R Code for engine data

```
#Models with two qualitative variables
engine=read.table("C:/Users/Mihinda/Desktop/engine.txt",
header=1) #the data file
engine
#Main effects model
fit1 <- lm(perform ~ F2 + F3 + B2, data=engine)
summary(fit1)
anova(fit1)

#Interaction model
fit2 <- lm(perform ~ F2 + F3 + B2 + F2B2 + F3B2, data=engine)
summary(fit2)
anova(fit2)

grp.means <- with(engine, tapply(perform,combination,mean))
grp.means
grp.lengths <- with(engine, tapply(perform,combination,length))
grp.lengths
```

R Output for engine data

```
> #Models with two qualitative variables
> engine=read.table("C:/Users/Mihinda/Desktop/engine.txt",
header=1) #the data file
> engine
   Row combination perform F2 F3 B2 F2B2 F3B2  F  B
1    1        F1B1      65  0  0  0    0    0 F1 B1
2    2        F1B1      73  0  0  0    0    0 F1 B1
3    3        F1B1      68  0  0  0    0    0 F1 B1
4    4        F1B2      36  0  0  1    0    0 F1 B2
5    5        F2B1      78  1  0  0    0    0 F2 B1
6    6        F2B1      82  1  0  0    0    0 F2 B1
7    7        F2B2      50  1  0  1    1    0 F2 B2
8    8        F2B2      43  1  0  1    1    0 F2 B2
9    9        F3B1      48  0  1  0    0    0 F3 B1
10  10        F3B1      46  0  1  0    0    0 F3 B1
11  11        F3B2      61  0  1  1    0    1 F3 B2
12  12        F3B2      62  0  1  1    0    1 F3 B2
> #Main effects model
> fit1 <- lm(perform ~ F2 + F3 + B2, data=engine)
> summary(fit1)

Call:
lm(formula = perform ~ F2 + F3 + B2, data = engine)

Residuals:
    Min      1Q  Median      3Q     Max
-16.159 -12.415   2.046   9.119  15.659

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)   64.455      7.180   8.976 1.89e-05 ***
F2             6.705      9.941   0.674   0.5190
F3            -2.295      9.941  -0.231   0.8232
B2           -15.818      8.291  -1.908   0.0928 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 13.75 on 8 degrees of freedom
Multiple R-squared: 0.362,      Adjusted R-squared: 0.1228
F-statistic: 1.513 on 3 and 8 DF,  p-value: 0.2838
```

```
> anova(fit1)
Analysis of Variance Table

Response: perform
          Df  Sum Sq Mean Sq F value  Pr(>F)
F2         1   92.04   92.04  0.4869 0.50510
F3         1   78.13   78.13  0.4132 0.53831
B2         1  688.09  688.09  3.6397 0.09285 .
Residuals  8 1512.41  189.05
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
>
> #Interaction model
> fit2 <- lm(perform ~ F2 + F3 + B2 + F2B2 + F3B2, data=engine)
> summary(fit2)

Call:
lm(formula = perform ~ F2 + F3 + B2 + F2B2 + F3B2, data =
engine)

Residuals:
   Min     1Q Median     3Q    Max
-3.667 -1.250 -0.250  1.250  4.333

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  68.6667     1.9389  35.416 3.38e-08 ***
F2           11.3333     3.0656   3.697 0.010126 *
F3          -21.6667     3.0656  -7.068 0.000402 ***
B2          -32.6667     3.8778  -8.424 0.000153 ***
F2B2         -0.8333     5.1298  -0.162 0.876285
F3B2         47.1667     5.1298   9.195 9.33e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 3.358 on 6 degrees of freedom
Multiple R-squared: 0.9715,     Adjusted R-squared: 0.9477
F-statistic: 40.84 on 5 and 6 DF,  p-value: 0.0001477
```

```
> anova(fit2)
Analysis of Variance Table

Response: perform
          Df Sum Sq Mean Sq F value    Pr(>F)
F2         1  92.04   92.04  8.1613 0.0289225 *
F3         1  78.13   78.13  6.9273 0.0389560 *
B2         1 688.09  688.09 61.0130 0.0002323 ***
F2B2       1 491.30  491.30 43.5637 0.0005815 ***
F3B2       1 953.44  953.44 84.5415  9.33e-05 ***
Residuals  6  67.67   11.28
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
>
> grp.means <- with(engine, tapply(perform,combination,mean))
> grp.means
    F1B1     F1B2     F2B1     F2B2     F3B1     F3B2
68.66667 36.00000 80.00000 46.50000 47.00000 61.50000
> grp.lengths <- with(engine,
tapply(perform,combination,length))
> grp.lengths
F1B1 F1B2 F2B1 F2B2 F3B1 F3B2
   3    1    2    2    2    2
```

Test whether there is an interaction between brand and fuel type.