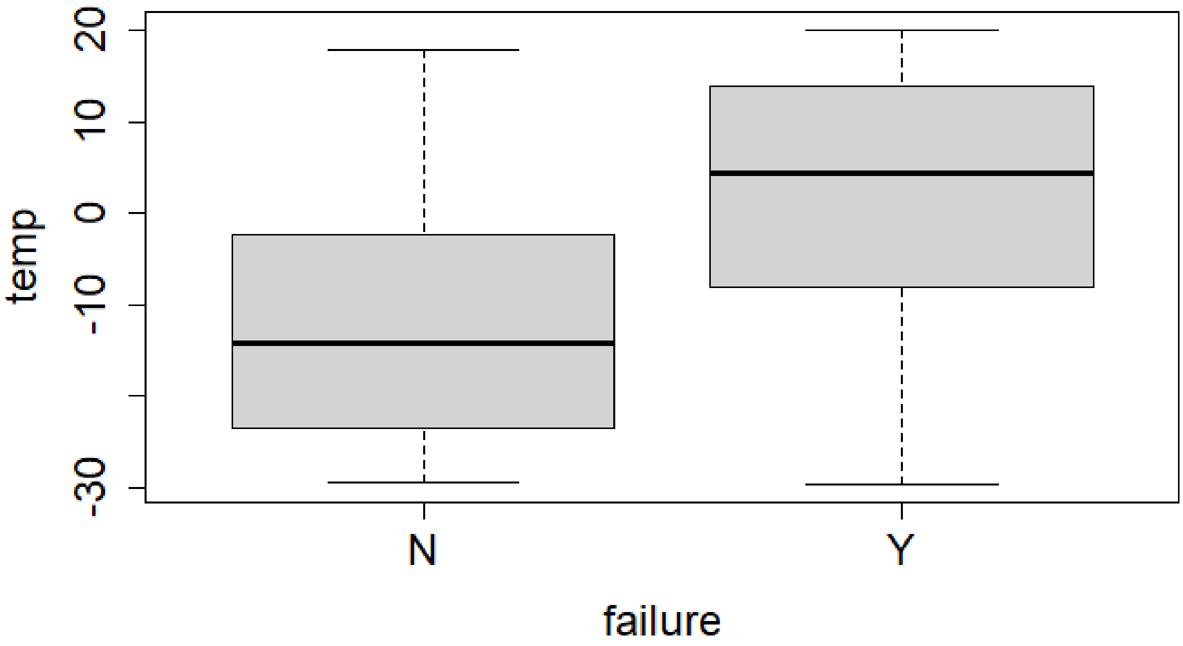
# ESI 4606: Analytics I - Foundations of Data Science

# Mid-term Exam - Part I

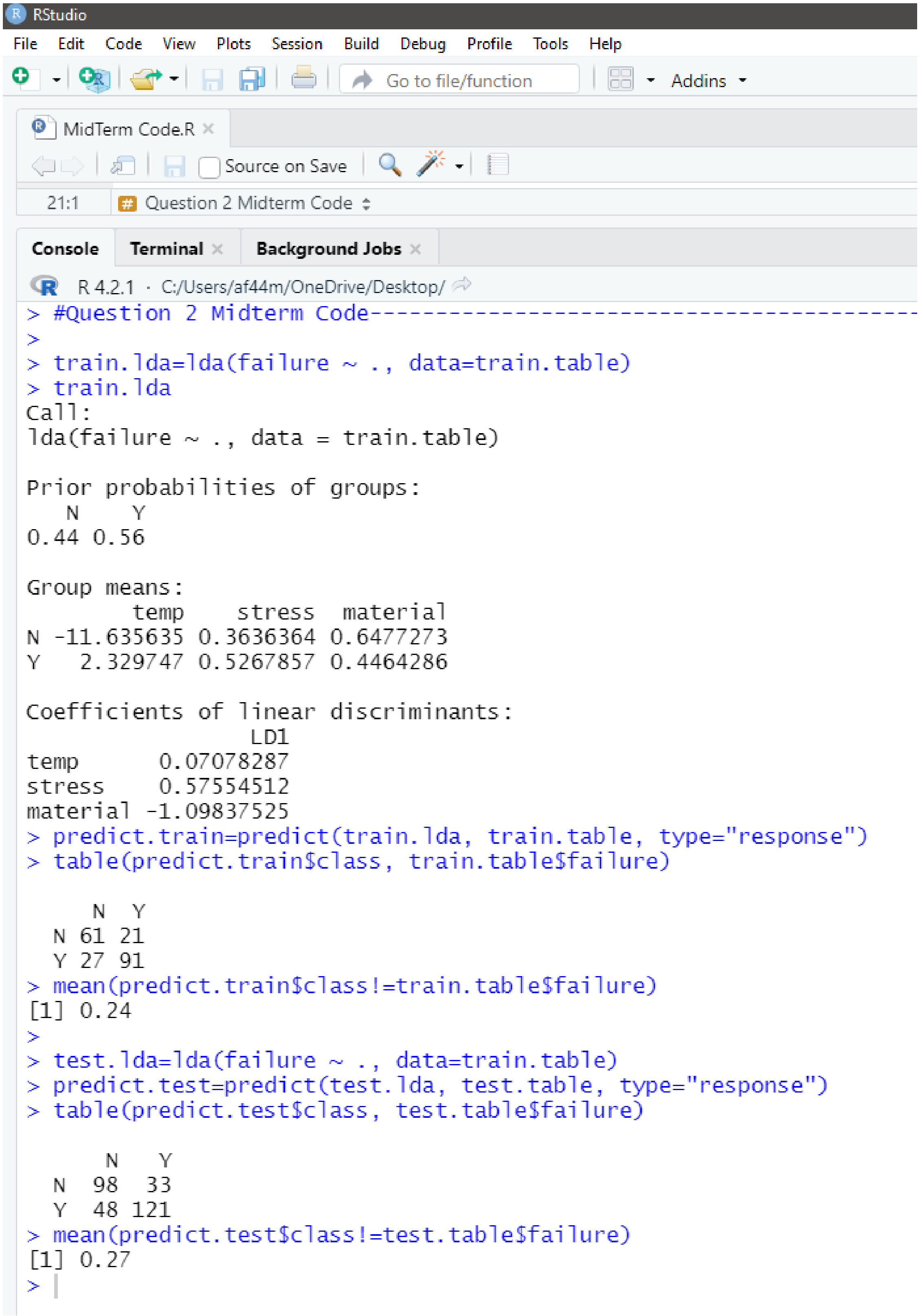
# Due: October 26st (11:30PM), 2022

# Morgan Harrison

1. The boxplots data visualization reveals that the median of Yes is higher than No. Based on the graphic created and the data, Yes and No have similar dispersions and no extreme recognizable outliers.

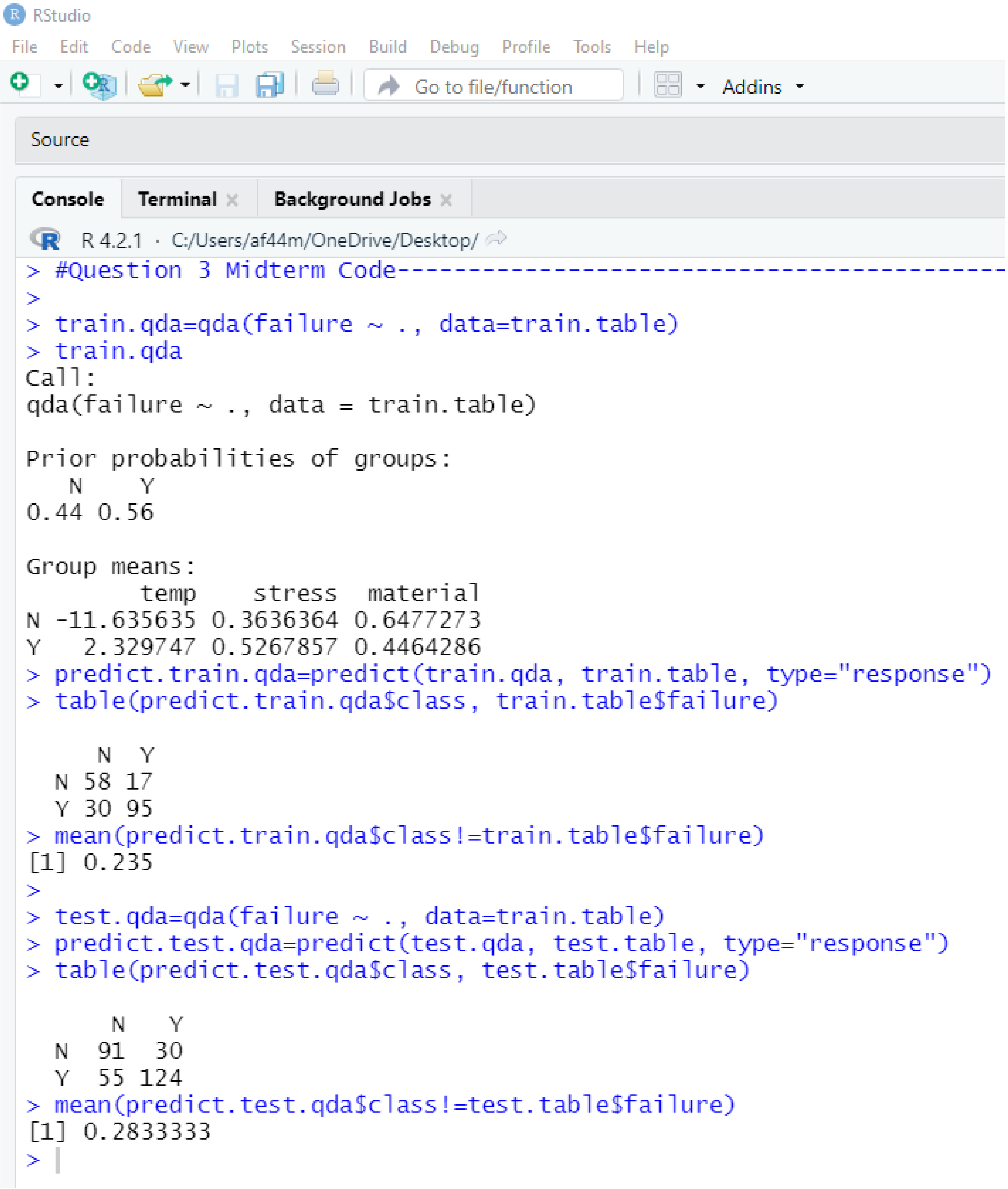


2. See Following Information.



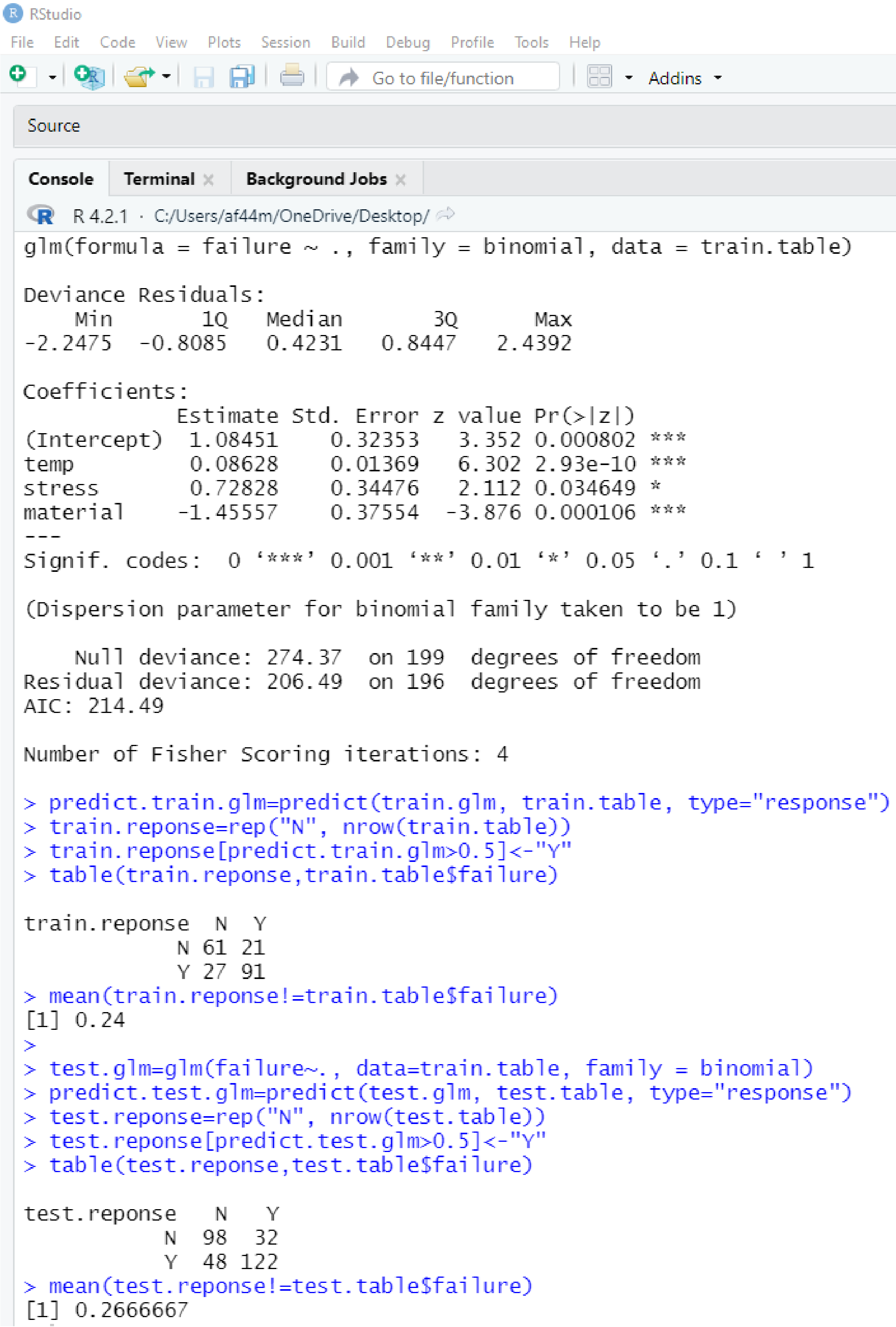
```
> #Question 2 Midterm Code-----------------------------------------
>
> train.lda=lda(failure ~ ., data=train.table)
> train.lda
Call:
lda(failure ~ ., data = train.table)

Prior probabilities of groups:
   N    Y
0.44 0.56

Group means:
        temp    stress  material
N -11.635635 0.3636364 0.6477273
Y   2.329747 0.5267857 0.4464286

Coefficients of linear discriminants:
                 LD1
temp      0.07078287
stress    0.57554512
material -1.09837525
> predict.train=predict(train.lda, train.table, type="response")
> table(predict.train$class, train.table$failure)

     N  Y
  N 61 21
  Y 27 91
> mean(predict.train$class!=train.table$failure)
[1] 0.24
>
> test.lda=lda(failure ~ ., data=train.table)
> predict.test=predict(test.lda, test.table, type="response")
> table(predict.test$class, test.table$failure)

      N   Y
  N  98  33
  Y  48 121
> mean(predict.test$class!=test.table$failure)
[1] 0.27
>
```

3. See Following Information.



```
> #Question 3 Midterm Code-------------------------------------------
>
> train.qda=qda(failure ~ ., data=train.table)
> train.qda
Call:
qda(failure ~ ., data = train.table)

Prior probabilities of groups:
   N    Y 
0.44 0.56 

Group means:
        temp    stress  material
N -11.635635 0.3636364 0.6477273
Y   2.329747 0.5267857 0.4464286
> predict.train.qda=predict(train.qda, train.table, type="response")
> table(predict.train.qda$class, train.table$failure)
   
     N  Y
  N 58 17
  Y 30 95
> mean(predict.train.qda$class!=train.table$failure)
[1] 0.235
>
> test.qda=qda(failure ~ ., data=train.table)
> predict.test.qda=predict(test.qda, test.table, type="response")
> table(predict.test.qda$class, test.table$failure)
   
      N   Y
  N  91  30
  Y  55 124
> mean(predict.test.qda$class!=test.table$failure)
[1] 0.2833333
> 
```

4. See Following Information.



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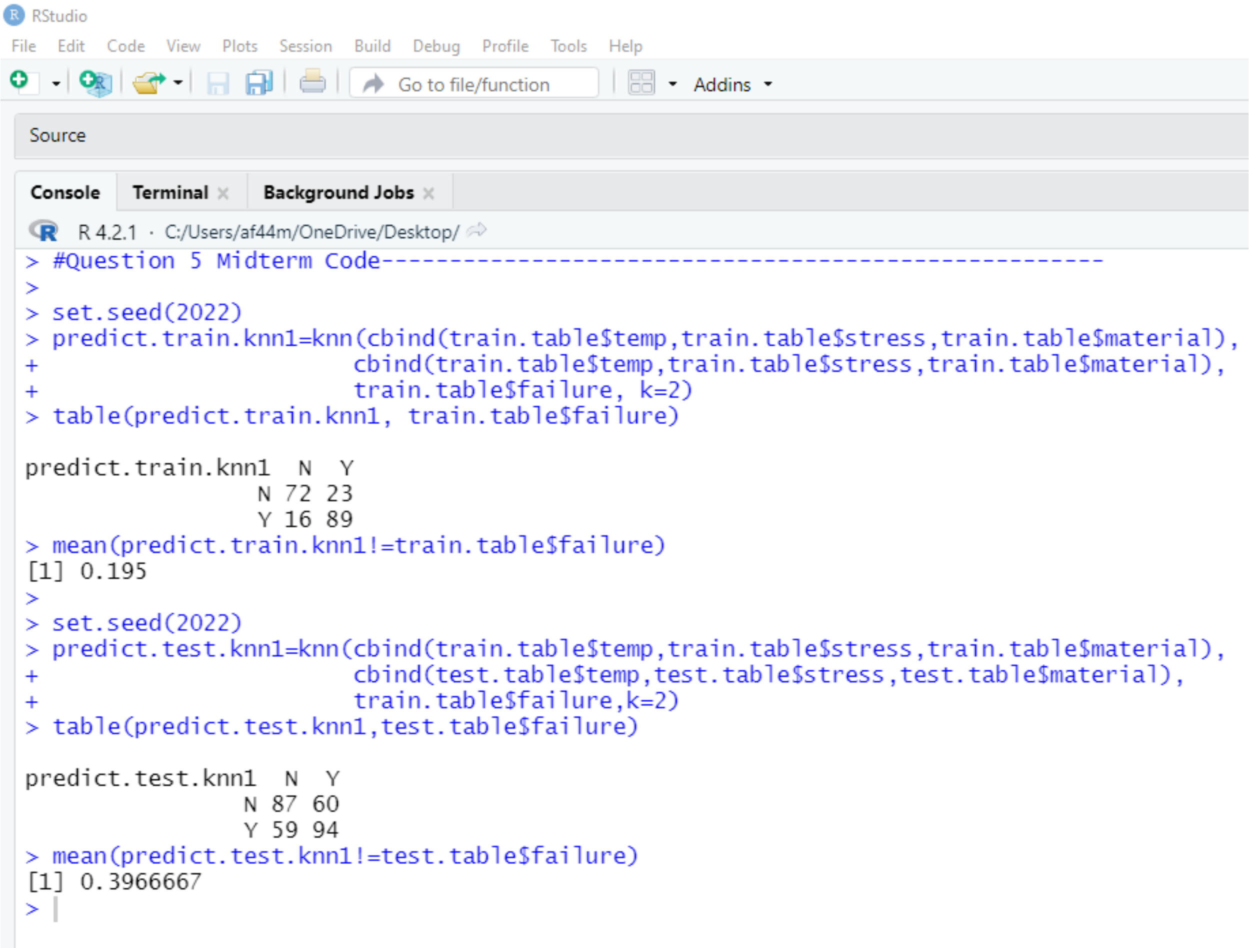
```
glm(formula = failure ~ ., family = binomial, data = train.table)

Deviance Residuals: 
    Min       1Q   Median       3Q      Max  
-2.2475  -0.8085   0.4231   0.8447   2.4392  

Coefficients:
            Estimate Std. Error z value Pr(>|z|)    
(Intercept)  1.08451    0.32353   3.352 0.000802 ***
temp         0.08628    0.01369   6.302 2.93e-10 ***
stress       0.72828    0.34476   2.112 0.034649 *  
material    -1.45557    0.37554  -3.876 0.000106 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 274.37  on 199  degrees of freedom
Residual deviance: 206.49  on 196  degrees of freedom
AIC: 214.49

Number of Fisher Scoring iterations: 4

> predict.train.glm=predict(train.glm, train.table, type="response")
> train.reponse=rep("N", nrow(train.table))
> train.reponse[predict.train.glm>0.5]<-"Y"
> table(train.reponse,train.table$failure)
             
train.reponse  N  Y
            N 61 21
            Y 27 91
> mean(train.reponse!=train.table$failure)
[1] 0.24
> 
> test.glm=glm(failure~., data=train.table, family = binomial)
> predict.test.glm=predict(test.glm, test.table, type="response")
> test.reponse=rep("N", nrow(test.table))
> test.reponse[predict.test.glm>0.5]<-"Y"
> table(test.reponse,test.table$failure)
            
test.reponse   N   Y
           N  98  32
           Y  48 122
> mean(test.reponse!=test.table$failure)
[1] 0.2666667
```

5. See Following Information.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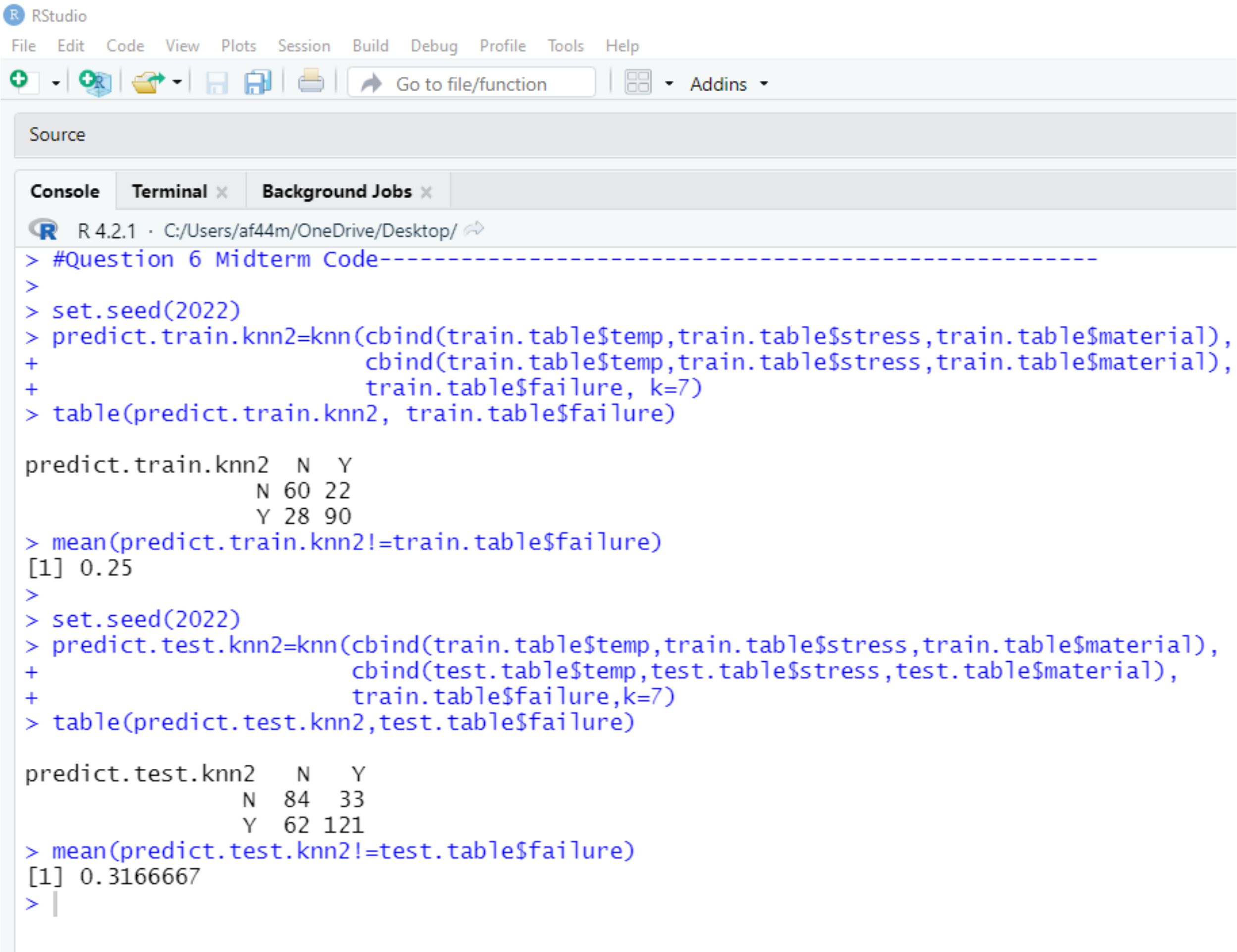
```
> #Question 5 Midterm Code-----------------------------------------------------
>
> set.seed(2022)
> predict.train.knn1=knn(cbind(train.table$temp,train.table$stress,train.table$material),
+                       cbind(train.table$temp,train.table$stress,train.table$material),
+                       train.table$failure, k=2)
> table(predict.train.knn1, train.table$failure)

predict.train.knn1  N  Y
                 N 72 23
                 Y 16 89
> mean(predict.train.knn1!=train.table$failure)
[1] 0.195
>
> set.seed(2022)
> predict.test.knn1=knn(cbind(train.table$temp,train.table$stress,train.table$material),
+                       cbind(test.table$temp,test.table$stress,test.table$material),
+                       train.table$failure,k=2)
> table(predict.test.knn1,test.table$failure)

predict.test.knn1  N  Y
                N 87 60
                Y 59 94
> mean(predict.test.knn1!=test.table$failure)
[1] 0.3966667
> 
```

6. See Following Information.


RStudio
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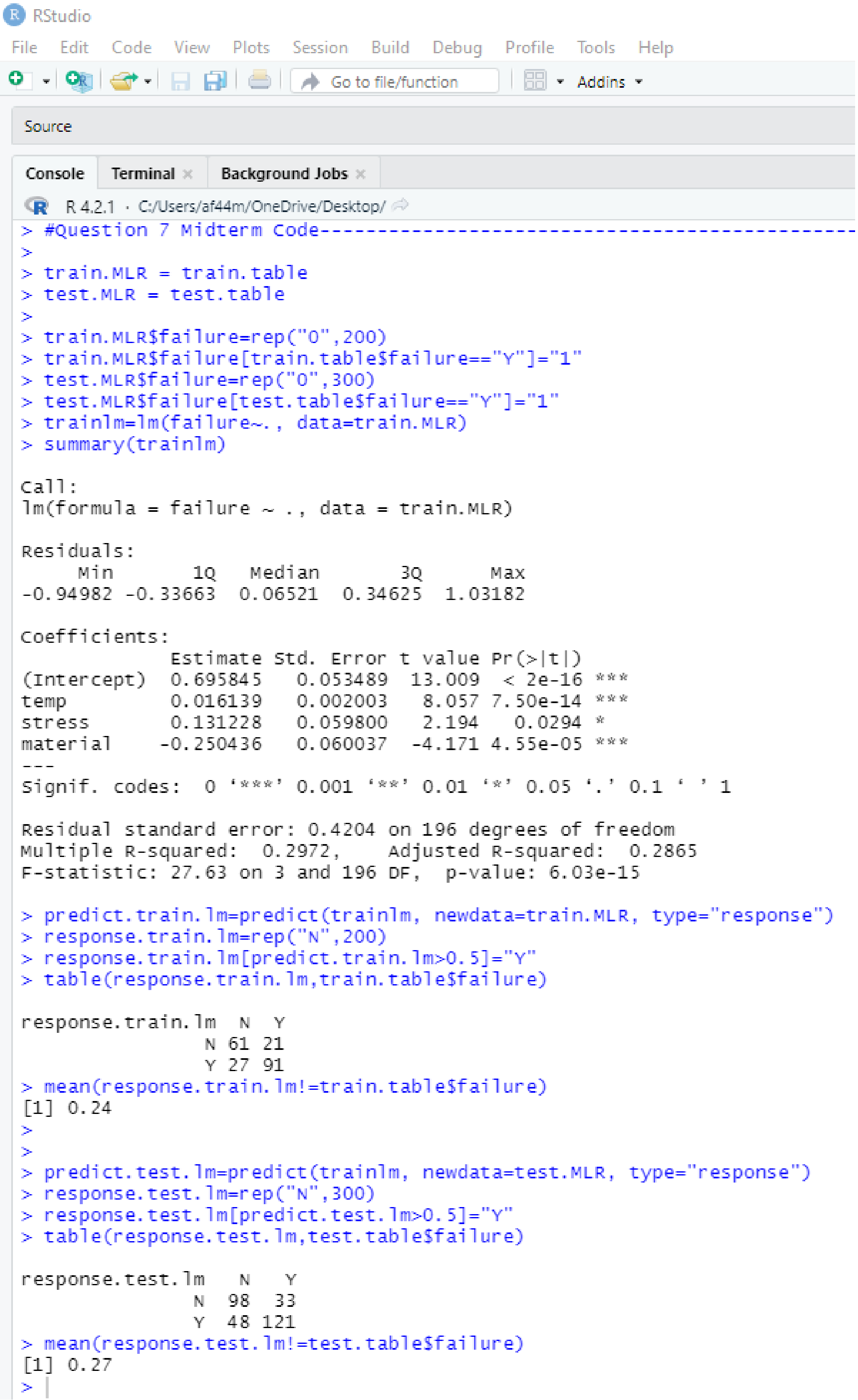
Go to file/function
Addins
Source
Console
Terminal
Background Jobs
R 4.2.1 · C:/Users/af44m/OneDrive/Desktop/

```
> #Question 6 Midterm Code-----------------------------------------------------
> 
> set.seed(2022)
> predict.train.knn2=knn(cbind(train.table$temp,train.table$stress,train.table$material),
+                        cbind(train.table$temp,train.table$stress,train.table$material),
+                        train.table$failure, k=7)
> table(predict.train.knn2, train.table$failure)
                  
predict.train.knn2  N  Y
                 N 60 22
                 Y 28 90
> mean(predict.train.knn2!=train.table$failure)
[1] 0.25
> 
> set.seed(2022)
> predict.test.knn2=knn(cbind(train.table$temp,train.table$stress,train.table$material),
+                       cbind(test.table$temp,test.table$stress,test.table$material),
+                       train.table$failure,k=7)
> table(predict.test.knn2,test.table$failure)
                 
predict.test.knn2   N   Y
                N  84  33
                Y  62 121
> mean(predict.test.knn2!=test.table$failure)
[1] 0.3166667
> 
```

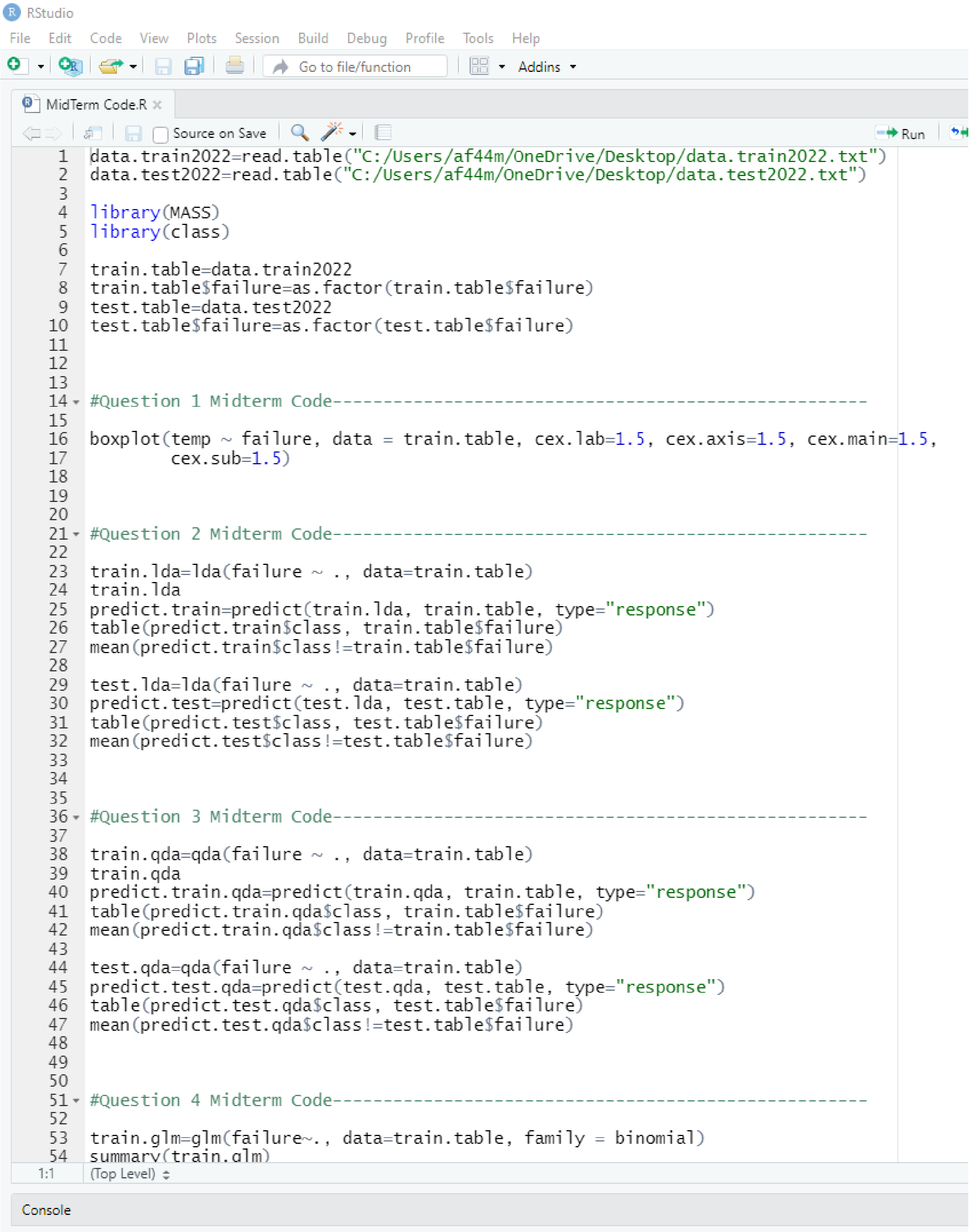
7. See Information Below.



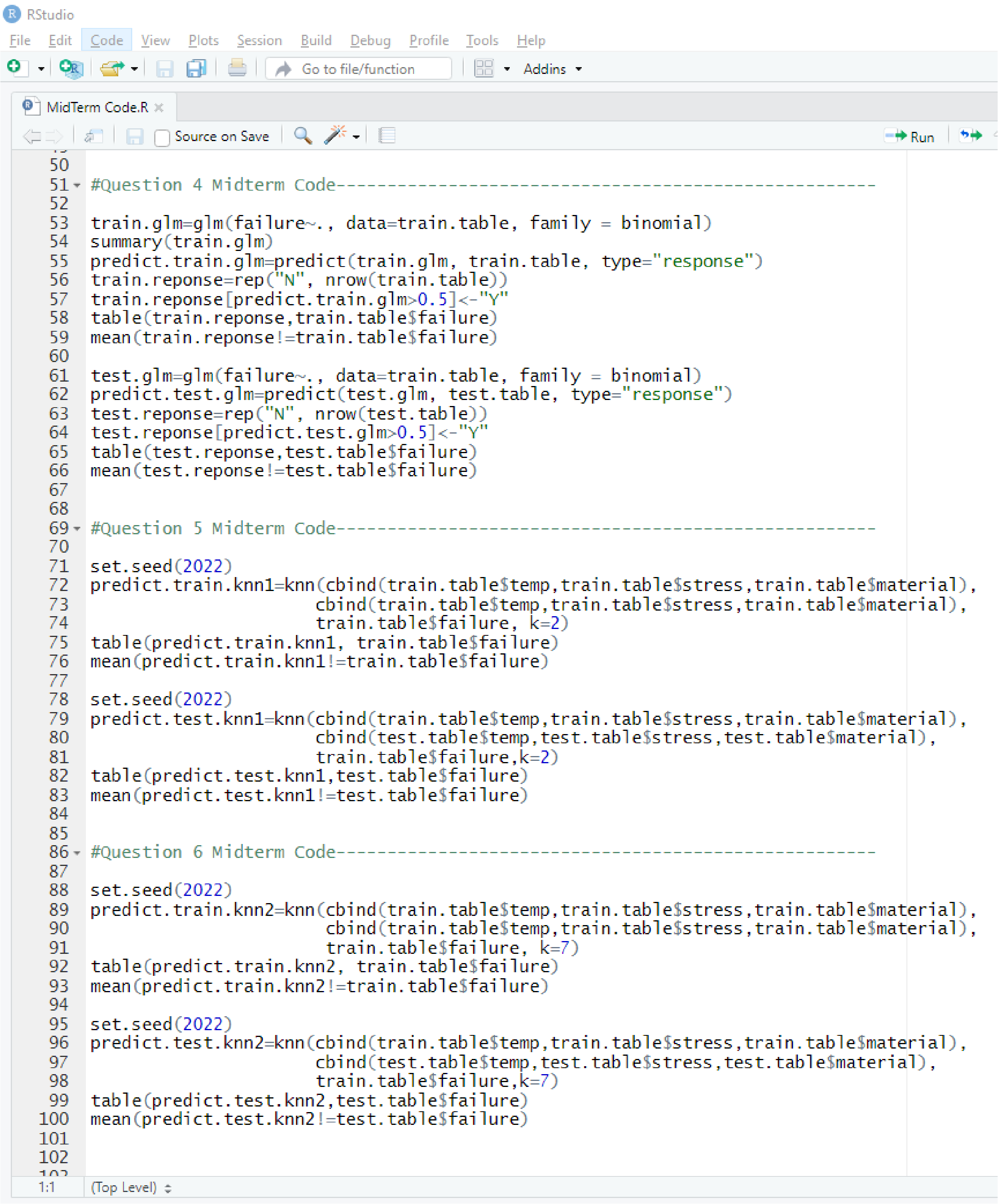
```
> #Question 7 Midterm Code---------------------------------------------------
>
> train.MLR = train.table
> test.MLR = test.table
>
> train.MLR$failure=rep("0",200)
> train.MLR$failure[train.table$failure=="Y"]="1"
> test.MLR$failure=rep("0",300)
> test.MLR$failure[test.table$failure=="Y"]="1"
> trainlm=lm(failure~., data=train.MLR)
> summary(trainlm)

Call:
lm(formula = failure ~ ., data = train.MLR)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.94982 -0.33663  0.06521  0.34625  1.03182 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept)  0.695845   0.053489  13.009  < 2e-16 ***
temp         0.016139   0.002003   8.057 7.50e-14 ***
stress       0.131228   0.059800   2.194   0.0294 *  
material    -0.250436   0.060037  -4.171 4.55e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.4204 on 196 degrees of freedom
Multiple R-squared:  0.2972,	Adjusted R-squared:  0.2865 
F-statistic: 27.63 on 3 and 196 DF,  p-value: 6.03e-15

> predict.train.lm=predict(trainlm, newdata=train.MLR, type="response")
> response.train.lm=rep("N",200)
> response.train.lm[predict.train.lm>0.5]="Y"
> table(response.train.lm,train.table$failure)
                 
response.train.lm  N  Y
                N 61 21
                Y 27 91
> mean(response.train.lm!=train.table$failure)
[1] 0.24
>
>
> predict.test.lm=predict(trainlm, newdata=test.MLR, type="response")
> response.test.lm=rep("N",300)
> response.test.lm[predict.test.lm>0.5]="Y"
> table(response.test.lm,test.table$failure)
                
response.test.lm   N   Y
               N  98  33
               Y  48 121
> mean(response.test.lm!=test.table$failure)
[1] 0.27
> 
```

8. The Logistic Regression is the best model to use as it has the lowest misclassification error rate of 0.267. The worst model to use is the K-Nearest Neighbor = 2 classification as its misclassification error rate is 0.397. It had the highest amount of incorrect error without being able to distinguish between positive and negative predictions.
9. The Multiple Linear Regression is the best model to use for reliability improvement based on the results as it analyzes the individual variables so that statistical analysis can better identify possible areas for improvement as opposed to the other models. For instance, as indicated by P-Value being less than the alpha value, we can conclude that temperature, stress, and material are all statistically significant factors. All three of these factors affect the number of failures within the real-life problem and model.

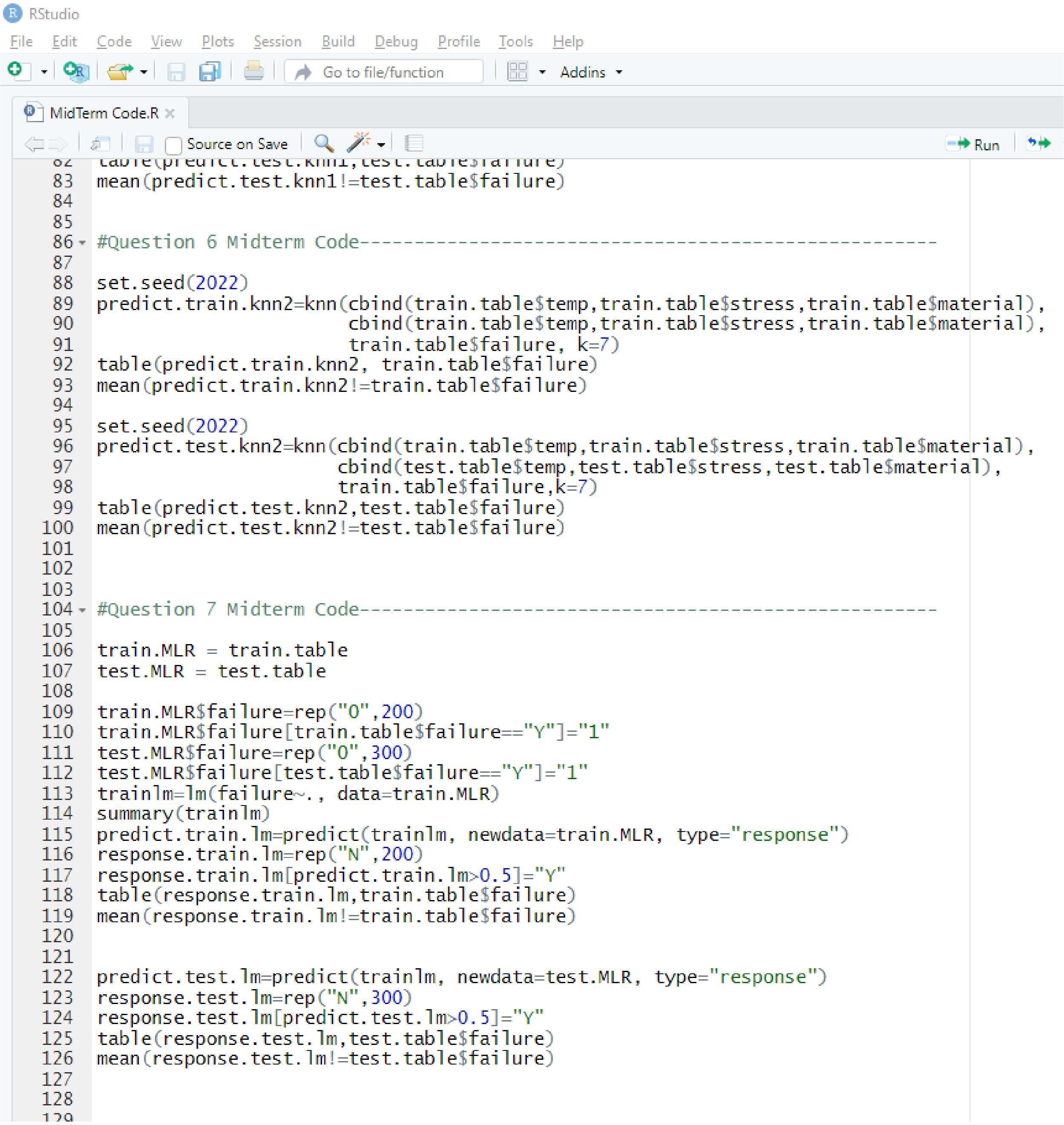
# Appendix



```r
data.train2022=read.table("C:/Users/af44m/OneDrive/Desktop/data.train2022.txt")
data.test2022=read.table("C:/Users/af44m/OneDrive/Desktop/data.test2022.txt")

library(MASS)
library(class)

train.table=data.train2022
train.table$failure=as.factor(train.table$failure)
test.table=data.test2022
test.table$failure=as.factor(test.table$failure)



#Question 1 Midterm Code-----------------------------------------------------

boxplot(temp ~ failure, data = train.table, cex.lab=1.5, cex.axis=1.5, cex.main=1.5,
        cex.sub=1.5)



#Question 2 Midterm Code-----------------------------------------------------

train.lda=lda(failure ~ ., data=train.table)
train.lda
predict.train=predict(train.lda, train.table, type="response")
table(predict.train$class, train.table$failure)
mean(predict.train$class!=train.table$failure)

test.lda=lda(failure ~ ., data=train.table)
predict.test=predict(test.lda, test.table, type="response")
table(predict.test$class, test.table$failure)
mean(predict.test$class!=test.table$failure)



#Question 3 Midterm Code-----------------------------------------------------

train.qda=qda(failure ~ ., data=train.table)
train.qda
predict.train.qda=predict(train.qda, train.table, type="response")
table(predict.train.qda$class, train.table$failure)
mean(predict.train.qda$class!=train.table$failure)

test.qda=qda(failure ~ ., data=train.table)
predict.test.qda=predict(test.qda, test.table, type="response")
table(predict.test.qda$class, test.table$failure)
mean(predict.test.qda$class!=test.table$failure)



#Question 4 Midterm Code-----------------------------------------------------

train.glm=glm(failure~., data=train.table, family = binomial)
summary(train.glm)
```



```
#Question 4 Midterm Code-------------------------------------------------------

train.glm=glm(failure~., data=train.table, family = binomial)
summary(train.glm)
predict.train.glm=predict(train.glm, train.table, type="response")
train.reponse=rep("N", nrow(train.table))
train.reponse[predict.train.glm>0.5]<-"Y"
table(train.reponse,train.table$failure)
mean(train.reponse!=train.table$failure)

test.glm=glm(failure~., data=train.table, family = binomial)
predict.test.glm=predict(test.glm, test.table, type="response")
test.reponse=rep("N", nrow(test.table))
test.reponse[predict.test.glm>0.5]<-"Y"
table(test.reponse,test.table$failure)
mean(test.reponse!=test.table$failure)


#Question 5 Midterm Code-------------------------------------------------------

set.seed(2022)
predict.train.knn1=knn(cbind(train.table$temp,train.table$stress,train.table$material),
                      cbind(train.table$temp,train.table$stress,train.table$material),
                      train.table$failure, k=2)
table(predict.train.knn1, train.table$failure)
mean(predict.train.knn1!=train.table$failure)

set.seed(2022)
predict.test.knn1=knn(cbind(train.table$temp,train.table$stress,train.table$material),
                      cbind(test.table$temp,test.table$stress,test.table$material),
                      train.table$failure,k=2)
table(predict.test.knn1,test.table$failure)
mean(predict.test.knn1!=test.table$failure)


#Question 6 Midterm Code-------------------------------------------------------

set.seed(2022)
predict.train.knn2=knn(cbind(train.table$temp,train.table$stress,train.table$material),
                       cbind(train.table$temp,train.table$stress,train.table$material),
                       train.table$failure, k=7)
table(predict.train.knn2, train.table$failure)
mean(predict.train.knn2!=train.table$failure)

set.seed(2022)
predict.test.knn2=knn(cbind(train.table$temp,train.table$stress,train.table$material),
                      cbind(test.table$temp,test.table$stress,test.table$material),
                      train.table$failure,k=7)
table(predict.test.knn2,test.table$failure)
mean(predict.test.knn2!=test.table$failure)
```



```r
table(predict.test.knn1,test.table$failure)
mean(predict.test.knn1!=test.table$failure)


#Question 6 Midterm Code-----------------------------------------------------

set.seed(2022)
predict.train.knn2=knn(cbind(train.table$temp,train.table$stress,train.table$material),
                       cbind(train.table$temp,train.table$stress,train.table$material),
                       train.table$failure, k=7)
table(predict.train.knn2, train.table$failure)
mean(predict.train.knn2!=train.table$failure)

set.seed(2022)
predict.test.knn2=knn(cbind(train.table$temp,train.table$stress,train.table$material),
                      cbind(test.table$temp,test.table$stress,test.table$material),
                      train.table$failure,k=7)
table(predict.test.knn2,test.table$failure)
mean(predict.test.knn2!=test.table$failure)



#Question 7 Midterm Code-----------------------------------------------------

train.MLR = train.table
test.MLR = test.table

train.MLR$failure=rep("0",200)
train.MLR$failure[train.table$failure=="Y"]="1"
test.MLR$failure=rep("0",300)
test.MLR$failure[test.table$failure=="Y"]="1"
trainlm=lm(failure~., data=train.MLR)
summary(trainlm)
predict.train.lm=predict(trainlm, newdata=train.MLR, type="response")
response.train.lm=rep("N",200)
response.train.lm[predict.train.lm>0.5]="Y"
table(response.train.lm,train.table$failure)
mean(response.train.lm!=train.table$failure)


predict.test.lm=predict(trainlm, newdata=test.MLR, type="response")
response.test.lm=rep("N",300)
response.test.lm[predict.test.lm>0.5]="Y"
table(response.test.lm,test.table$failure)
mean(response.test.lm!=test.table$failure)
```