HW5

1.a.

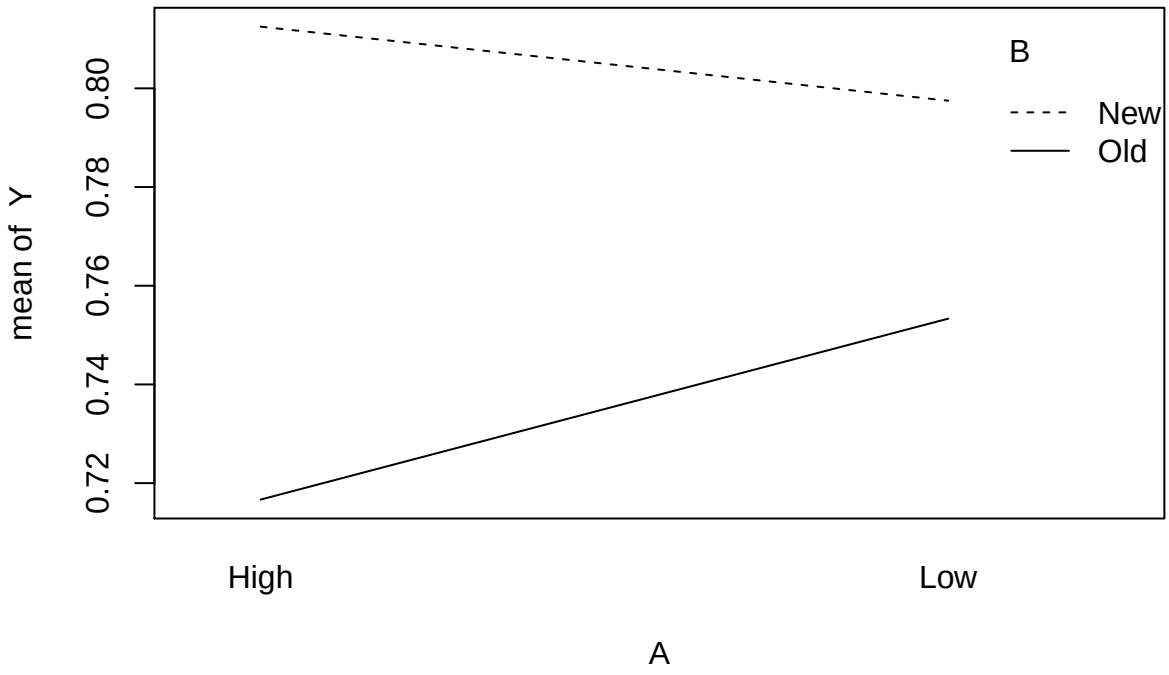
```
Y<-c(0.83, 0.78, 0.75, 0.83, 0.86, 0.67, 0.73, 0.72, 0.81, 0.85, 0.87, 0.68, 0.73, 0.74)
A<-c(rep('Low', 7), rep('High', 7))
B<-c(rep(c(rep('New', 4), rep('Old', 3)), 2))
data<-data.frame(Y, A, B)
```

```
model.matrix(~A*B, contrasts=list(A=contr.sum, B=contr.sum))
```

```
##    (Intercept) A1 B1 A1:B1
## 1            1 -1  1    -1
## 2            1 -1  1    -1
## 3            1 -1  1    -1
## 4            1 -1  1    -1
## 5            1 -1 -1     1
## 6            1 -1 -1     1
## 7            1 -1 -1     1
## 8            1  1  1     1
## 9            1  1  1     1
## 10           1  1  1     1
## 11           1  1  1     1
## 12           1  1 -1    -1
## 13           1  1 -1    -1
## 14           1  1 -1    -1
## attr(,"assign")
## [1] 0 1 2 3
## attr(,"contrasts")
## attr(,"contrasts")$A
##      [,1]
## High    1
## Low    -1
##
## attr(,"contrasts")$B
##     [,1]
## New    1
## Old   -1
```

1.b.

```
interaction.plot(A, B, Y)
```



The lines in the interaction plot are not parallel to each other, which suggests that there is interaction between fertilizer type and wheat type.

1.c.

```
summary(aov(Y~A*B))
```

```
##             Df  Sum Sq  Mean Sq F value Pr(>F)
## A            1 0.00018 0.000179   0.046 0.8346
## B            1 0.01680 0.016800   4.321 0.0643 .
## A:B          1 0.00229 0.002288   0.588 0.4607
## Residuals   10 0.03888 0.003888
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

From the ANOVA table above, we could see that p value of the test is 0.4607, which is larger than α. So we could not reject H_0 and there is no interaction between A and B.

1.d.

```
library(car)
```

```
## Loading required package: carData
```

```
model<-lm(Y~A+B)
Anova(model, type=3)
```

```
## Anova Table (Type III tests)
##
## Response: Y
##             Sum Sq Df  F value    Pr(>F)
## (Intercept) 3.2698  1 873.6183 7.838e-12 ***
## A           0.0002  1   0.0477   0.83110
## B           0.0168  1   4.4885   0.05771 .
```

```
## Residuals   0.0412 11
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

From the above ANOVA table with type III SS, we could see that the p value of the test is 0.83110, which is larger than α. So we accept H0 and there is no A effect.

1.e.

From the above ANOVA table with type III SS, we could see that the p value of the test is 0.05771, which is larger than α. So we accept H0 and there is no B effect.

2.a.

```
y<-c(28.0,28.6,27.4,33.3,34.5,33.0,32.0,35.6,34.4,35.0,34.0,33.3,34.7,33.5,32.3,33.4,33.0,32.0,29.6,30.
D1<-factor(c(rep(0,3),rep(1,2),rep(0,4),rep(1,3),rep(0,3),1,rep(0,2),rep(1,2),rep(0,2)))
D2<-factor(c(rep(0,12),1,rep(0,3),rep(1,2),rep(0,2),rep(1,2)))
x1<-c(rep('A',3),rep('B',2),rep('A',4),rep('B',3),'C',rep('A',2),'B',rep('C',2),rep('B',2),rep('C',2))
x2<-c(rep(0,5),rep(1,8),rep(2,5),rep(3,4))
```

```
fit2<-lm(y~D1+D2+x2)
summary(fit2)
```

```
##
## Call:
## lm(formula = y ~ D1 + D2 + x2)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4.6171 -1.6321  0.5508  1.3756  4.0021
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  32.0171     1.0005  32.002   <2e-16 ***
## D11           1.5218     1.2650   1.203    0.245
## D21           0.5252     1.6194   0.324    0.749
## x2           -0.4192     0.6042  -0.694    0.497
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.532 on 18 degrees of freedom
## Multiple R-squared:  0.09453,    Adjusted R-squared:  -0.05638
## F-statistic: 0.6264 on 3 and 18 DF,  p-value: 0.6072
```

β_0 stands for the average mileage with type A gasoline when there is no gasoline additive.

β_1 stands for the difference between the average mileages of type B and type A when the amount of gasoline additive remains fixed.

Similar interpretation for β_2.

β_3 represents the increase of mileage with the same unleaded type when the amount of additive increases by 1 unit.

Among all these β_i, only β_0 is significant while others are not. The fitted result suggests that neither difference between different types or the amount of additive is significant to mileage.

2.b.

```
confint(fit2,"x2",level = 0.95)
```

```
##        2.5 %    97.5 %
## x2 -1.688644 0.8502126
```

The 95% confidence interval for β_3 is [-1.688644, 0.8502126], which covers 0. From the confidence interval result, we could see that amount of additive is not a significant variable to the mileage.

2.c.

```
fit3<-lm(y~x2)
anova(fit3,fit2)
```

```
## Analysis of Variance Table
##
## Model 1: y ~ x2
## Model 2: y ~ D1 + D2 + x2
##   Res.Df    RSS Df Sum of Sq      F Pr(>F)
## 1     20 125.14
## 2     18 115.42  2    9.7138 0.7574 0.4832
```

The p value for the test is 0.4832, which is larger than α. So H_0 could not be rejected and the premium gasoline unleaded type (A, B, C) is not a significant variable.