HW6

1.

```
yield<-c(5.1,5.3,5.3,5.2,4.8,5.3,5.4,6.0,5.7,4.8,4.8,4.5,5.3,4.7,5.5,5.0,4.4,4.9,4.7,4.3,4.7,4.4,4.7,4.
rates<-factor(rep(c(25,50,75,100,125,150),4))
field<-factor(c(rep(1,6),rep(2,6),rep(3,6),rep(4,6)))
```

```
fit1<-lm(yield~rates+field)
library(car)
```

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

```
Anova(fit1)
```

```
## Anova Table (Type II tests)
##
## Response: yield
##           Sum Sq Df F value   Pr(>F)
## rates     1.2671  5  2.1261 0.118366
## field     1.9646  3  5.4941 0.009488 **
## Residuals 1.7879 15
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

From the ANOVA table above, we could see that the p-value for the test is 0.118366, which is larger than $\alpha = 0.05$. So we could reject not H_0, which means that the average yields are not different for the 6 seeding rates.

2.a.

```
y<-c(12,2,1,8,7,20,14,17,12,17,13,7,13,8,14,11,5,10,3,6)
block<-factor(rep(c(1,2,3,4,5),4))
trt<-factor(c(rep(1,5),rep(2,5),rep(3,5),rep(4,5)))
data2<-data.frame(y,trt,block)
```

```
fit2<-lm(y~trt+block)
Anova(fit2)
```

```
## Anova Table (Type II tests)
##
## Response: y
##           Sum Sq Df F value    Pr(>F)
## trt        310.0  3 14.8503 0.0002421 ***
## block      124.5  4  4.4731 0.0192167 *
## Residuals   83.5 12
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

From the ANOVA table above, we could see that the p-value for the test is 0.0002421, which is smaller than $\alpha = 0.05$. So we could reject H_0, which means that the mean cutting speeds are different for the four tools.

2.b.

```r
pairwise.t.test(data2$y,data2$trt,pool.sd=TRUE,p.adjust.method="bonf")
```

```
##
##  Pairwise comparisons using t tests with pooled SD
##
## data:  data2$y and data2$trt
##
##   1      2      3
## 2 0.0028 -      -
## 3 0.2608 0.2608 -
## 4 1.0000 0.0069 0.5912
##
## P value adjustment method: bonferroni
```

From the table above, $H_0 : \mu_1 - \mu_2 = 0$ and $H_0 : \mu_2 - \mu_4 = 0$ have p-values that are smaller than 0.05. So tool 1 has different effect from tool 2 and tool 4 has different effect from tool 2. Other pairs could not differ. So we could put 1 and 4 into one group while tool 2 into another group. Tool 3 is not significantly different from group $\{2\}$ or group$\{1,4\}$ either.

3.

We use Latin Square Design to solve this problem.

```r
period<-c(rep("1",4),rep("2",4),rep("3",4),rep("4",4))
cow<-rep(c("1","2","3","4"),4)
trt<-c("D4","D1","D3","D2","D1","D4","D2","D3","D3","D2","D1","D4","D2","D3","D4","D1")
yield<-c(192,195,292,249,190,203,218,210,214,139,245,163,221,152,204,134)
```

Assuming there is no interaction between block and treatments, we could model the cutting speeds as the sum of treatment effect and block effect.

```r
library(car)
fit3<-lm(yield~trt+period+cow)
Anova(fit3)
```

```
## Anova Table (Type II tests)
##
## Response: yield
##           Sum Sq Df F value Pr(>F)
## trt       1995.7  3  0.5377 0.6736
## period    6539.2  3  1.7618 0.2540
## cow       9929.2  3  2.6751 0.1409
## Residuals 7423.4  6
```

From the ANOVA table above, we could see that the p-value for the test is 0.6736, which is quite large, much larger than the commonly used $\alpha = 0.05$. So we could not reject H_0, which means that there is no difference between the four diets.