 288.66
##
## Step:  AIC=157.62
## PF10 ~ age + Medu + goout1 + goout4 + G1 + G3 + F0 + F1 + absences
##
##           Df Deviance    AIC
## - age        1   32.736 157.25
## <none>           32.601 157.62
## - goout4     1   32.789 157.89
## - goout1     1   32.818 158.23
## - Medu       1   32.867 158.82
## - F1         1   32.917 159.43
## - F0         1   32.967 160.03
## - G1         1   32.971 160.08
## - absences   1   33.397 165.14
## - G3         1   45.429 286.68
##
## Step:  AIC=157.25
## PF10 ~ Medu + goout1 + goout4 + G1 + G3 + F0 + F1 + absences
##
##           Df Deviance    AIC
## <none>           32.736 157.25
## - goout4     1   32.951 157.83
## - Medu       1   32.960 157.94
## - goout1     1   32.967 158.02
## - F1         1   33.044 158.95
## - G1         1   33.047 158.99
## - F0         1   33.172 160.47
## - absences   1   33.682 166.50
## - G3         1   46.354 292.64
```

Question 3

Displaying the model with only the significant variables

```
model_logreg2$call[[2]]
```

```
## PF10 ~ Medu + goout1 + goout4 + G1 + G3 + F0 + F1 + absences
```

Question 4

Using the model to make predictions using the entire dataset.

Since logistic regression models result in possibilities ie. continuous values, using a threshold of 0.5 to convert them in to binary values.

Calculating the RMSE for the logistic regression model.

```
final_logreg <- glm(model_logreg2$call[[2]], data = data)
pred <- predict(final_logreg, data)
pred <- ifelse(pred < 0.5, 0, 1)
rmse1_glm <- sqrt(mean((data$PF10 - pred)^2))
rmse2_glm <- sqrt(mean(round(final_logreg$residuals)^2))
paste("RMSE for Logistic Regression -", rmse2_glm)
```

```
## [1] "RMSE for Logistic Regression - 0.256559515142445"
```

Problem 3

Question 1

Step 1 - Collecting Data

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

Step 2 - Exploring and preparing the data

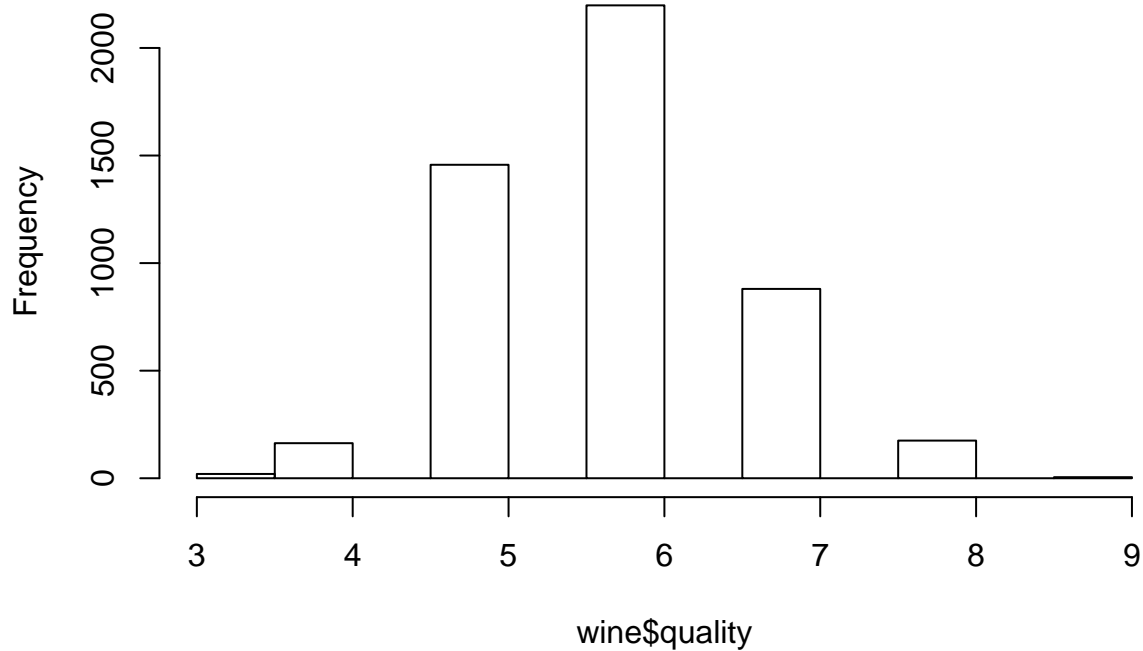
Creating the train and test datasets.

```
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)
```


Histogram of wine\$quality



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

Step 3 - Training a model on the data

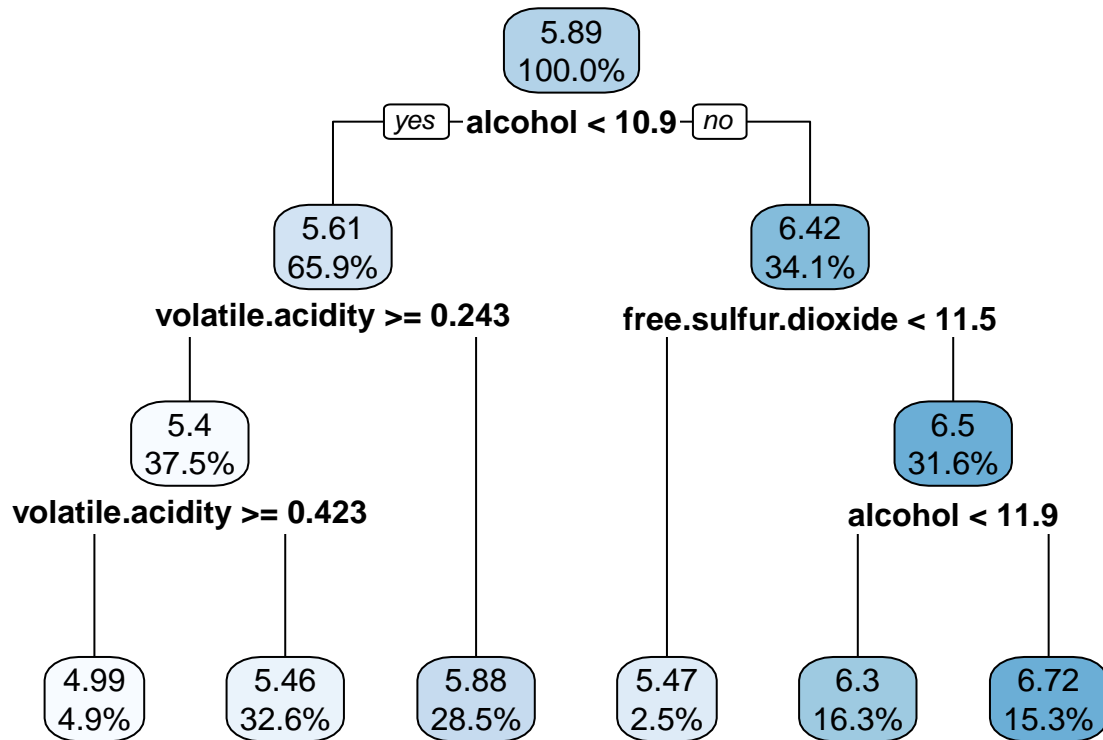
Using the rpart function with the training data.

Next, using rpart.plot to visualize the model.

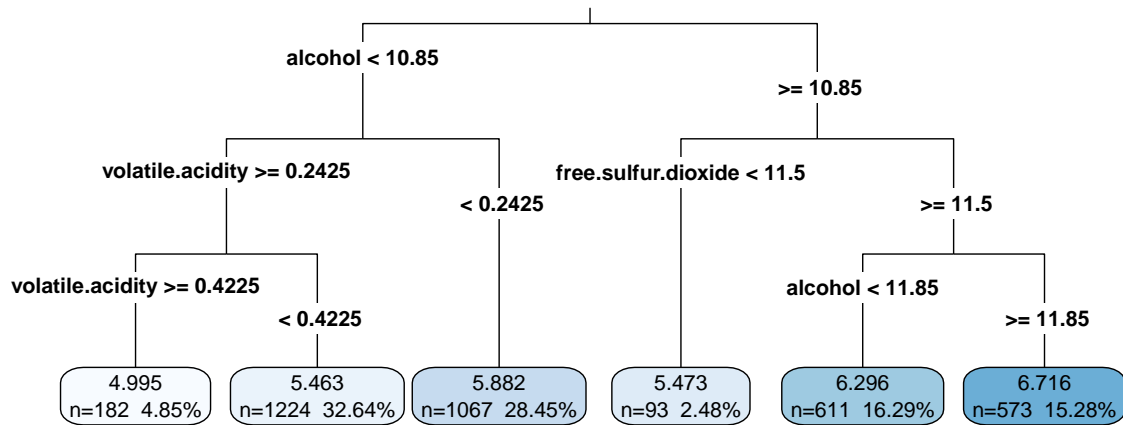
```
library(rpart)  
library(rpart.plot)  
m.rpart <- rpart(quality ~ ., data = wine_train)  
m.rpart  
  
## n= 3750  
##  
## node), split, n, deviance, yval  
## * denotes terminal node  
##  
## 1) root 3750 3140.06000 5.886933  
## 2) alcohol< 10.85 2473 1510.66200 5.609381  
## 4) volatile.acidity>=0.2425 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 decision trees
rpart.plot(m.rpart, digits = 3)
```



```
rpart.plot(m.rpart, digits = 4, fallen.leaves = TRUE, type = 3, extra = 101)
```



Step 4 - Evaluating model performance

Using the model to make predictions.

Next, finding the Mean Absolute Error for the model and its predictions

```
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
```

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

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

```
# Measuring performance with the mean absolute error
```

```
MAE <- function(actual, predicted)
{
  mean(abs(actual - predicted))
}
```

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

```
## [1] 0.5732104
mean(wine_train$quality)

## [1] 5.886933
MAE(5.89, wine_test$quality)

## [1] 0.5741115
```

Step 5 - Improving model performance

Using the M5P function from the Rweka package.

Next, finding the MAE for this model.

```
library(Rweka)
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
```

Question 2

RMSEs for the two models used above.

```
rmse_rpart <- sqrt(mean((wine_test$quality - p.rpart)^2))
paste("RMSE for Rpart model -", rmse_rpart)

## [1] "RMSE for Rpart model - 0.705715302969198"

rmse_m5p <- sqrt(mean((wine_test$quality - p.m5p)^2))
paste("RMSE for M5P model - ", rmse_m5p)

## [1] "RMSE for M5P model - 145.442183477609"
```