

a5

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24/06/2020

q1

```
options(contrasts = c('contr.sum', 'contr.poly'))
y = c(90.4, 90.2, 90.7, 90.6, 90.2, 90.4, 90.1, 90.3, 90.5,
      90.6, 89.9, 90.1, 90.5, 90.7, 90.8, 90.9, 90.4, 90.1)
x = as.factor(c('00', '00', '01', '01', '02', '02', '10', '10', '11',
                '11', '12', '12', '20', '20', '21', '21', '22', '22'))
```

(a)

```
model1 = lm(y ~ x)
anova(model1)
```

```
## Analysis of Variance Table
##
## Response: y
##           Df Sum Sq Mean Sq F value    Pr(>F)
## x           8 1.1378  0.142222      8 0.002638 **
## Residuals   9 0.1600  0.017778
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

$H_0: \tau_{11} = \tau_{12} = \dots = \tau_{33} = 0$ vs H_a : at least one of them is not zero.

From anova table $d = 8$ and $D \sim F_{8,9}$

From anova table p-value = 0.002638

Hence there is tons of evidence against H_0 , therefore there is a treatment effect.

(b)

```
temp = as.factor(c(rep(150, 6), rep(160, 6), rep(170, 6)))
psig = as.factor(rep(c(rep(200, 2), rep(215, 2), rep(230, 2)), 3))

model2 = lm(y ~ temp + psig + temp * psig)
anova(model2)
```

```
## Analysis of Variance Table
##
## Response: y
##           Df Sum Sq Mean Sq F value    Pr(>F)
## temp        2 0.30111  0.15056   8.4687 0.0085392 **
## psig        2 0.76778  0.38389  21.5937 0.0003673 ***
## temp:psig   4 0.06889  0.01722   0.9687 0.4700058
## Residuals   9 0.16000  0.01778
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

H_0 : no interaction vs H_a : interaction

From anova table, $d = \frac{ms_{int}}{ms_{res}} = \frac{0.01722}{0.01778} = 0.9685039$, $D \sim F_{4,9}$

From anova table, p-value = 0.4700058

There is no evidence against H_0 , hence no interaction.

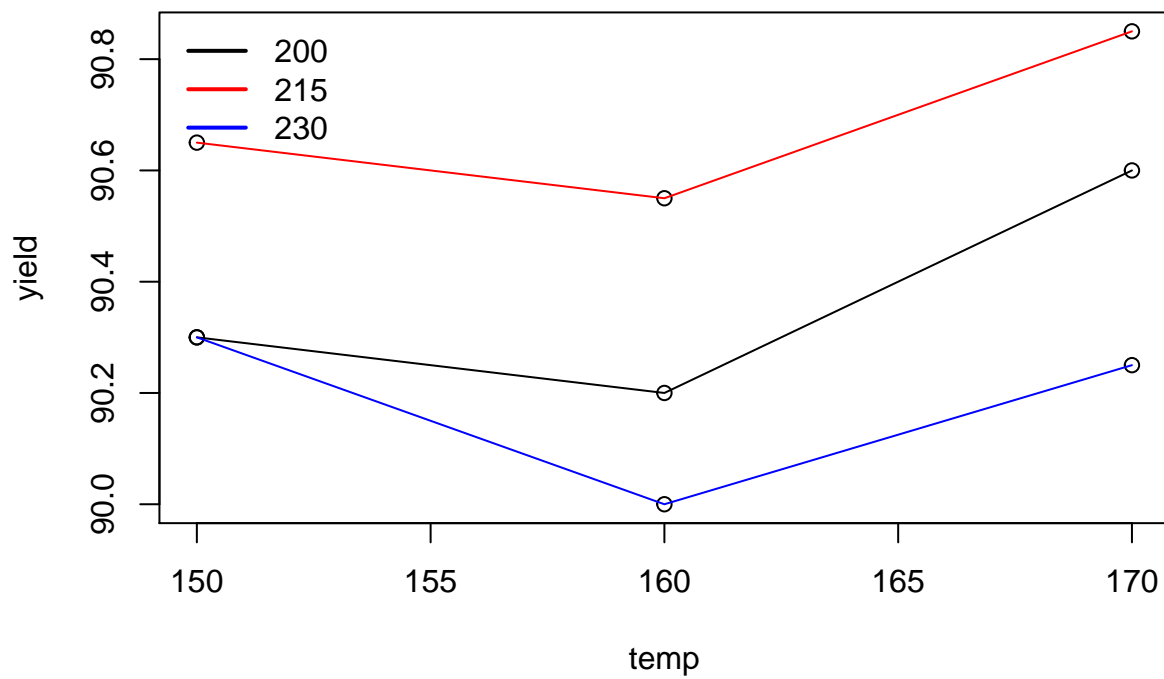
(c)

```
#calculate mean for each
hat = vector(length = 9)
calmean = function(m, v) {
  j = 1
  for (i in seq(from = 1, to = 17, by = 2)) {
    m[j] = (v[i] + v[i + 1]) / 2
    j = j + 1
  }
  return(m)
}
hat = calmean(hat, y)

plot(x = c(rep(150, 3), rep(160, 3), rep(170, 3)),
     y = hat,
     xlab = "temp", ylab = "yield")

clrs = c('black', 'red', 'blue')
for (i in 1:3) {
  lines(x = c(150, 160, 170), y = c(hat[i], hat[i + 3], hat[i + 6]), col = clrs[i])
}

legend("topleft", bty='n', cex=1,
      legend = c("200", "215", "230"),
      col = c('black', 'red', 'blue'),
      lty=c(1, 1), lwd=c(2,2),
      text.width = 1
)
```



From the plot, the groups where pressure is 230 and the groups where pressure is 200 at temperature 150 and 160 have a little interaction. The other lines are roughly parallel to each other. So there is a little interaction.