

# Homework 6

## Group 3

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## Homework 6

### Problem 8.1

#### Question 8.1.a

```
UniversalBank$Personal.Loan<-as.factor(UniversalBank$Personal.Loan)
UniversalBank$online<-as.factor(UniversalBank$Online)
UniversalBank$CreditCard<-as.factor(UniversalBank$CreditCard)
set.seed(123)
split<-sample.split(UniversalBank$Personal.Loan, SplitRatio=0.6)
train<-subset(UniversalBank,split==TRUE)
test<-subset(UniversalBank, split==FALSE)
table(train$CreditCard, train$Online, train$Personal.Loan)

## , , = 0
##
##
##      0      1
## 0  809 1126
## 1  325  452
##
## , , = 1
##
##
##      0      1
## 0   73  132
## 1   40   43
```

#### Question 8.1.b

```
#The probability is 0.087 that loan offer will be accepted
43/(452+43)

## [1] 0.08686869
```

#### Question 8.1.c

```
#online function
table(train$Personal.Loan, train$Online)

##
##      0      1
## 0 1134 1578
## 1  113  175

#Loan function
table(train$Personal.Loan, train$CreditCard)
```

```
##
##      0      1
##  0 1935  777
##  1  205   83
```

## Question 8.1.d

### Task 8.1.d.i

$83/(83+205)$

```
## [1] 0.2881944
```

*#i. 0.288*

### Task 8.1.d.ii

$175/(175+113)$

```
## [1] 0.6076389
```

*#ii. 0.608*

### Task 8.1.d.iii

```
table(train$Personal.Loan)
```

```
##
##      0      1
## 2712  288
```

$288/(288+2712)$

```
## [1] 0.096
```

*#iii. 0.096*

### Task 8.1.d.iv

$777/(777+1935)$

```
## [1] 0.2865044
```

*#iv. 0.58*

### Task 8.1.d.v

$1578/(1578+1134)$

```
## [1] 0.5818584
```

*#v. 0.904*

### Task 8.1.d.vi

$2712/(2712+288)$

```
## [1] 0.904
```

```
#vi. 0.904
```

### Question 8.1.e

```
(0.096*0.288*0.608)/((0.096*0.288*0.0608)+(0.904*0.29*0.58))
```

```
## [1] 0.1093448
```

### Question 8.1.f

*#the calculated b value= 0.087 and we get 8.1 e)0.0995 when we have more predictors*

### Question 8.1.g

```
model<-naiveBayes(Personal.Loan~., data=train)
y_pred<-predict(model, newdata=train[, -3], type="raw")

## Warning in predict.naiveBayes(model, newdata = train[, -3], type = "raw"):
Type
## mismatch between training and new data for variable 'Experience'. Did you
use
## factors with numeric labels for training, and numeric values for new data?

valid<-data.frame(CreditCard="1", Online="1")
y_pred1<-predict(model, newdata=valid, type="raw")

## Warning in predict.naiveBayes(model, newdata = valid, type = "raw"): Type
## mismatch between training and new data for variable 'ID'. Did you use
factors
## with numeric labels for training, and numeric values for new data?

## Warning in predict.naiveBayes(model, newdata = valid, type = "raw"): Type
## mismatch between training and new data for variable 'Age'. Did you use
factors
## with numeric labels for training, and numeric values for new data?

## Warning in predict.naiveBayes(model, newdata = valid, type = "raw"): Type
## mismatch between training and new data for variable 'Experience'. Did you
use
## factors with numeric labels for training, and numeric values for new data?

## Warning in predict.naiveBayes(model, newdata = valid, type = "raw"): Type
## mismatch between training and new data for variable 'Income'. Did you use
## factors with numeric labels for training, and numeric values for new data?

## Warning in predict.naiveBayes(model, newdata = valid, type = "raw"): Type
## mismatch between training and new data for variable 'ZIP.Code'. Did you
use
## factors with numeric labels for training, and numeric values for new data?

## Warning in predict.naiveBayes(model, newdata = valid, type = "raw"): Type
## mismatch between training and new data for variable 'Family'. Did you use
## factors with numeric labels for training, and numeric values for new data?
```

```
## Warning in predict.naiveBayes(model, newdata = valid, type = "raw"): Type
## mismatch between training and new data for variable 'CCAvg'. Did you use
## factors
## with numeric labels for training, and numeric values for new data?

## Warning in predict.naiveBayes(model, newdata = valid, type = "raw"): Type
## mismatch between training and new data for variable 'Education'. Did you
## use
## factors with numeric labels for training, and numeric values for new data?

## Warning in predict.naiveBayes(model, newdata = valid, type = "raw"): Type
## mismatch between training and new data for variable 'Mortgage'. Did you
## use
## factors with numeric labels for training, and numeric values for new data?

## Warning in predict.naiveBayes(model, newdata = valid, type = "raw"): Type
## mismatch between training and new data for variable 'Securities.Account'.
## Did
## you use factors with numeric labels for training, and numeric values for
## new
## data?

## Warning in predict.naiveBayes(model, newdata = valid, type = "raw"): Type
## mismatch between training and new data for variable 'CD.Account'. Did you
## use
## factors with numeric labels for training, and numeric values for new data?

## Warning in predict.naiveBayes(model, newdata = valid, type = "raw"): Type
## mismatch between training and new data for variable 'Online'. Did you use
## factors with numeric labels for training, and numeric values for new data?

y_pred1

##              0              1
## [1,] 0.9034884 0.09651163

#the value is 0.1003 is more
```

## Problem 8.2

### Question 8.2.a

```
accidents <- read_excel("Accidents(2).xlsx",
  sheet = "Data")
accidents$INJURY <- ifelse(accidents$MAX_SEV_IR>0, "yes", "no")
set.seed(1)
#creating a table based on injury
injury.table <- table(accidents$INJURY)
# Calculating the probability of injury
injury.prob <-
```

```
scales::percent(injury.table['yes']/(injury.table['yes']+injury.table['no']))
injury.prob

##    yes
## "51%"
```

Almost 51% of the total accidents that have been recorded, have resulted in an injury, we must conclude that an accident is more probable to have an injury.

## Question 8.2.b

### Task 8.2.b.i

```
newdf <- accidents[1:12, c('INJURY', 'WEATHER_R', 'TRAF_CON_R')]
newdf

## # A tibble: 12 x 3
##   INJURY WEATHER_R TRAF_CON_R
##   <chr>      <dbl>      <dbl>
## 1 yes          1          0
## 2 no           2          0
## 3 no           2          1
## 4 no           1          1
## 5 no           1          0
## 6 yes          2          0
## 7 no           2          0
## 8 yes          1          0
## 9 no           2          0
## 10 no          2          0
## 11 no          2          0
## 12 no          1          2
```

### Task 8.2.b.ii

```
#To find P(Injury=yes|WEATHER_R = 1, TRAF_CON_R =0):
numerator1 <- 2/3 * 3/12
denominator1 <- 3/12
prob1 <- numerator1/denominator1

#To find P(Injury=yes|WEATHER_R = 1, TRAF_CON_R =1):
numerator2 <- 0 * 3/12
denominator2 <- 1/12
prob2 <- numerator2/denominator2

#To find P(Injury=yes| WEATHER_R = 1, TRAF_CON_R =2):
numerator3 <- 0 * 3/12
denominator3 <- 1/12
prob3 <- numerator3/denominator3

#To find P(Injury=yes| WEATHER_R = 2, TRAF_CON_R =0):
numerator4 <- 1/3 * 3/12
denominator4 <- 6/12
```

```

prob4 <- numerator4/denominator4

#To find P(Injury=yes| WEATHER_R = 2, TRAF_CON_R =1):
numerator5 <- 0 * 3/12
denominator5 <- 1/12
prob5 <- numerator5/denominator5

#To find P(Injury=yes| WEATHER_R = 2, TRAF_CON_R =2):
numerator6 <- 0 * 3/12
denominator6 <- 0
prob6 <- numerator6/denominator6

a<-c(1,2,3,4,5,6)
b<-c(prob1,prob2,prob3,prob4,prob5,prob6)
prob.df<-data.frame(a,b)
names(prob.df)<-c('Record No.','Probability')
prob.df %>% mutate_if(is.numeric, round, 3)

##   Record No. Probability
## 1         1      0.667
## 2         2      0.000
## 3         3      0.000
## 4         4      0.167
## 5         5      0.000
## 6         6      NaN

```

### Task 8.2.b.iii

```

probinj <- c(0.667, 0.167, 0, 0, 0.667, 0.167, 0.167, 0.667, 0.167, 0.167,
0.167, 0)
newdfprob <- newdf
newdfprob$PROB_INJ <- probinj
newdfprob$PREDICT <- ifelse(newdfprob$PROB_INJ>.5,'YES','NO')
newdfprob

## # A tibble: 12 x 5
##   INJURY WEATHER_R TRAF_CON_R PROB_INJ PREDICT
##   <chr>      <dbl>      <dbl>    <dbl> <chr>
## 1 yes         1         0    0.667 YES
## 2 no          2         0    0.167 NO
## 3 no          2         1     0     NO
## 4 no          1         1     0     NO
## 5 no          1         0    0.667 YES
## 6 yes         2         0    0.167 NO
## 7 no          2         0    0.167 NO
## 8 yes         1         0    0.667 YES
## 9 no          2         0    0.167 NO
## 10 no         2         0    0.167 NO
## 11 no         2         0    0.167 NO
## 12 no         1         2     0     NO

```

### Task 8.2.b.iv

```
# Find  $p(\text{INJURY} = \text{yes} | \text{WEATHER\_R} = 1, \text{TRAF\_CON\_R} = 1)$ :  
manprob <- 2/3 * 0/3 * 3/12  
manprob  
  
## [1] 0
```

### Task 8.2.b.v

```
nbmodel <- naiveBayes(INJURY~., data = newdf)  
predict(nbmodel, newdata = newdf, type = 'raw')  
  
## Warning in data.matrix(newdata): NAs introduced by coercion  
  
##           no           yes  
## [1,] 0.001916916 0.9980830837  
## [2,] 0.006129754 0.9938702459  
## [3,] 0.999548668 0.0004513316  
## [4,] 0.998552097 0.0014479028  
## [5,] 0.001916916 0.9980830837  
## [6,] 0.006129754 0.9938702459  
## [7,] 0.006129754 0.9938702459  
## [8,] 0.001916916 0.9980830837  
## [9,] 0.006129754 0.9938702459  
## [10,] 0.006129754 0.9938702459  
## [11,] 0.006129754 0.9938702459  
## [12,] 0.989399428 0.0106005719  
  
x=newdf[, -3]  
y=newdf$INJURY  
model <- train(x,y,'nb', trControl = trainControl(method = 'cv', number=10))  
  
## Warning: Setting row names on a tibble is deprecated.  
  
## Warning: NAs introduced by coercion  
  
## Warning: Setting row names on a tibble is deprecated.  
  
## Warning in data.matrix(newdata): NAs introduced by coercion  
## Warning: Setting row names on a tibble is deprecated.  
  
## Warning in data.matrix(newdata): NAs introduced by coercion  
## Warning: Setting row names on a tibble is deprecated.  
  
## Warning in data.matrix(newdata): NAs introduced by coercion  
## Warning: Setting row names on a tibble is deprecated.  
  
## Warning in data.matrix(newdata): NAs introduced by coercion  
## Warning: Setting row names on a tibble is deprecated.
```



```
## Warning in data.matrix(newdata): NAs introduced by coercion
## Warning: Setting row names on a tibble is deprecated.
## Warning in data.matrix(newdata): NAs introduced by coercion
## Warning: Setting row names on a tibble is deprecated.
## Warning in data.matrix(newdata): NAs introduced by coercion
## Warning: Setting row names on a tibble is deprecated.
## Warning in data.matrix(newdata): NAs introduced by coercion
## Warning: Setting row names on a tibble is deprecated.
## Warning: model fit failed for Fold5: usekernel=FALSE, fL=0, adjust=1 Error
in NaiveBayes.default(x, y, usekernel = FALSE, fL = param$fL, ...) :
##   Zero variances for at least one class in variables: WEATHER_R
## Warning: Setting row names on a tibble is deprecated.
## Warning in data.matrix(newdata): NAs introduced by coercion
## Warning: Setting row names on a tibble is deprecated.
## Warning in data.matrix(newdata): NAs introduced by coercion
## Warning: Setting row names on a tibble is deprecated.
## Warning in data.matrix(newdata): NAs introduced by coercion
## Warning: Setting row names on a tibble is deprecated.
## Warning in data.matrix(newdata): NAs introduced by coercion
## Warning: Setting row names on a tibble is deprecated.
## Warning in data.matrix(newdata): NAs introduced by coercion
## Warning: Setting row names on a tibble is deprecated.
## Warning in data.matrix(newdata): NAs introduced by coercion
## Warning: Setting row names on a tibble is deprecated.
## Warning in data.matrix(newdata): NAs introduced by coercion
## Warning: Setting row names on a tibble is deprecated.
## Warning in data.matrix(newdata): NAs introduced by coercion
## Warning: Setting row names on a tibble is deprecated.
## Warning in nominalTrainWorkflow(x = x, y = y, wts = weights, info =
trainInfo, :
## There were missing values in resampled performance measures.
```

```
## Warning: Setting row names on a tibble is deprecated.

model

## Naive Bayes
##
## 12 samples
## 2 predictor
## 2 classes: 'no', 'yes'
##
## No pre-processing
## Resampling: Cross-Validated (10 fold)
## Summary of sample sizes: 11, 10, 11, 11, 10, 10, ...
## Resampling results across tuning parameters:
##
## usekernel Accuracy Kappa
## FALSE      0.8750000 0
## TRUE       0.8333333 0
##
## Tuning parameter 'fL' was held constant at a value of 0
## Tuning
## parameter 'adjust' was held constant at a value of 1
## Accuracy was used to select the optimal model using the largest value.
## The final values used for the model were fL = 0, usekernel = FALSE and
adjust
## = 1.

model.pred <- predict(model$finalModel,x)

## Warning in data.matrix(newdata): NAs introduced by coercion

model.pred

## $class
## [1] no no no no no no no no no no no no no
## Levels: no yes
##
## $posterior
##           no           yes
## [1,] 0.6272018 0.3727982
## [2,] 0.8438158 0.1561842
## [3,] 0.8438158 0.1561842
## [4,] 0.6272018 0.3727982
## [5,] 0.6272018 0.3727982
## [6,] 0.8438158 0.1561842
## [7,] 0.8438158 0.1561842
## [8,] 0.6272018 0.3727982
## [9,] 0.8438158 0.1561842
## [10,] 0.8438158 0.1561842
## [11,] 0.8438158 0.1561842
## [12,] 0.6272018 0.3727982
```

```
table(model.pred$class,y)

##      y
##      no yes
## no    9   3
## yes   0   0

# Comparing this to exact Bayes classification
newdfprob$PREDICT_PROBNB <- model.pred$class
newdfprob

## # A tibble: 12 x 6
##   INJURY WEATHER_R TRAF_CON_R PROB_INJ PREDICT PREDICT_PROBNB
##   <chr>      <dbl>      <dbl>   <dbl> <chr>      <fct>
## 1 yes          1          0  0.667 YES      no
## 2 no           2          0  0.167 NO       no
## 3 no           2          1   0      NO       no
## 4 no           1          1   0      NO       no
## 5 no           1          0  0.667 YES      no
## 6 yes          2          0  0.167 NO       no
## 7 no           2          0  0.167 NO       no
## 8 yes          1          0  0.667 YES      no
## 9 no           2          0  0.167 NO       no
## 10 no          2          0  0.167 NO       no
## 11 no          2          0  0.167 NO       no
## 12 no          1          2   0      NO       no
```

## Question 8.2.c

### Task 8.2.c.i

```
set.seed(1)
train.index <- sample(c(1:dim(accidents)[1]), dim(accidents)[1]*0.6)
train.df <- accidents[train.index,]
valid.df <- accidents[-train.index,]
```

We can use predictors that describe the road condition and calendar time: HOUR\_I\_R, ALIGN\_I, WRK\_ZONE, WKDY\_I\_R, INT\_HWY, LGTCON\_I\_R, PROFIL\_I\_R SPD\_LIM, SUR\_CON, TRAF\_CON\_R, TRAF\_WAY, WEATHER\_R

### Task 8.2.c.ii

```
vars <- c("INJURY", "HOUR_I_R", "ALIGN_I", "WRK_ZONE", "WKDY_I_R",
          "INT_HWY", "LGTCON_I_R", "PROFIL_I_R", "SPD_LIM", "SUR_COND",
          "TRAF_CON_R", "TRAF_WAY", "WEATHER_R")
# Converting the columns of the dataframes in train.df and valid.df to
# factors
train.df[,vars] <- lapply(train.df[,vars], factor)
valid.df[,vars] <- lapply(valid.df[,vars], factor)
nbmodel <- naiveBayes(INJURY ~ ., data = train.df[,vars])
predictacc <- predict(nbmodel, train.df[,vars])
confusionMatrix(train.df$INJURY, predictacc, positive = 'yes')
```



no																	
##	[145]	no	no	no	yes	no	no	no	no	no	no	no	no	no	no	no	no
no																	
##	[163]	no	no	no	no	no	no	no	no	no	no	no	yes	no	yes	yes	yes
yes	no																
##	[181]	no	no	no	no	no	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no
yes	yes																
##	[199]	no	no	yes	no	yes	yes	yes	yes	no	no	yes	yes	yes	yes	yes	yes
no																	
##	[217]	no	yes	no	yes	yes	yes	yes	yes	yes	yes	yes	no	no	no	yes	no
no																	
##	[235]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no	no	no	yes	yes	yes
yes	no																
##	[253]	yes	yes	yes	yes	no	no	yes	yes	yes	yes	yes	no	no	no	no	yes
no																	
##	[271]	no	yes	no	yes	yes	no	yes	yes	no	yes	yes	no	yes	yes	no	yes
no																	
##	[289]	no	yes	yes	no	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
yes																	
##	[307]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
yes	yes																
##	[325]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no	no
yes	yes																
##	[343]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
yes	yes																
##	[361]	yes	yes	yes	yes	yes	yes	yes	no	no	yes	yes	yes	yes	yes	yes	yes
yes	yes																
##	[379]	yes	yes	no	yes	yes	yes	yes	yes	no	yes	yes	yes	yes	yes	yes	yes
yes	yes																
##	[397]	no	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no	no	yes	yes	yes
yes	yes																
##	[415]	yes	yes	yes	no	yes	yes	yes	yes	yes	yes	yes	yes	no	no	no	yes
yes	yes																
##	[433]	yes	yes	yes	no	yes	yes	no	yes	no	yes	no	yes	yes	yes	yes	yes
yes	yes																
##	[451]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
yes	yes																
##	[469]	yes	yes	yes	yes	yes	no	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
yes	yes																
##	[487]	yes	yes	yes	no	yes	yes	yes	yes	yes	no	yes	yes	yes	yes	yes	yes
yes	yes																
##	[505]	yes	yes	yes	yes	no	no	no	no	no	yes	yes	yes	yes	yes	yes	yes
yes	yes																
##	[523]	yes	yes	yes	yes	yes	yes	no	yes	yes	no	no	no	no	yes	yes	yes
yes	yes																
##	[541]	yes	yes	yes	yes	yes	yes	no	no	no	no	no	no	no	yes	yes	yes
yes	yes																
##	[559]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no	yes
yes	yes																
##	[577]	yes	yes	no	no	yes	yes	no	no	no	yes	yes	yes	yes	yes	yes	yes

yes	yes																
##	[595]	no	no	yes	yes	yes	no	yes	yes	no	no	no	no	no	no	yes	yes
yes	yes																
##	[613]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no
no																	no
##	[631]	no	yes	no	no	no	no	no	no	yes	no	no	no	no	no	no	no
no																	no
##	[649]	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no
no																	no
##	[667]	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no
no																	no
##	[685]	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no
no																	no
##	[703]	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no
no																	no
##	[721]	no	no	no	no	no	no	no	no	no	no	no	no	yes	no	no	no
no																	no
##	[739]	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no
yes																	no
##	[757]	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no
no																	no
##	[775]	no	yes	no	no	no	no	no	no	yes	no	no	no	no	no	no	no
no																	no
##	[793]	no	no	no	no	no	no	no	yes	no	no	no	no	no	no	no	no
no																	no
##	[811]	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no
no																	no
##	[829]	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no
no																	no
##	[847]	no	no	no	no	yes	no	no	no	no	no	no	no	no	no	no	no
no																	no
##	[865]	no	no	no	no	no	no	no	no	no	yes	no	no	no	no	no	no
no																	no
##	[883]	no	no	no	no	no	no	no	yes	no	no	yes	no	no	no	no	no
no																	no
##	[901]	no	no	yes	no	yes	yes	yes	no	no	no	no	yes	no	no	no	no
no																	no
##	[919]	no	yes	no	no	no	no	no	no	no	no	no	no	no	no	no	no
no																	no
##	[937]	no	no	no	no	no	no	no	no	yes	yes	yes	yes	yes	yes	yes	no
no																	no
##	[955]	no	no	no	no	no	yes	yes	yes	yes	yes	yes	yes	yes	yes	no	yes
no																	

yes	yes																
##	[1045]	yes	yes	yes	no	no	no	no	no	no	no	no	no	no	no	no	no
no																	
##	[1063]	no	yes	no	yes	no	no	yes	no	yes	no	no	no	yes	no	yes	yes
yes	no																
##	[1081]	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no
yes	no																
##	[1099]	no	no	no	no	no	yes	yes	no	no	no	no	no	yes	no	no	no
no																	
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no  
## [16327] yes no no no no no no yes no yes no no yes no no no



no																	
## [16345]	no	no	yes	no	yes	no	no	no	no	no	no	no	no	no	no	no	no
no																	
## [16363]	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no
no																	
## [16381]	no	no	no	no	no	no	no	no	no	no	yes	no	no	no	no	no	no
no																	
## [16399]	no	no	no	no	yes	no	no	no	no	no	no	no	yes	yes	yes	yes	yes
yes yes																	
## [16417]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
yes yes																	
## [16435]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
yes yes																	
## [16453]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
yes yes																	
## [16471]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
yes yes																	
## [16489]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
yes yes																	
## [16507]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
yes yes																	
## [16525]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
yes yes																	
## [16543]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
yes yes																	
## [16561]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
yes yes																	
## [16579]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
yes yes																	
## [16597]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
yes yes																	
## [16615]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
yes yes																	
## [16633]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
yes yes																	
## [16651]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
yes yes																	
## [16669]	yes	yes	yes	no	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
yes yes																	
## [16687]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
yes yes																	
## [16705]	yes	yes	yes														

```

yes yes
## [16795] yes yes yes yes yes yes yes yes yes yes yes yes yes yes yes
yes yes
## [16813] yes yes yes yes yes yes yes yes yes yes yes yes yes yes yes
yes yes
## [16831] yes yes yes yes yes yes yes yes yes yes yes yes yes yes yes
yes yes
## [16849] yes yes yes yes yes yes yes yes yes yes yes yes yes yes no no no
yes
## [16867] no no no yes no yes yes yes
## Levels: no yes

confusionMatrix(valid.df$INJURY,predictvalid,positive = 'yes')

## Confusion Matrix and Statistics
##
##              Reference
## Prediction    no  yes
##          no  3203 5016
##          yes 2862 5793
##
##              Accuracy : 0.5331
##              95% CI : (0.5256, 0.5407)
##      No Information Rate : 0.6406
##      P-Value [Acc > NIR] : 1
##
##              Kappa : 0.0594
##
##  Mcnemar's Test P-Value : <2e-16
##
##              Sensitivity : 0.5359
##              Specificity : 0.5281
##              Pos Pred Value : 0.6693
##              Neg Pred Value : 0.3897
##              Prevalence : 0.6406
##              Detection Rate : 0.3433
##      Detection Prevalence : 0.5129
##              Balanced Accuracy : 0.5320
##
##              'Positive' Class : yes
##

validerror <- 1 - 0.5331
validerrp <- scales::percent(validerror,0.01)
# Overall Error
validerrp
## [1] "46.69%"

```

### Task 8.2.c.iv

```
improvement.percent <- scales::percent(validerror-nerror, 0.01)
# Percent Improvement
improvement.percent

## [1] "0.72%"
```

### Task 8.2.c.v

```
nbmodel

##
## Naive Bayes Classifier for Discrete Predictors
##
## Call:
## naiveBayes.default(x = X, y = Y, laplace = laplace)
##
## A-priori probabilities:
## Y
##      no      yes
## 0.4939745 0.5060255
##
## Conditional probabilities:
##      HOUR_I_R
## Y      0      1
## no 0.5689490 0.4310510
## yes 0.5703131 0.4296869
##
##      ALIGN_I
## Y      1      2
## no 0.8712206 0.1287794
## yes 0.8652300 0.1347700
##
##      WRK_ZONE
## Y      0      1
## no 0.97664374 0.02335626
## yes 0.97727805 0.02272195
##
##      WKDY_I_R
## Y      0      1
## no 0.2194049 0.7805951
## yes 0.2381510 0.7618490
##
##      INT_HWY
## Y      0      1      9
## no 0.8513837786 0.1481362982 0.0004799232
## yes 0.8593737800 0.1397673147 0.0008589053
##
##      LGTCON_I_R
## Y      1      2      3
## no 0.6870101 0.1251000 0.1878899
```

```

## yes 0.7014914 0.1096275 0.1888811
##
## PROFIL_I_R
## Y 0 1
## no 0.7531595 0.2468405
## yes 0.7633326 0.2366674
##
## SPD_LIM
## Y 5 10 15 20 25
## no 0.0000799872 0.0004799232 0.0043992961 0.0085586306 0.1121420573
## yes 0.0001561646 0.0003123292 0.0040602795 0.0039041149 0.0906535488
## SPD_LIM
## Y 30 35 40 45 50
## no 0.0860662294 0.1896496561 0.0962246041 0.1553351464 0.0407934730
## yes 0.0860466932 0.2123057703 0.1068946670 0.1574139143 0.0394315609
## SPD_LIM
## Y 55 60 65 70 75
## no 0.1590145577 0.0355143177 0.0645496721 0.0409534474 0.0062390018
## yes 0.1549152807 0.0430233466 0.0621535098 0.0311548372 0.0075739830
##
## SUR_COND
## Y 1 2 3 4 9
## no 0.774196129 0.176931691 0.016717325 0.028155495 0.003999360
## yes 0.815725775 0.151245413 0.010697275 0.016709612 0.005621926
##
## TRAF_CON_R
## Y 0 1 2
## no 0.6566149 0.1902096 0.1531755
## yes 0.6213009 0.2191770 0.1595221
##
## TRAF_WAY
## Y 1 2 3
## no 0.57998720 0.36690130 0.05311150
## yes 0.56063090 0.39743890 0.04193019
##
## WEATHER_R
## Y 1 2
## no 0.8390657 0.1609343
## yes 0.8744437 0.1255563

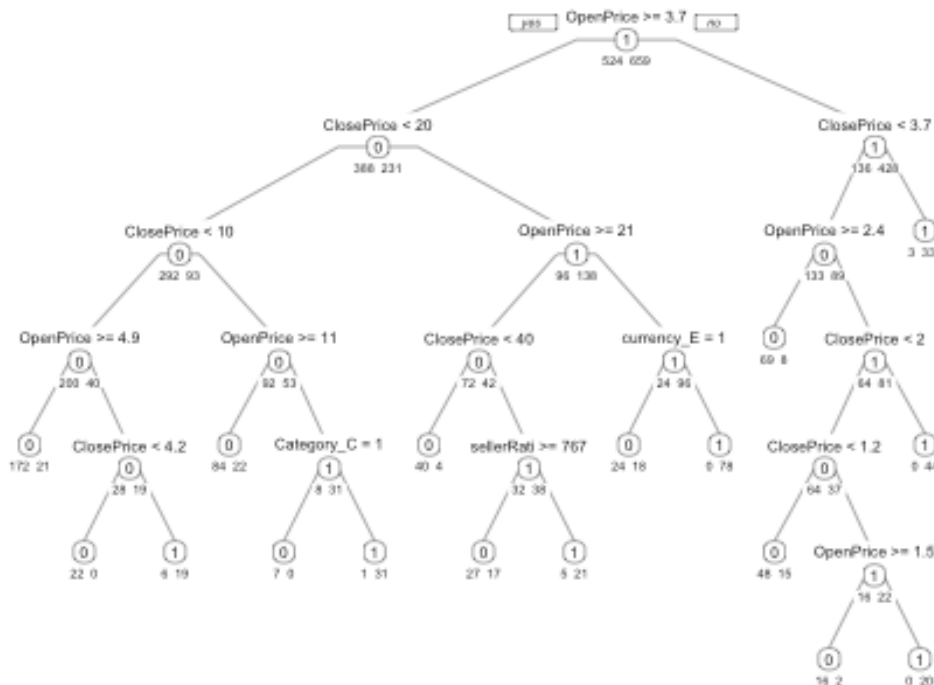
```

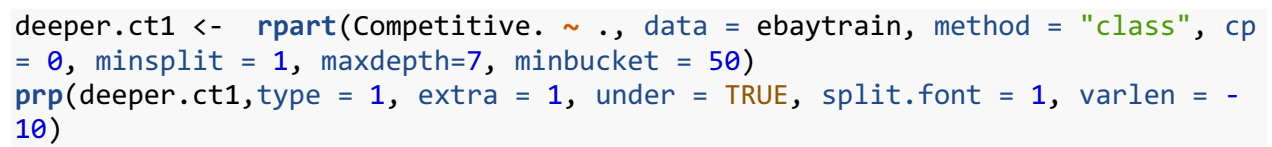
From the conditionoal probability output, we can see that  $P(\text{INJURY} = \text{No} \mid \text{SPD\_LIM} = 5)$  is 0.0000799872, which is a really small value that's close to zero. Since we cannot rule out the possibility of inflicting injury, that's why the probability is equal to 0.0000799872. Since, the car is such at a low speed, it makes sense to say that there will be no injury.

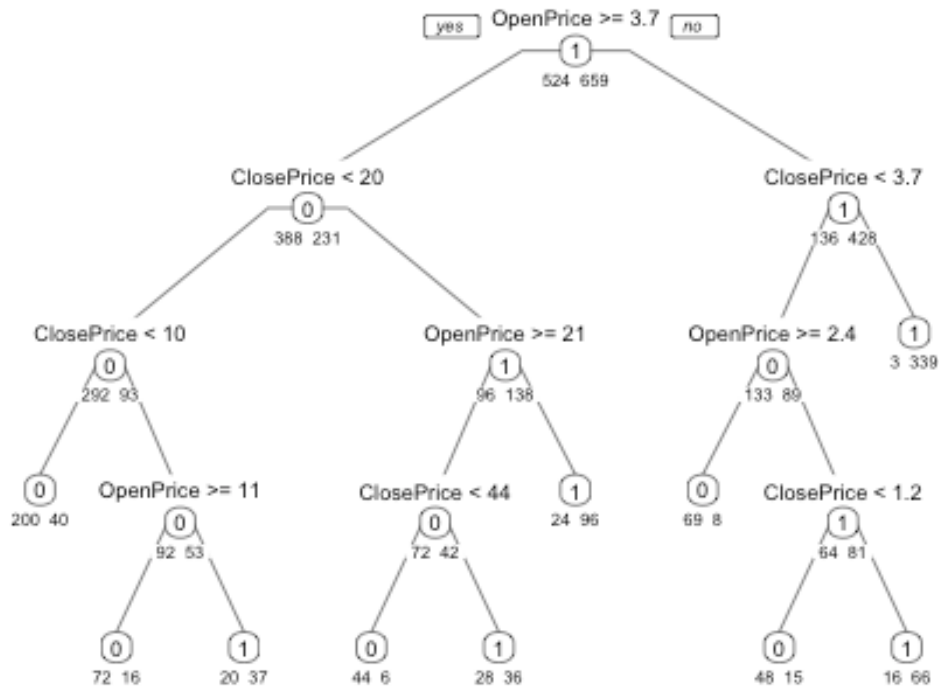
## Problem 9.1

### Question 9.1.a

```
ebay <- fastDummies::dummy_cols(eBayAuctions, select_columns = "Category")
ebay <- ebay[, -1]
ebay <- fastDummies::dummy_cols(ebay, select_columns = "currency")
ebay <- ebay[, -1]
ebay <- fastDummies::dummy_cols(ebay, select_columns = "endDay")
ebay <- ebay[, -3]
set.seed(1)
ebaytrainindex <- sample(c(1:dim(ebay)[1]), dim(ebay)[1]*0.6)
ebaytrain <- ebay[ebaytrainindex,]
ebayvalid <- ebay[-ebaytrainindex,]
default.ct <- rpart(Competitive. ~ ., data = ebaytrain, method = "class")
prp(default.ct, type = 1, extra = 1, under = TRUE, split.font = 1, varlen = -10)
```





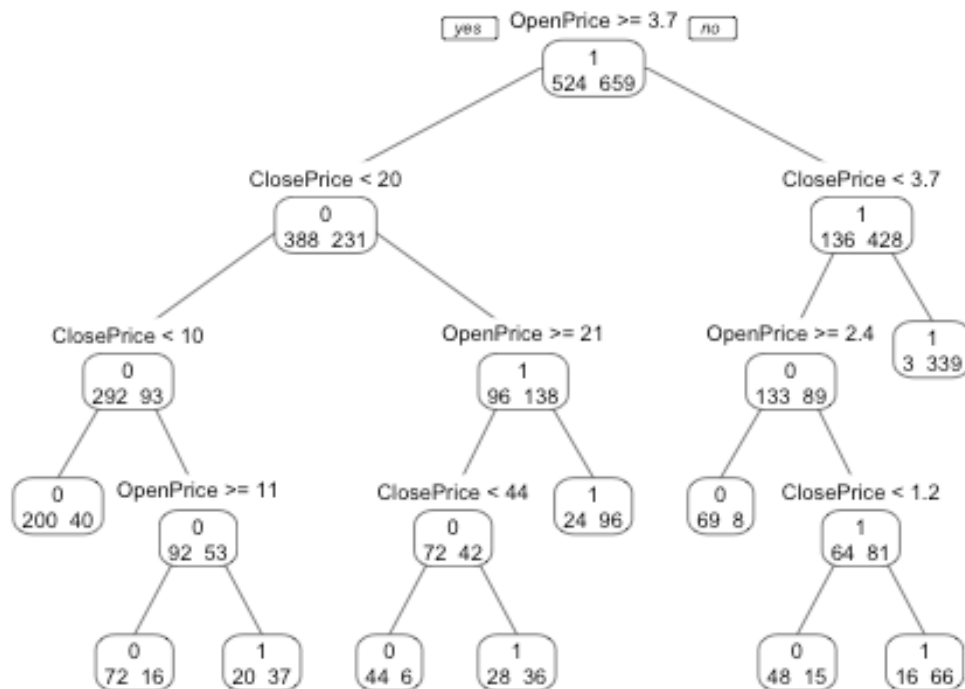


###Create a pruned tree, prune on the Lowest xerror value

```

prunedtree = prune(deeper.ct1, cp=
deeper.ct1$cptable[which.min(deeper.ct1$cptable[, "xerror"]), "CP"])
prp(prunedtree, type= 1, extra = 1, split.font=1, varlen=-10)

```



```
summary(prunedtree)
```

```
## Call:
## rpart(formula = Competitive. ~ ., data = ebaytrain, method = "class",
##       cp = 0, minsplit = 1, maxdepth = 7, minbucket = 50)
##   n = 1183
##
##           CP nsplit rel error   xerror   xstd
## 1 0.29961832    0 1.0000000 1.0000000 0.03260504
## 2 0.08396947    1 0.7003817 0.7500000 0.03091620
## 3 0.08015267    2 0.6164122 0.6564885 0.02980825
## 4 0.05725191    3 0.5362595 0.5916031 0.02886452
## 5 0.04770992    4 0.4790076 0.4866412 0.02699109
## 6 0.01622137    6 0.3835878 0.4045802 0.02517410
## 7 0.01526718    8 0.3511450 0.4083969 0.02526650
## 8 0.00000000    9 0.3358779 0.3702290 0.02430387
##
## Variable importance
##           ClosePrice           OpenPrice
##                41                32
##      currency_US      currency_EUR
##                5                5
##      sellerRating      Duration
```



```

##           4           3
##      Category_Automotive      endDay_Mon
##           2           2
##      Category_Books Category_Antique/Art/Craft
##           1           1
##      Category_Toys/Hobbies      endDay_Tue
##           1           1
##
## Node number 1: 1183 observations,      complexity param=0.2996183
##   predicted class=1   expected loss=0.4429417   P(node) =1
##   class counts:   524   659
##   probabilities: 0.443 0.557
##   left son=2 (619 obs) right son=3 (564 obs)
##   Primary splits:
##       OpenPrice    < 3.685   to the right, improve=87.796120, (0 missing)
##       sellerRating < 3291.5 to the right, improve=31.795140, (0 missing)
##       ClosePrice   < 20.015 to the left,  improve=30.371070, (0 missing)
##       endDay_Mon   < 0.5     to the left,  improve=18.236450, (0 missing)
##       Duration     < 6       to the right, improve= 9.020225, (0 missing)
##   Surrogate splits:
##       ClosePrice   < 3.87    to the right, agree=0.724, adj=0.422, (0
split)
##       currency_US  < 0.5     to the right, agree=0.630, adj=0.223, (0
split)
##       currency_EUR < 0.5     to the left,  agree=0.604, adj=0.168, (0
split)
##       endDay_Mon   < 0.5     to the left,  agree=0.585, adj=0.129, (0
split)
##       Duration     < 8.5     to the left,  agree=0.584, adj=0.128, (0
split)
##
## Node number 2: 619 observations,      complexity param=0.08015267
##   predicted class=0   expected loss=0.3731826   P(node) =0.523246
##   class counts:   388   231
##   probabilities: 0.627 0.373
##   left son=4 (385 obs) right son=5 (234 obs)
##   Primary splits:
##       ClosePrice           < 20.195 to the left,  improve=35.288760, (0
missing)
##       sellerRating          < 562    to the right, improve=19.401220, (0
missing)
##       OpenPrice             < 9.895   to the left,  improve= 6.751646, (0
missing)
##       Category_Toys/Hobbies < 0.5     to the left,  improve= 5.474394, (0
missing)
##       endDay_Mon            < 0.5     to the left,  improve= 1.902447, (0
missing)
##   Surrogate splits:
##       OpenPrice           < 19.97   to the left,  agree=0.811,
adj=0.500, (0 split)

```

```

##      Category_Automotive    < 0.5    to the left,  agree=0.677,
adj=0.145, (0 split)
##      sellerRating           < 603    to the right, agree=0.670,
adj=0.128, (0 split)
##      Category_Electronics   < 0.5    to the left,  agree=0.638,
adj=0.043, (0 split)
##      Category_Pottery/Glass < 0.5    to the left,  agree=0.632,
adj=0.026, (0 split)
##
## Node number 3: 564 observations,    complexity param=0.08396947
## predicted class=1 expected loss=0.2411348 P(node) =0.476754
## class counts:   136   428
## probabilities: 0.241 0.759
## left son=6 (222 obs) right son=7 (342 obs)
## Primary splits:
##      ClosePrice             < 3.685  to the left,  improve=93.824340, (0
missing)
##      OpenPrice              < 1.805  to the right, improve=15.102490, (0
missing)
##      Duration               < 6      to the right, improve=12.714280, (0
missing)
##      sellerRating           < 3263   to the right, improve= 8.780467, (0
missing)
##      Category_Toys/Hobbies  < 0.5    to the right, improve= 6.192000, (0
missing)
## Surrogate splits:
##      Category_Books         < 0.5    to the right, agree=0.631,
adj=0.063, (0 split)
##      Category_Toys/Hobbies  < 0.5    to the right, agree=0.621,
adj=0.036, (0 split)
##      sellerRating           < 2483   to the right, agree=0.613,
adj=0.018, (0 split)
##      Category_Health/Beauty < 0.5    to the right, agree=0.612,
adj=0.014, (0 split)
##      endDay_Sat             < 0.5    to the right, agree=0.610,
adj=0.009, (0 split)
##
## Node number 4: 385 observations,    complexity param=0.01622137
## predicted class=0 expected loss=0.2415584 P(node) =0.3254438
## class counts:   292   93
## probabilities: 0.758 0.242
## left son=8 (240 obs) right son=9 (145 obs)
## Primary splits:
##      ClosePrice             < 10     to the left,  improve=7.1482910, (0
missing)
##      Category_Toys/Hobbies  < 0.5    to the left,  improve=4.2361510, (0
missing)
##      OpenPrice              < 4.935  to the right, improve=3.6593840, (0
missing)
##      sellerRating           < 577    to the right, improve=2.7267260, (0

```

```

missing)
##      endDay_Sat          < 0.5    to the left,  improve=0.5686656, (0
missing)
##      Surrogate splits:
##      OpenPrice          < 10.47  to the left,  agree=0.901, adj=0.738,
(0 split)
##      sellerRating       < 4427.5 to the left,  agree=0.696, adj=0.193,
(0 split)
##      Category_Automotive < 0.5    to the left,  agree=0.647, adj=0.062,
(0 split)
##      Category_Jewelry   < 0.5    to the left,  agree=0.647, adj=0.062,
(0 split)
##      Duration          < 4       to the right, agree=0.642, adj=0.048,
(0 split)
##
## Node number 5: 234 observations,    complexity param=0.05725191
## predicted class=1 expected loss=0.4102564 P(node) =0.1978022
## class counts:    96   138
## probabilities: 0.410 0.590
## left son=10 (114 obs) right son=11 (120 obs)
## Primary splits:
##      OpenPrice          < 20.5    to the right, improve=21.778140, (0
missing)
##      Category_Automotive < 0.5    to the right, improve= 8.581506, (0
missing)
##      sellerRating       < 990.5   to the right, improve= 8.485962, (0
missing)
##      ClosePrice        < 39.995   to the left,  improve= 3.460277, (0
missing)
##      endDay_Mon        < 0.5      to the left,  improve= 1.539547, (0
missing)
##      Surrogate splits:
##      Category_Automotive < 0.5    to the right, agree=0.697, adj=0.377,
(0 split)
##      currency_US       < 0.5      to the right, agree=0.667, adj=0.316,
(0 split)
##      currency_EUR      < 0.5      to the left,  agree=0.654, adj=0.289,
(0 split)
##      ClosePrice        < 29.725   to the right, agree=0.620, adj=0.219,
(0 split)
##      sellerRating       < 2179.5  to the right, agree=0.615, adj=0.211,
(0 split)
##
## Node number 6: 222 observations,    complexity param=0.04770992
## predicted class=0 expected loss=0.4009009 P(node) =0.1876585
## class counts:    133   89
## probabilities: 0.599 0.401
## left son=12 (77 obs) right son=13 (145 obs)
## Primary splits:
##      OpenPrice          < 2.445    to the right, improve=20.798530,

```

```

(0 missing)
##      Duration          < 6      to the right, improve=11.614950,
(0 missing)
##      Category_Music/Movie/Game < 0.5    to the left,  improve= 6.984001,
(0 missing)
##      sellerRating          < 3263    to the right, improve= 6.271213,
(0 missing)
##      currency_EUR          < 0.5     to the right, improve= 5.560722,
(0 missing)
##      Surrogate splits:
##      ClosePrice            < 2.39    to the right, agree=0.842,
adj=0.545, (0 split)
##      Category_Antique/Art/Craft < 0.5    to the right, agree=0.716,
adj=0.182, (0 split)
##      sellerRating          < 3377.5  to the right, agree=0.703,
adj=0.143, (0 split)
##      endDay_Fri            < 0.5     to the right, agree=0.698,
adj=0.130, (0 split)
##      Category_Health/Beauty   < 0.5    to the right, agree=0.671,
adj=0.052, (0 split)
##
## Node number 7: 342 observations
##   predicted class=1 expected loss=0.00877193 P(node) =0.2890955
##   class counts:      3    339
##   probabilities: 0.009 0.991
##
## Node number 8: 240 observations
##   predicted class=0 expected loss=0.1666667 P(node) =0.202874
##   class counts:    200    40
##   probabilities: 0.833 0.167
##
## Node number 9: 145 observations,    complexity param=0.01622137
##   predicted class=0 expected loss=0.3655172 P(node) =0.1225697
##   class counts:     92    53
##   probabilities: 0.634 0.366
##   left son=18 (88 obs) right son=19 (57 obs)
##   Primary splits:
##   OpenPrice    < 11.285 to the right, improve=15.108440, (0 missing)
##   ClosePrice   < 13.855 to the right, improve= 4.762865, (0 missing)
##   sellerRating < 3820.5 to the right, improve= 2.000270, (0 missing)
##   Duration     < 6      to the left,  improve= 1.925177, (0 missing)
##   Surrogate splits:
##   ClosePrice            < 11.815 to the right, agree=0.807,
adj=0.509, (0 split)
##   currency_EUR          < 0.5     to the left,  agree=0.703,
adj=0.246, (0 split)
##   currency_US          < 0.5     to the right, agree=0.703,
adj=0.246, (0 split)
##   Duration            < 8.5     to the left,  agree=0.655,
adj=0.123, (0 split)

```

```

##      Category_SportingGoods < 0.5      to the left,  agree=0.648,
adj=0.105, (0 split)
##
## Node number 10: 114 observations,      complexity param=0.01526718
## predicted class=0 expected loss=0.3684211 P(node) =0.09636517
## class counts:      72      42
## probabilities: 0.632 0.368
## left son=20 (50 obs) right son=21 (64 obs)
## Primary splits:
##      ClosePrice < 43.64 to the left,  improve=10.992630, (0 missing)
##      sellerRating < 1074 to the right, improve= 2.737039, (0 missing)
##      OpenPrice < 44.225 to the left,  improve= 2.413674, (0 missing)
##      Duration < 6 to the left,  improve= 1.043947, (0 missing)
## Surrogate splits:
##      OpenPrice < 44.225 to the left,  agree=0.895,
adj=0.76, (0 split)
##      sellerRating < 2998 to the right, agree=0.667,
adj=0.24, (0 split)
##      Duration < 4 to the left,  agree=0.614,
adj=0.12, (0 split)
##      Category_Jewelry < 0.5 to the right, agree=0.579,
adj=0.04, (0 split)
##      Category_Music/Movie/Game < 0.5 to the right, agree=0.579,
adj=0.04, (0 split)
##
## Node number 11: 120 observations
## predicted class=1 expected loss=0.2 P(node) =0.101437
## class counts:      24      96
## probabilities: 0.200 0.800
##
## Node number 12: 77 observations
## predicted class=0 expected loss=0.1038961 P(node) =0.06508876
## class counts:      69      8
## probabilities: 0.896 0.104
##
## Node number 13: 145 observations,      complexity param=0.04770992
## predicted class=1 expected loss=0.4413793 P(node) =0.1225697
## class counts:      64      81
## probabilities: 0.441 0.559
## left son=26 (63 obs) right son=27 (82 obs)
## Primary splits:
##      ClosePrice < 1.24 to the left,  improve=22.890210, (0 missing)
##      currency_EUR < 0.5 to the right, improve= 4.869764, (0 missing)
##      Duration < 6 to the right, improve= 4.606012, (0 missing)
##      OpenPrice < 1.035 to the right, improve= 3.297679, (0 missing)
##      endDay_Mon < 0.5 to the left,  improve= 1.630721, (0 missing)
## Surrogate splits:
##      OpenPrice < 1.24 to the left,  agree=0.683, adj=0.270, (0
split)
##      Duration < 8.5 to the right, agree=0.655, adj=0.206, (0

```

```

split)
##      currency_EUR < 0.5      to the right, agree=0.621, adj=0.127, (0
split)
##      endDay_Tue   < 0.5      to the right, agree=0.621, adj=0.127, (0
split)
##      sellerRating < 5496.5 to the right, agree=0.614, adj=0.111, (0
split)
##
## Node number 18: 88 observations
##   predicted class=0   expected loss=0.1818182   P(node) =0.07438715
##   class counts:      72      16
##   probabilities: 0.818 0.182
##
## Node number 19: 57 observations
##   predicted class=1   expected loss=0.3508772   P(node) =0.04818259
##   class counts:       20      37
##   probabilities: 0.351 0.649
##
## Node number 20: 50 observations
##   predicted class=0   expected loss=0.12   P(node) =0.04226543
##   class counts:       44      6
##   probabilities: 0.880 0.120
##
## Node number 21: 64 observations
##   predicted class=1   expected loss=0.4375   P(node) =0.05409975
##   class counts:       28      36
##   probabilities: 0.438 0.562
##
## Node number 26: 63 observations
##   predicted class=0   expected loss=0.2380952   P(node) =0.05325444
##   class counts:       48      15
##   probabilities: 0.762 0.238
##
## Node number 27: 82 observations
##   predicted class=1   expected loss=0.195122   P(node) =0.0693153
##   class counts:       16      66
##   probabilities: 0.195 0.805

### Predicting using the model

predtree = predict(prunedtree, ebayvalid, type="class")
confusionMatrix(predtree, (as.factor(ebayvalid$Competitive.)))

## Confusion Matrix and Statistics
##
##              Reference
## Prediction    0    1
##              0 286  57
##              1  96 350
##

```



```
#if(closeprice<3)
  #label:0
#else
  #label:1
```

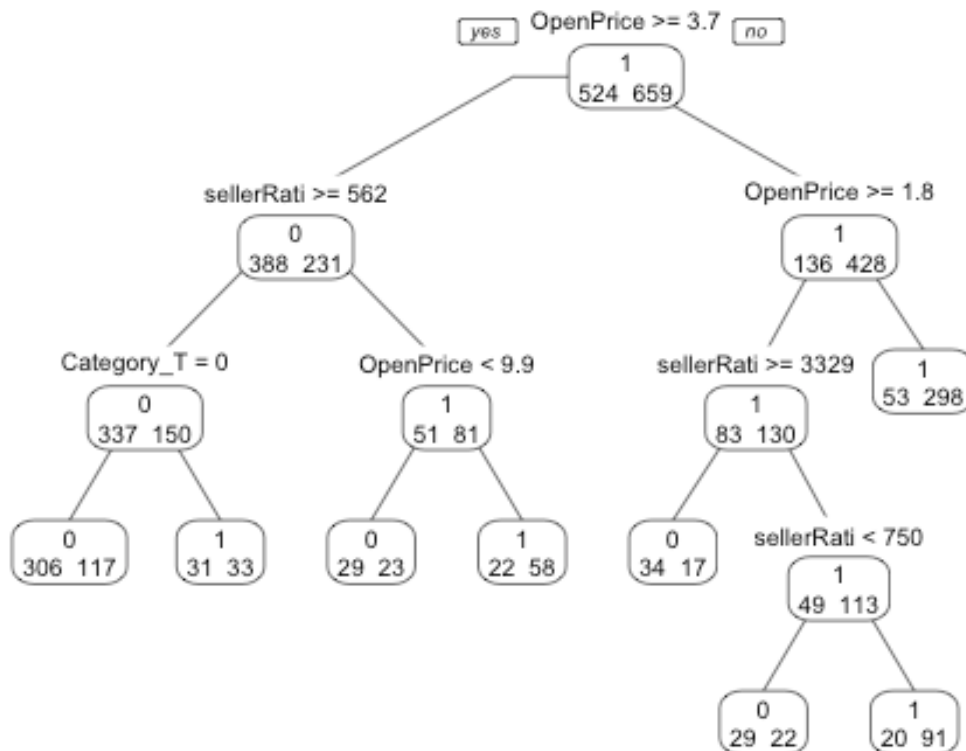
*#The rules show that not all variables have the same importance to determine the competitiveness of the auction. Prices and Seller rating hold the most importance.*

### Question 9.1.d

```
prunedtree2 = rpart(formula = Competitive. ~
OpenPrice+sellerRating+`Category_Music/Movie/Game`+
Category_Automotive+Category_SportingGoods+`Category_Home/Garden`+
Category_Books+Category_Collectibles+`Category_Business/Industrial`+
`Category_Toys/Hobbies`+Category_Electronics
+Category_Computer+
Category_EverythingElse+`Category_Clothing/Accessories`
+
`Category_Coins/Stamps`+`Category_Antique/Art/Craft`+
Category_Jewelry+`Category_Pottery/Glass`+`Category_Health/Beauty`+
Category_Photography+currency_US+currency_GBP+currency_EUR+Duration+
endDay_Mon+endDay_Tue+endDay_Wed+endDay_Thu+endDay_Fri+
endDay_Sat+endDay_Sun, data = ebaytrain, method =
"class", cp = 0, minsplit = 1, maxdepth=7, minbucket = 50)

prunedtree2 = prune(prunedtree2, cp=
prunedtree2$cptable[which.min(prunedtree2$cptable[, "xerror"]), "CP"])
prp(prunedtree2, type= 1, extra = 1, split.font=1, varlen=-10)
```





```
summary(prunedtree2)
```

```
## Call:
## rpart(formula = Competitive. ~ OpenPrice + sellerRating +
##   `Category_Music/Movie/Game` +
##   Category_Automotive + Category_SportingGoods + `Category_Home/Garden`
##   +
##   Category_Books + Category_Collectibles +
##   `Category_Business/Industrial` +
##   `Category_Toys/Hobbies` + Category_Electronics + Category_Computer +
##   Category_EverythingElse + `Category_Clothing/Accessories` +
##   `Category_Coins/Stamps` + `Category_Antique/Art/Craft` +
##   Category_Jewelry + `Category_Pottery/Glass` + `Category_Health/Beauty`
##   +
##   Category_Photography + currency_US + currency_GBP + currency_EUR +
##   Duration + endDay_Mon + endDay_Tue + endDay_Wed + endDay_Thu +
##   endDay_Fri + endDay_Sat + endDay_Sun, data = ebaytrain, method =
## "class",
##   cp = 0, minsplit = 1, maxdepth = 7, minbucket = 50)
##   n= 1183
##
##           CP nsplit rel error   xerror   xstd
## 1 0.299618321    0 1.0000000 1.0000000 0.03260504
```

```

## 2 0.057251908      1 0.7003817 0.7251908 0.03064968
## 3 0.016221374      2 0.6431298 0.6755725 0.03005766
## 4 0.013358779      4 0.6106870 0.6793893 0.03010607
## 5 0.011450382      5 0.5973282 0.6908397 0.03024839
## 6 0.003816794      6 0.5858779 0.6908397 0.03024839
## 7 0.000000000      7 0.5820611 0.6679389 0.02995938
##
## Variable importance
##               OpenPrice               sellerRating
##               43                16
##               currency_US           currency_EUR
##               8                  6
##               Duration  Category_Music/Movie/Game
##               6                5
##               endDay_Mon    Category_Toys/Hobbies
##               5                4
## Category_Antique/Art/Craft           currency_GBP
##               2                  1
##               endDay_Sat             endDay_Thu
##               1                  1
##               endDay_Fri
##               1
##
## Node number 1: 1183 observations,    complexity param=0.2996183
##   predicted class=1 expected loss=0.4429417 P(node) =1
##   class counts:   524   659
##   probabilities: 0.443 0.557
##   left son=2 (619 obs) right son=3 (564 obs)
##   Primary splits:
##       OpenPrice          < 3.685   to the right, improve=87.796120, (0
missing)
##       sellerRating       < 3291.5 to the right, improve=31.795140, (0
missing)
##       endDay_Mon         < 0.5     to the left,  improve=18.236450, (0
missing)
##       Duration           < 6       to the right, improve= 9.020225, (0
missing)
##       Category_Automotive < 0.5    to the right, improve= 5.774742, (0
missing)
##   Surrogate splits:
##       currency_US        < 0.5     to the right, agree=0.630,
adj=0.223, (0 split)
##       currency_EUR       < 0.5     to the left,  agree=0.604,
adj=0.168, (0 split)
##       endDay_Mon         < 0.5     to the left,  agree=0.585,
adj=0.129, (0 split)
##       Duration           < 8.5     to the left,  agree=0.584,
adj=0.128, (0 split)
##       Category_Music/Movie/Game < 0.5 to the left,  agree=0.569,
adj=0.096, (0 split)

```

```

##
## Node number 2: 619 observations,    complexity param=0.05725191
##   predicted class=0   expected loss=0.3731826   P(node) =0.523246
##   class counts:    388    231
##   probabilities: 0.627 0.373
##   left son=4 (487 obs) right son=5 (132 obs)
##   Primary splits:
##       sellerRating          < 562    to the right, improve=19.401220, (0
missing)
##       OpenPrice             < 9.895  to the left,  improve= 6.751646, (0
missing)
##       Category_Toys/Hobbies < 0.5    to the left,  improve= 5.474394, (0
missing)
##       endDay_Mon            < 0.5    to the left,  improve= 1.902447, (0
missing)
##       Category_Collectibles < 0.5    to the left,  improve= 1.716101, (0
missing)
##   Surrogate splits:
##       currency_GBP < 0.5    to the left,  agree=0.801, adj=0.068, (0
split)
##       endDay_Thu    < 0.5    to the left,  agree=0.795, adj=0.038, (0
split)
##
## Node number 3: 564 observations,    complexity param=0.01622137
##   predicted class=1   expected loss=0.2411348   P(node) =0.476754
##   class counts:    136    428
##   probabilities: 0.241 0.759
##   left son=6 (213 obs) right son=7 (351 obs)
##   Primary splits:
##       OpenPrice             < 1.805  to the right, improve=15.102490, (0
missing)
##       Duration              < 6       to the right, improve=12.714280, (0
missing)
##       sellerRating          < 3263   to the right, improve= 8.780467, (0
missing)
##       Category_Toys/Hobbies < 0.5    to the right, improve= 6.192000, (0
missing)
##       endDay_Mon            < 0.5    to the left, improve= 6.053778, (0
missing)
##   Surrogate splits:
##       Category_Antique/Art/Craft < 0.5    to the right, agree=0.732,
adj=0.291, (0 split)
##       Duration              < 6       to the right, agree=0.690,
adj=0.178, (0 split)
##       endDay_Fri            < 0.5    to the right, agree=0.667,
adj=0.117, (0 split)
##       Category_Toys/Hobbies < 0.5    to the right, agree=0.654,
adj=0.085, (0 split)
##       sellerRating          < 3377.5 to the right, agree=0.633,
adj=0.028, (0 split)

```

```

##
## Node number 4: 487 observations,    complexity param=0.003816794
## predicted class=0 expected loss=0.3080082 P(node) =0.4116653
## class counts: 337 150
## probabilities: 0.692 0.308
## left son=8 (423 obs) right son=9 (64 obs)
## Primary splits:
## Category_Toys/Hobbies < 0.5 to the left, improve=6.352190, (0
missing)
## endDay_Mon < 0.5 to the left, improve=2.875117, (0
missing)
## OpenPrice < 9.895 to the left, improve=2.487823, (0
missing)
## sellerRating < 4336.5 to the right, improve=2.175189, (0
missing)
## Category_Collectibles < 0.5 to the left, improve=1.401587, (0
missing)
## Surrogate splits:
## Duration < 2 to the right, agree=0.873, adj=0.031, (0 split)
##
## Node number 5: 132 observations,    complexity param=0.01145038
## predicted class=1 expected loss=0.3863636 P(node) =0.1115807
## class counts: 51 81
## probabilities: 0.386 0.614
## left son=10 (52 obs) right son=11 (80 obs)
## Primary splits:
## OpenPrice < 9.915 to the left, improve=5.037063, (0 missing)
## sellerRating < 113.5 to the right, improve=4.455299, (0 missing)
## currency_US < 0.5 to the left, improve=3.544311, (0 missing)
## Surrogate splits:
## Category_Music/Movie/Game < 0.5 to the right, agree=0.758,
adj=0.385, (0 split)
## endDay_Thu < 0.5 to the right, agree=0.712,
adj=0.269, (0 split)
## currency_GBP < 0.5 to the right, agree=0.682,
adj=0.192, (0 split)
## currency_US < 0.5 to the left, agree=0.667,
adj=0.154, (0 split)
## Duration < 8.5 to the right, agree=0.636,
adj=0.077, (0 split)
##
## Node number 6: 213 observations,    complexity param=0.01622137
## predicted class=1 expected loss=0.3896714 P(node) =0.1800507
## class counts: 83 130
## probabilities: 0.390 0.610
## left son=12 (51 obs) right son=13 (162 obs)
## Primary splits:
## sellerRating < 3328.5 to the right,
improve=10.2898600, (0 missing)
## OpenPrice < 3.585 to the left, improve=

```

```

8.7116640, (0 missing)
##      Category_Antique/Art/Craft < 0.5    to the left, improve=
5.6831610, (0 missing)
##      Duration                    < 8.5    to the left, improve=
0.4206673, (0 missing)
##      currency_US                 < 0.5    to the left, improve=
0.2727624, (0 missing)
##      Surrogate splits:
##      endDay_Sat                  < 0.5    to the right, agree=0.812,
adj=0.216, (0 split)
##      Category_Toys/Hobbies      < 0.5    to the right, agree=0.803,
adj=0.176, (0 split)
##      Category_Coins/Stamps     < 0.5    to the right, agree=0.789,
adj=0.118, (0 split)
##      Category_Electronics      < 0.5    to the right, agree=0.784,
adj=0.098, (0 split)
##      Category_SportingGoods    < 0.5    to the right, agree=0.779,
adj=0.078, (0 split)
##
## Node number 7: 351 observations
##   predicted class=1   expected loss=0.1509972   P(node) =0.2967033
##   class counts:      53    298
##   probabilities: 0.151 0.849
##
## Node number 8: 423 observations
##   predicted class=0   expected loss=0.2765957   P(node) =0.3575655
##   class counts:      306    117
##   probabilities: 0.723 0.277
##
## Node number 9: 64 observations
##   predicted class=1   expected loss=0.484375    P(node) =0.05409975
##   class counts:       31     33
##   probabilities: 0.484 0.516
##
## Node number 10: 52 observations
##   predicted class=0   expected loss=0.4423077   P(node) =0.04395604
##   class counts:       29     23
##   probabilities: 0.558 0.442
##
## Node number 11: 80 observations
##   predicted class=1   expected loss=0.275    P(node) =0.06762468
##   class counts:       22     58
##   probabilities: 0.275 0.725
##
## Node number 12: 51 observations
##   predicted class=0   expected loss=0.3333333   P(node) =0.04311074
##   class counts:       34     17
##   probabilities: 0.667 0.333
##
## Node number 13: 162 observations,      complexity param=0.01335878

```

```

## predicted class=1 expected loss=0.3024691 P(node) =0.13694
## class counts: 49 113
## probabilities: 0.302 0.698
## left son=26 (51 obs) right son=27 (111 obs)
## Primary splits:
## sellerRating < 750 to the left, improve=10.545620,
(0 missing)
## OpenPrice < 3.585 to the left, improve= 4.171749,
(0 missing)
## currency_US < 0.5 to the left, improve= 2.420448,
(0 missing)
## Category_Antique/Art/Craft < 0.5 to the left, improve= 2.383186,
(0 missing)
## currency_EUR < 0.5 to the right, improve= 2.030186,
(0 missing)
## Surrogate splits:
## Category_Music/Movie/Game < 0.5 to the right, agree=0.747,
adj=0.196, (0 split)
## Category_Clothing/Accessories < 0.5 to the right, agree=0.722,
adj=0.118, (0 split)
## endDay_Wed < 0.5 to the right, agree=0.716,
adj=0.098, (0 split)
## currency_US < 0.5 to the left, agree=0.710,
adj=0.078, (0 split)
## currency_EUR < 0.5 to the right, agree=0.710,
adj=0.078, (0 split)
##
## Node number 26: 51 observations
## predicted class=0 expected loss=0.4313725 P(node) =0.04311074
## class counts: 29 22
## probabilities: 0.569 0.431
##
## Node number 27: 111 observations
## predicted class=1 expected loss=0.1801802 P(node) =0.09382925
## class counts: 20 91
## probabilities: 0.180 0.820

```

*# Describing the tree*

*## Shortest set of rules required for classification is Openprice>=3.6 and Duration>=6*

```

#if(openprice>=3.6)
  #if(duration>=6)
    #label:0
  #else
    #label:1
#else
  #if(sellerrating>=589)
    #if(OpenPrice<9)
      #label:0
    
```

```

#else
#label:1
#else
#label:1

```

## Question 9.1.e

```

predtree2 = predict(prunedtree2, ebayvalid, type="class")
summary(predtree2)

##    0    1
## 381 408

x = confusionMatrix(predtree2, (as.factor(ebayvalid$Competitive.)))
sensitivity(predtree2, as.factor(ebayvalid$Competitive.))

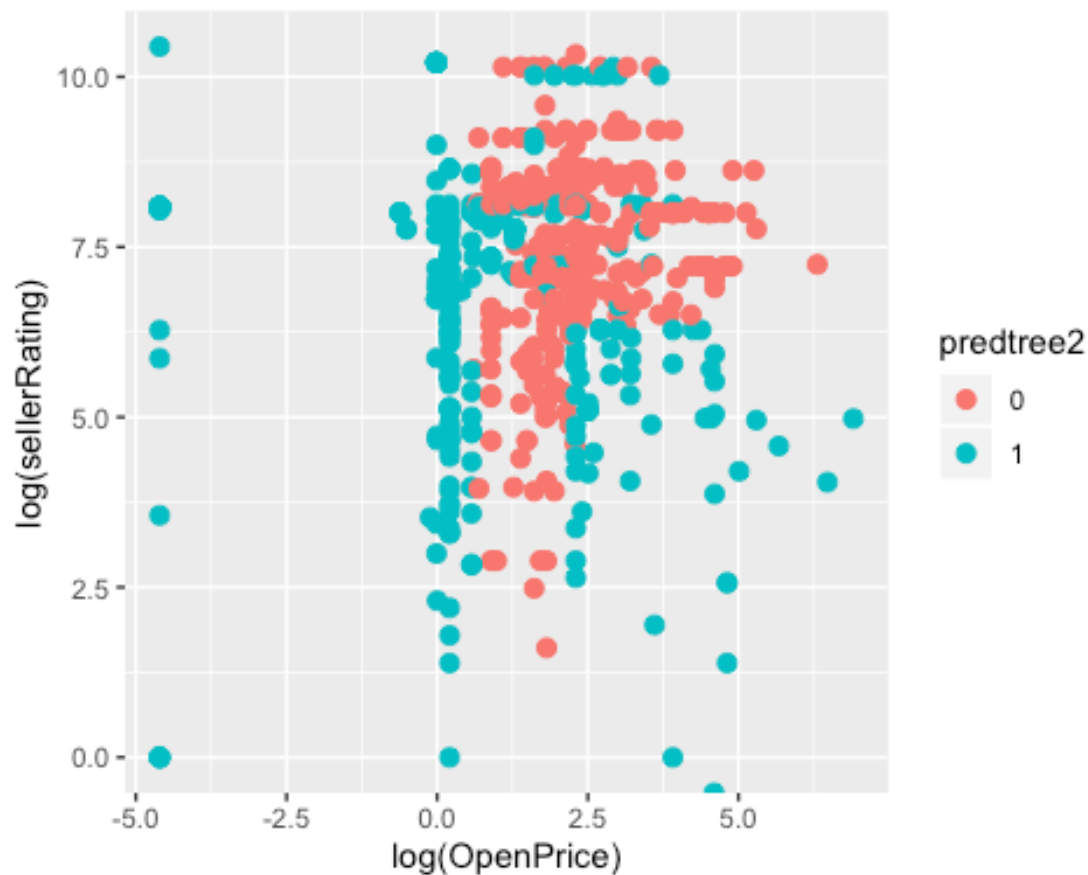
## [1] 0.6780105

specificity(predtree2, as.factor(ebayvalid$Competitive.))

## [1] 0.7002457

ggplot(ebayvalid, aes(x=log(OpenPrice),
y=log(sellerRating))) + geom_point(aes(color=predtree2), size = 2.5)

```



*## A cursory look at the scatter plot means that a line would do a reasonable job at splitting the data.*

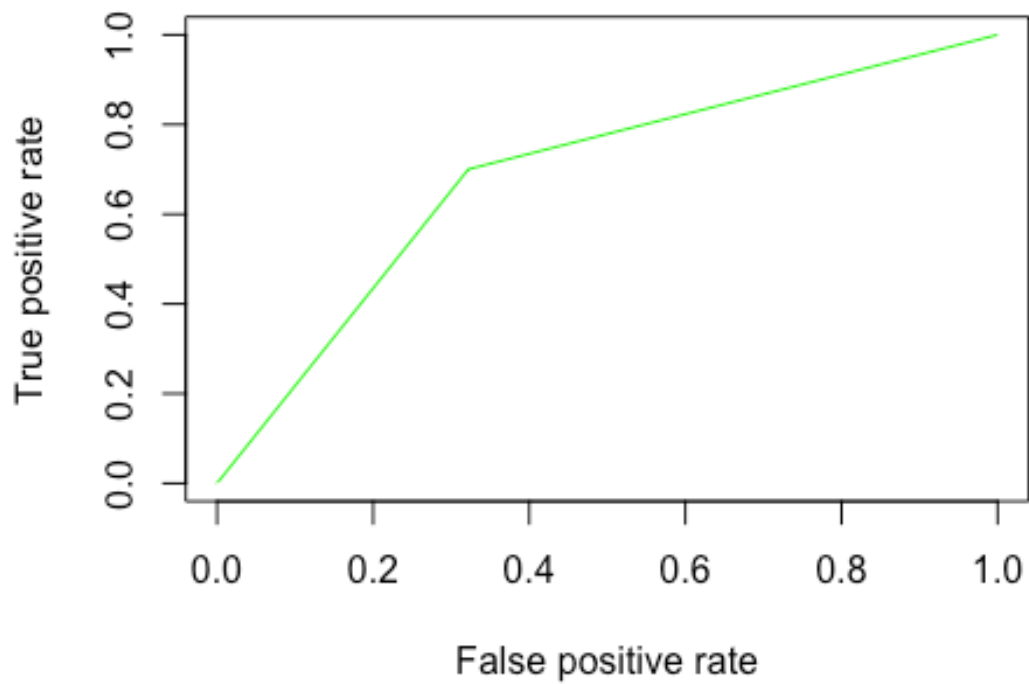
### Question 9.1.f

```
confusionMatrix(predtree2,(as.factor(ebayvalid$Competitive.)))

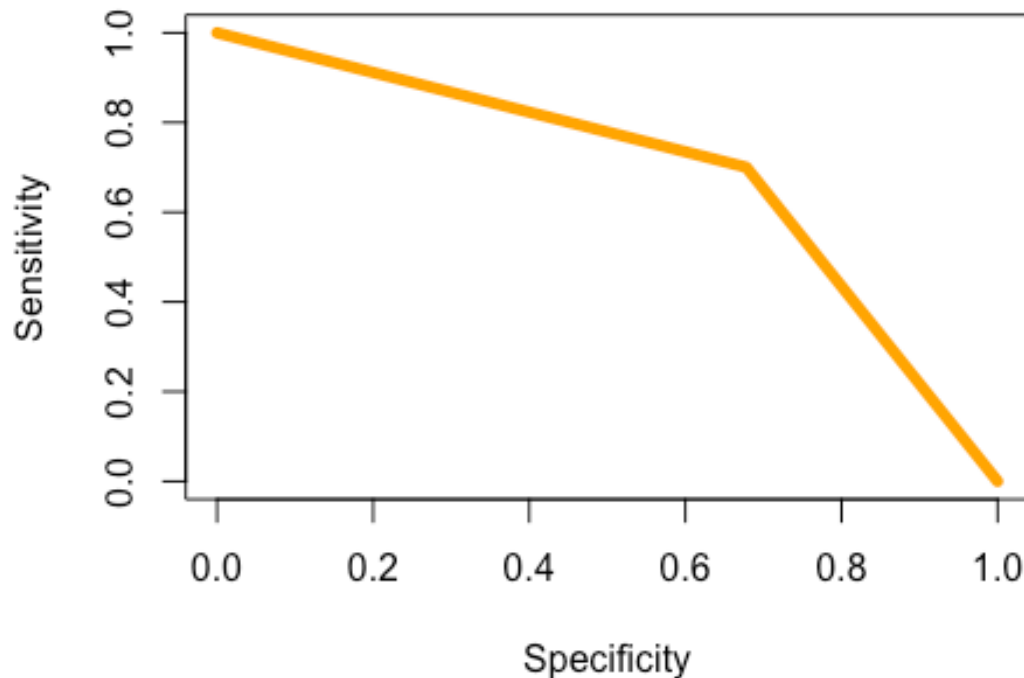
## Confusion Matrix and Statistics
##
##           Reference
## Prediction    0    1
##           0 259 122
##           1 123 285
##
##              Accuracy : 0.6895
##              95% CI : (0.6559, 0.7216)
##      No Information Rate : 0.5158
##      P-Value [Acc > NIR] : <2e-16
##
##              Kappa : 0.3783
##
##  Mcnemar's Test P-Value : 1
##
##              Sensitivity : 0.6780
##              Specificity : 0.7002
##              Pos Pred Value : 0.6798
##              Neg Pred Value : 0.6985
##              Prevalence : 0.4842
##              Detection Rate : 0.3283
##      Detection Prevalence : 0.4829
##      Balanced Accuracy : 0.6891
##
##      'Positive' Class : 0
##

p = c(predtree2)
pp = prediction(p,ebayvalid$Competitive.)
p3 = performance(pp,"tpr","fpr")
plot(p3,col="green")
```





```
p4 = performance(pp,"sens","spec")  
plot(p4,col="orange",lwd=5)
```



*# The model has an okay accuracy and sensitivity to specficty graph. It is not a decent model to be put into use, howEver better models can be made.*

### Question 9.1.g

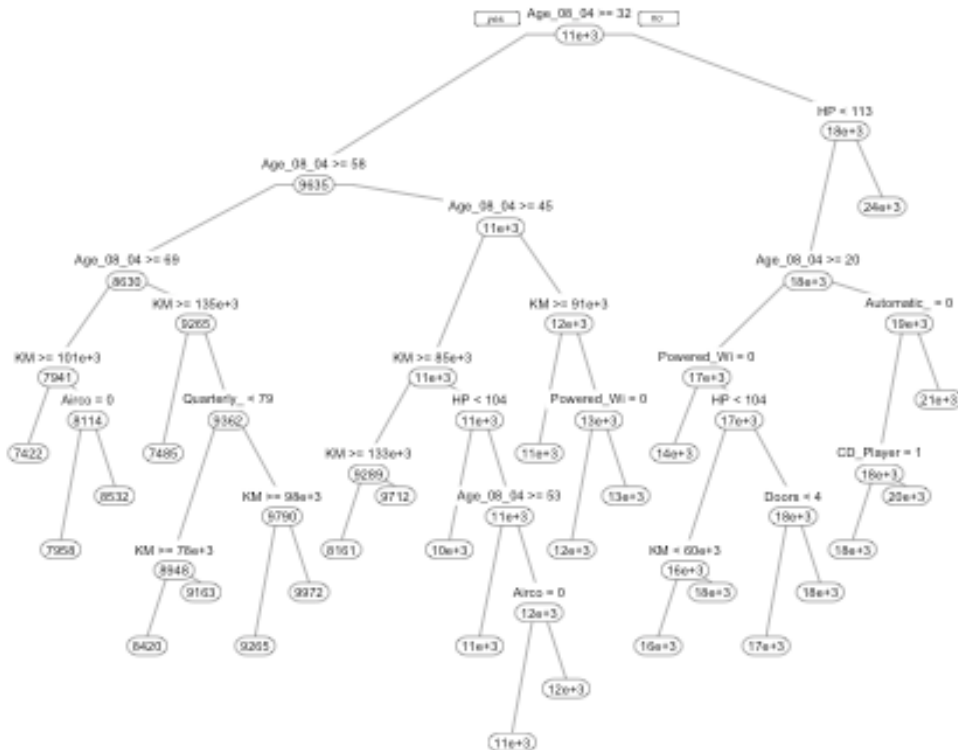
Based on the tree, the seller needs to have a higher rating and needs to keep the opening price higher than 3.6 The duration of auction should be kept longer than 6 days.

## Problem 9.2

### Question 9.2.a

```
#partition
set.seed(123)
traincars.index <-
sample(c(1:dim(ToyotaCorolla)[1]),dim(ToyotaCorolla)[1]*0.6)
train.cars <- ToyotaCorolla[traincars.index,]
valid.cars <- ToyotaCorolla[-traincars.index,]
class.tree <- rpart(Price
~Age_08_04+KM+Fuel_Type+HP+Automatic+Doors+Quarterly_Tax+Mfr_Guarantee+Guaran
tee_Period+Airco+Automatic_airco+CD_Player+Powered_Windows+Sport_Model+Tow_Ba
```

```
r, data = train.cars, control = rpart.control(maxdepth = 30, cp = 0.001))
prp(class.tree, type = 1, under = TRUE, split.font = 1, varlen = 10)
```



### Task 9.2.a.i

```
t(t(class.tree$variable.importance))
```

```
##           [,1]
## Age_08_04  9188959189
## KM        2702017486
## Automatic_airco 2465659993
## Quarterly_Tax 1153999034
## HP        1048448871
## Guarantee_Period 730646431
## CD_Player    455884117
## Airco       121014851
## Powered_Windows 110733220
## Fuel_Type    76595911
## Doors       55445451
## Sport_Model  32463606
## Tow_Bar     10543296
## Mfr_Guarantee 6028598
## Automatic   2389898
```

The four most important car specifications for predicting the car's price are Age\_08\_04, KM, Automatic\_airco, Quarterly\_Tax.

### Task 9.2.a.ii

```
train.err <- train.cars$Price - predict(class.tree,train.cars)
valid.err <- valid.cars$Price - predict(class.tree,valid.cars)
train.rmse <- RMSE(predict(class.tree,train.cars),train.cars$Price)
valid.rmse <- RMSE(predict(class.tree,valid.cars),valid.cars$Price)
train.rmse

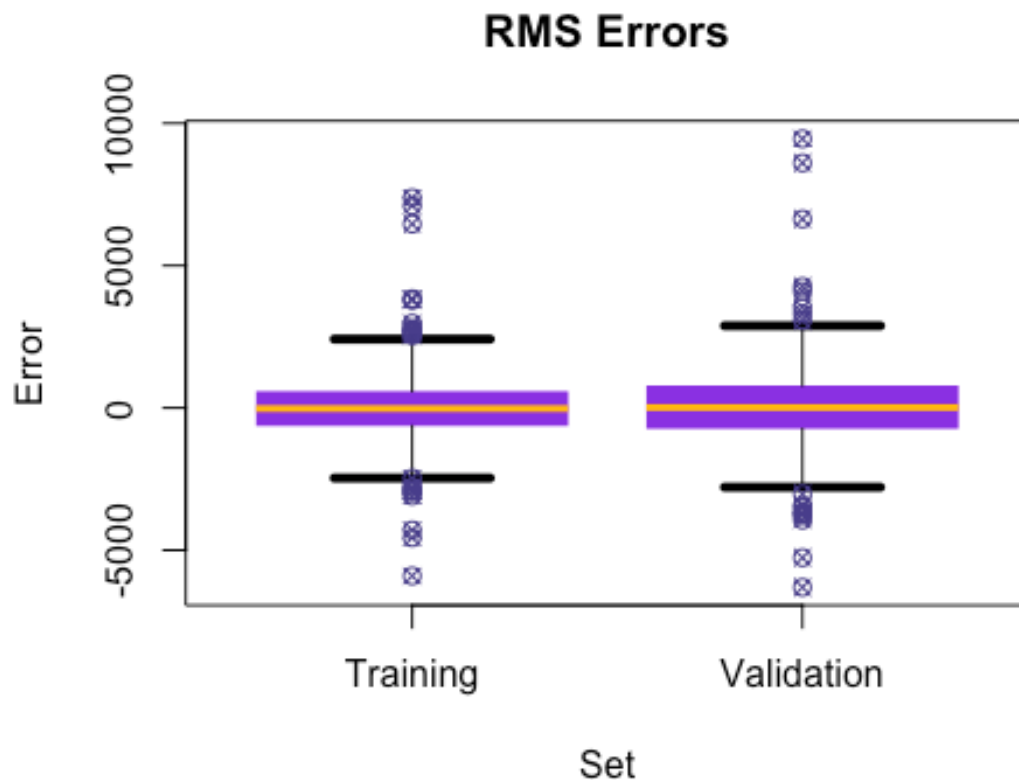
## [1] 1112.902

valid.rmse

## [1] 1328.958

#create a data fram from the training and validation errors in order to plot
err <-data.frame(Error =c(train.err, valid.err),
                  Set =c(rep("Training", length(train.err)),
                        rep("Validation", length(valid.err))))

#create error box plots
boxplot(Error~Set, data=err, main="RMS Errors",
        xlab = "Set", ylab = "Error",
        col="blueviolet",medcol="darkgoldenrod1",boxlty=0,border="black",
        whisklty=1,staplelwd=4,outpch=13,outcex=1,outcol="darkslateblue")
```



From the boxplots, we can see that most number of outliers are in the validation data rather than in training which means that we have made the train data into a large enough sample.

#### Task 9.2.a.iii

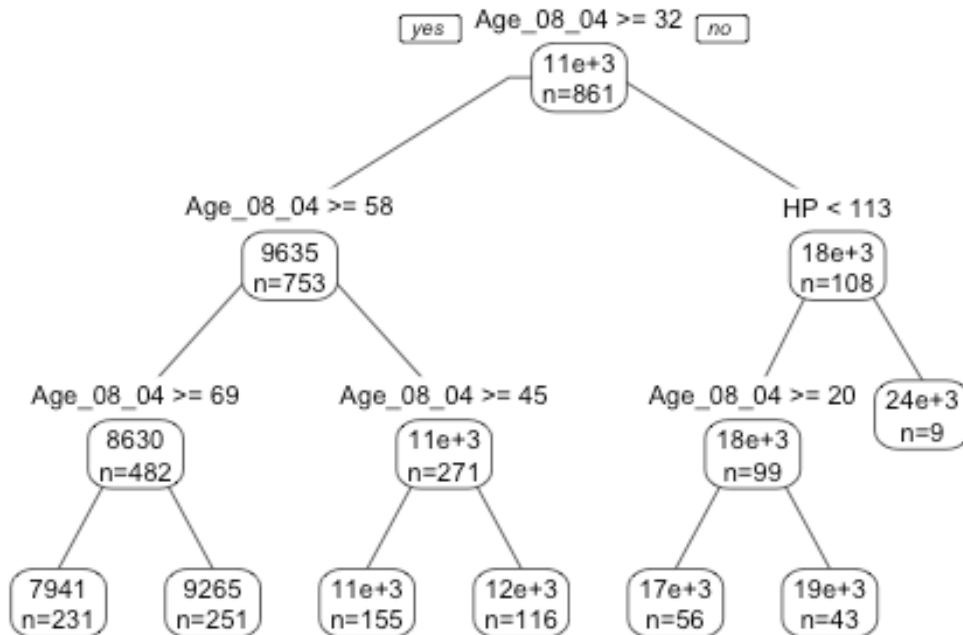
```
cross.tree <- rpart(Price
~Age_08_04+KM+Fuel_Type+HP+Automatic+Doors+Quarterly_Tax+Mfr_Guarantee+Guaran
tee_Period+Airco+Automatic_airco+CD_Player+Powered_Windows+Sport_Model+Tow_Ba
r, data =train.cars)
printcp(cross.tree)

##
## Regression tree:
## rpart(formula = Price ~ Age_08_04 + KM + Fuel_Type + HP + Automatic +
##   Doors + Quarterly_Tax + Mfr_Guarantee + Guarantee_Period +
##   Airco + Automatic_airco + CD_Player + Powered_Windows + Sport_Model +
##   Tow_Bar, data = train.cars)
##
## Variables actually used in tree construction:
## [1] Age_08_04 HP
##
## Root node error: 1.1075e+10/861 = 12863139
##
## n= 861
```

```
##
##          CP nsplit rel error  xerror    xstd
## 1 0.648917      0  1.00000 1.00183 0.081301
## 2 0.122138      1  0.35108 0.35592 0.026724
## 3 0.027146      2  0.22895 0.23542 0.025091
## 4 0.019048      3  0.20180 0.22853 0.025060
## 5 0.017894      4  0.18275 0.19939 0.018977
## 6 0.017794      5  0.16486 0.19342 0.019179
## 7 0.010000      6  0.14706 0.17054 0.018144
```

*# From the table we can see that xerror is Lowest at CP = 0.01*

```
pruned.ct <- prune(cross.tree,
cp = cross.tree$cptable[which.min(cross.tree$cptable[, "xerror"]), "CP"])
prp(pruned.ct, type = 1, extra = 1, split.font = 1, varlen = -10)
```



```
trainrmse.prun <- RMSE(predict(pruned.ct,train.cars),train.cars$Price)
validrmse.prun <- RMSE(predict(pruned.ct,valid.cars),valid.cars$Price)
trainrmse.prun
## [1] 1375.392
validrmse.prun
## [1] 1486.168
```

As expected, compared to the full tree, our pruned tree performs worse on the training set (RMSE=1396.864 compared to 1112.902 for the full tree). The validation set also performed worse (RMSE=1341.264 compared to 1328.958).

## Problem 9.2

### Question 9.2.b

```
bins <- seq(min(ToyotaCorolla$Price),
            max(ToyotaCorolla$Price),
            (max(ToyotaCorolla$Price) - min(ToyotaCorolla$Price))/20)

bins

## [1] 4350.0 5757.5 7165.0 8572.5 9980.0 11387.5 12795.0 14202.5
## [10] 17017.5 18425.0 19832.5 21240.0 22647.5 24055.0 25462.5 26870.0
## [19] 29685.0 31092.5 32500.0

Binned_Price <- .bincode(ToyotaCorolla$Price,
                        bins,
                        include.lowest = TRUE)
Binned_Price <- as.factor(Binned_Price)
Binned_Price

## [1] 7 7 7 8 7 7 9 11 13 7 12 12 11 13 13 13 14 10 9 9 9 9 9
## [25] 9 9 10 9 9 10 7 9 9 8 8 9 9 8 9 8 7 9 7 9 9 11
## [49] 10 13 10 9 12 13 8 7 8 8 11 9 8 9 11 10 10 9 11 8 13 9 9
## [73] 11 9 12 9 11 11 9 8 11 10 8 10 9 10 8 10 9 13 9 13 12 9
## [97] 9 9 11 10 11 9 11 11 11 9 11 10 10 20 19 20 15 15 14 15 13 10
## [121] 11 12 9 11 9 13 9 9 10 9 9 9 9 9 9 9 11 9 14 12 9 14
## [145] 11 9 12 15 11 12 10 12 11 11 13 9 11 11 11 11 11 12 11 11 10 12
## [169] 12 10 10 14 11 11 13 12 11 12 13 13 11 11 12 13 10 10 2 4 6 3 6
## [193] 1 6 7 6 6 8 4 6 6 5 5 5 7 6 6 5 6 6 7 8 6 6 7
## [217] 7 5 5 7 6 6 6 8 6 7 6 6 6 6 6 7 6 7 6 6 5 7 7
## [241] 5 6 6 7 6 7 6 7 7 6 6 5 6 8 4 7 7 6 6 7 6 6 7
## [265] 6 6 6 6 8 5 7 7 7 7 7 6 7 6 6 8 7 7 7 7 6 7 6
## [289] 6 7 6 7 5 6 7 5 7 7 7 7 6 6 7 6 7 6 4 7 6 6 7
```

7																								
##	[313]	6	6	4	7	7	5	4	6	6	5	7	5	7	6	5	7	7	6	5	7	6	6	6
6																								
##	[337]	7	6	6	6	6	6	8	6	7	8	7	7	7	6	6	4	6	6	8	7	6	8	6
8																								
##	[361]	7	6	6	7	7	5	5	6	6	7	5	7	6	7	7	6	6	7	2	2	2	3	4
3																								
##	[385]	4	4	5	4	3	4	3	3	4	1	4	4	4	6	5	5	4	5	1	5	4	4	5
6																								
##	[409]	4	6	3	5	4	6	5	4	4	5	4	4	5	4	4	6	4	4	6	6	5	7	6
5																								
##	[433]	5	5	5	5	6	4	5	6	6	5	6	6	6	5	6	5	6	4	5	6	6	6	6
4																								
##	[457]	5	5	4	5	4	6	5	4	4	6	4	6	7	5	5	4	4	6	5	4	5	4	5
6																								
##	[481]	6	6	6	4	4	5	5	4	6	4	5	5	4	6	6	5	6	5	5	4	4	6	4
5																								
##	[505]	4	6	6	6	5	5	6	6	7	5	5	5	6	5	5	6	4	6	4	11	6	5	6
4																								
##	[529]	5	7	4	5	5	6	7	6	5	4	5	6	5	6	5	5	7	5	6	4	5	6	5
5																								
##	[553]	7	5	6	5	6	7	5	7	5	5	4	7	4	5	5	5	5	7	7	6	5	6	4
6																								
##	[577]	6	6	6	6	6	5	4	5	5	7	4	7	4	4	5	5	4	5	5	5	5	5	5
7																								
##	[601]	5	3	4	2	3	2	3	3	2	1	2	3	3	3	3	2	4	2	3	3	4	2	4
4																								
##	[625]	3	4	4	4	3	3	3	4	4	4	4	4	4	5	3	5	4	4	4	3	5	4	3
2																								
##	[649]	3	4	4	3	4	4	2	3	4	3	4	5	3	4	4	4	4	3	4	4	4	4	2
3																								
##	[673]	3	4	2	4	4	4	4	4	3	4	3	4	4	4	4	4	4	4	4	4	4	4	4
4																								
##	[697]	6	4	5	4	3	4	3	5	3	4	5	3	4	4	4	3	4	4	3	3	4	4	4
3																								
##	[721]	3	3	4	3	2	3	5	4	4	4	6	5	5	4	5	5	4	4	4	4	3	5	4
4																								
##	[745]	3	3	3	5	4	4	5	5	3	4	4	4	4	4	3	5	3	3	4	4	5	5	4
4																								
##	[769]	5	3	3	3	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
3																								
##	[793]	3	4	6	4	6	4	4	3	4	5	4	5	4	4	4	3	3	4	3	4	4	5	4
4																								
##	[817]	3	4	4	5	4	3	4	5	2	4	2	4	4	4	4	4	5	5	4	4	5	4	4
5																								
##	[841]	5	4	5	4	3	4	5	5	4	4	3	4	3	4	4	4	3	3	4	4	5	4	4
3																								
##	[865]	4	4	5	4	4	5	4	4	5	4	4	4	4	4	3	4	5	4	4	3	4	4	5
4																								
##	[889]	5	4	3	6	4	3	5	4	3	4	4	4	3	4	4	4	4	4	4	4	3	3	4



```

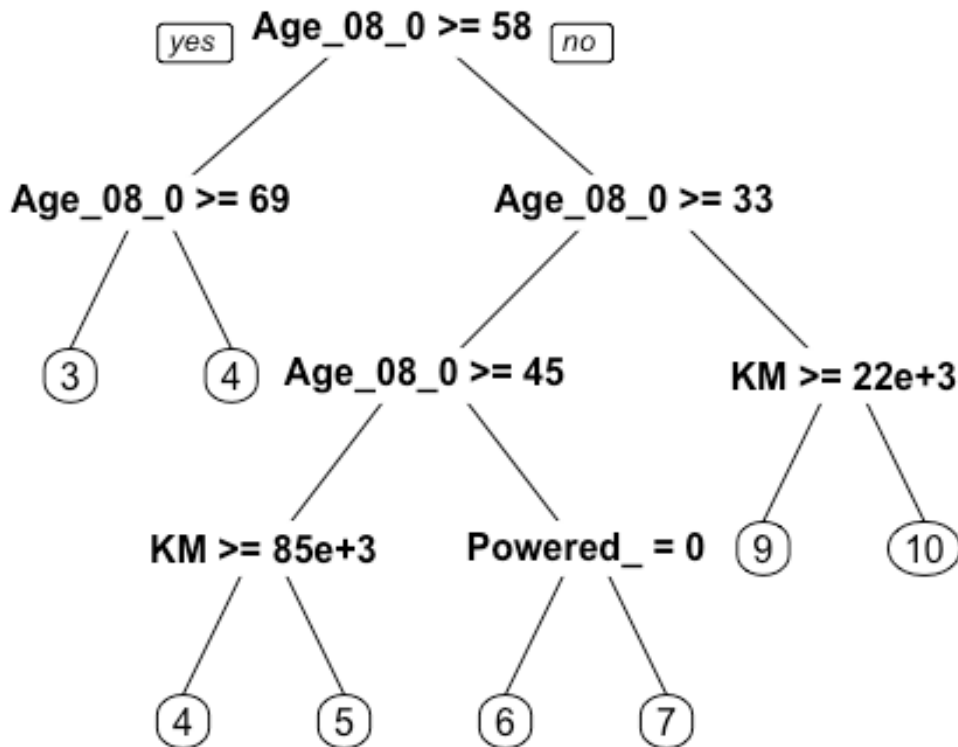
4
## [913] 4 7 4 5 3 5 4 4 5 4 4 3 4 4 5 4 4 5 4 5 5 4 4
5
## [937] 5 4 4 5 4 4 5 3 5 5 6 4 3 4 3 4 3 4 4 4 5 4 4
4
## [961] 4 4 4 4 5 4 4 4 4 5 4 5 4 3 5 4 4 4 4 4 5 4 4
3
## [985] 4 4 3 4 5 4 5 3 4 4 3 4 4 4 4 5 4 4 3 5 4 4 5
5
## [1009] 4 4 4 4 4 3 5 5 4 4 5 4 6 3 5 5 5 4 5 4 5 5 4
5
## [1033] 5 5 5 6 4 5 4 5 4 5 5 4 2 2 2 1 1 2 3 2 2 1 4
2
## [1057] 2 2 5 3 3 2 2 2 1 2 4 2 3 3 3 3 2 3 2 1 2 2 3
4
## [1081] 3 4 4 2 3 3 2 3 2 3 4 3 3 1 3 2 3 3 3 3 3 2 2
3
## [1105] 3 3 3 3 3 4 3 3 3 1 2 2 2 3 4 3 3 3 3 4 3 2 2
4
## [1129] 3 3 3 4 2 4 3 2 2 2 4 3 2 3 3 4 3 2 2 3 2 3 4
3
## [1153] 3 3 2 3 2 4 2 4 3 3 3 4 4 4 3 2 3 4 2 2 3 2 3
4
## [1177] 4 3 3 4 3 2 4 3 4 2 3 3 3 3 2 3 2 3 3 4 4 4 3
4
## [1201] 4 3 2 3 3 2 3 3 3 3 3 3 3 3 2 4 4 3 3 4 3 3 3
3
## [1225] 4 3 2 3 3 4 4 2 3 3 4 3 3 2 3 2 4 4 3 3 2 3 3
2
## [1249] 3 3 4 3 3 2 3 3 3 3 3 4 3 4 4 3 3 4 2 3 4 4 3
2
## [1273] 3 2 4 3 3 4 3 3 3 3 3 4 4 3 3 3 4 3 3 3 3 3 2
3
## [1297] 3 2 3 4 3 2 3 3 3 4 3 4 3 4 4 4 4 2 3 4 3 3 3
3
## [1321] 4 3 4 4 3 2 3 4 2 3 4 2 3 5 2 4 3 4 3 4 4 2 3
3
## [1345] 4 3 3 3 4 2 3 2 3 3 4 2 3 3 3 4 4 2 3 2 3 3 3
4
## [1369] 4 3 4 4 2 3 4 3 3 4 4 3 4 3 2 5 4 3 4 3 4 4 3
4
## [1393] 3 3 3 4 4 3 4 4 3 4 5 2 3 3 4 3 4 3 3 3 4 4 3
2
## [1417] 4 4 3 3 3 3 3 3 3 3 4 4 3 4 3 3 5 3 3 2
## Levels: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 19 20

train.cars$Binned_Price <- Binned_Price[traincars.index]
valid.cars$Binned_Price <- Binned_Price[-traincars.index]

```

### Task 9.2.b.i

```
tr.binned <- rpart(Binned_Price ~ Age_08_04 + KM + Fuel_Type +  
  HP + Automatic + Doors + Quarterly_Tax +  
  Mfr_Guarantee + Guarantee_Period + Airco +  
  Automatic_airco + CD_Player + Powered_Windows +  
  Sport_Model + Tow_Bar, data = train.cars)  
prp(tr.binned)
```



```
t(t(tr.binned$variable.importance))
```

```
##           [,1]
## Age_08_04 146.857190
## KM        53.665182
## CD_Player 28.972423
## Airco     23.881571
## Automatic_airco 17.259249
## Quarterly_Tax 14.815708
## Sport_Model 13.063749
## Powered_Windows 8.212048
## Guarantee_Period 3.171908
## Fuel_Type  1.926651
## HP         1.467326
```

```
## Tow_Bar          1.321867
## Automatic        0.439766
```

When creating bins the intent is to decrease the number of variables. This unsurprisingly results in the binned tree being significantly smaller than the original full tree. One interesting thing to note is the in our binned tree, CD Player replaces Quarterly Tax as one of the top four specifications in indicating price. This could be because tax variations are less significant within bins.

### Task 9.2.b.ii

```
newrec <- data.frame(Age_08_04 = 77,
                     KM = 117000,
                     Fuel_Type = "Petrol",
                     HP = 110,
                     Automatic = 0,
                     Doors = 5,
                     Quarterly_Tax = 100,
                     Mfr_Guarantee = 0,
                     Guarantee_Period = 3,
                     Airco = 1,
                     Automatic_airco = 0,
                     CD_Player = 0,
                     Powered_Windows = 0,
                     Sport_Model = 0,
                     Tow_Bar = 1)

price.tr <- predict(class.tree, newdata = newrec)
price.tr.bin <- bins[predict(tr.binned, newdata = newrec, type = "class")]
price.tr

##          1
## 7422.414

price.tr.bin

## [1] 7165
```

### Task 9.2.b.iii

Our predictions for the two models were very similar. The regression tree gave a prediction value of 7422.414 and the classification tree gave 7165. Our binned model returned a whole number while the full model returned a more “accurate” price, but ultimately it is a wash. Both models had comparable accuracy, but the full regression seemed to be better trained.