Homework 2

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Problem 1

A pharmaceutical manufacturer wants to investigate the bioactivity of a new drug. A completely randomized single-factor experiment was conducted with three dosage levels, and the following results were obtained.

Dosage	Observations			
20g	24	28	37	30
30g	37	44	31	35
40g	42	47	52	38

Complete the ANOVA table:

```
nt <- 3 * 4
a <- 3
df_tr <- ( a - 1 )
df_tr
```

```
[1] 2
```

```
df_e <- nt - a
df_e
```

```
[1] 9
```

```
SStr <- 450.7
SST <- 783.9
SSe <- SST - SStr
SSe
```

```
[1] 333.2
```

```
MStr <- SStr / df_tr
MStr
```

```
[1] 225.35
```

```
MSe <- SSe / df_e
MSe
```

```
[1] 37.02222
```

```
F_v <- MStr / MSe
F_v
```

```
[1] 6.086885
```

```
P_v <- pf(F_v, df_tr, df_e, lower.tail = F)
P_v
```

```
[1] 0.02128136
```

	df	SS	MS	F-Value	P-Value
Bet_ Dossage	2	450.7	225.35	6.09	0.021
Error	9	333.2	37.02		
Total	11	783.9			

a.

Is there evidence to indicate that dosage level affects bioactivity?

R/
Assuming an $\alpha = 0.05$, There is strong evidence to conclude that the at least one of the mean bioactivities is different from the others (P-value $< \alpha$).

b.

Compute a 95 percent interval estimate of the mean of dosage level is 30g.

R/

```
dos20 <- c(24, 25, 37, 30)
dos30 <- c(37, 44, 31, 35)
dos40 <- c(42, 47, 52, 38)
x2 <- mean(dos30)
x2
```

```
[1] 36.75
```

```
s2 <- sd(dos30)
s2
```

```
[1] 5.439056
```

```
n2 <- 4
n2
```

```
[1] 4
```

```
t2_star <- qt(.975, n2-1)
t2_star
```

```
[1] 3.182446
```

```
SE2 <- s2 / sqrt(n2)
SE2
```

```
[1] 2.719528
```

```
Upper <- x2 + t2_star * SE2
Upper
```

```
[1] 45.40475
```

```
Lower<- x2 - t2_star * SE2
Lower
```

```
[1] 28.09525
```

We are 95% confident that the true mean bioactivity of the new drug at a dosage of 30 mg is between (28.1, 45.4).

c.

Compute a 99 percent interval estimate of the mean difference between dosages levels 20g and 40g.

R/

```
x1 <- mean(dos20)
x1
```

```
[1] 29
```

```
x3 <- mean(dos40)
x3
```

```
[1] 44.75
```

```
s1 <- sd(dos20)
s1
```

```
[1] 5.944185
```

```
s2 <- sd(dos40)
s2
```

```
[1] 6.075909
```

```
n1 = n3 = 4
PEs <- x3 - x1
PEs
```

```
[1] 15.75
```

```r
df <- n1+n3-2
df
```

```
[1] 6
```

```r
SE <- sqrt(MSe / n1 + MSe / n3)
SE
```

```
[1] 4.302454
```

```r
t_star <- qt(0.995, df, lower.tail = T)
t_star
```

```
[1] 3.707428
```

```r
Upper1 <- PEs + (SE * t_star)
Upper1
```

```
[1] 31.70104
```

```r
Lower1 <- PEs - (SE * t_star)
Lower1
```

```
[1] -0.2010388
```

We are 99% confident that the bioactivity of the new drug at a dosage of 40 mg is between 31.7 higher, and -0.2) lower than the dosage of 20 mg.

d.

Compute simultaneous 95% CIs for the difference in means for dosage levels 20g and 40g, based on Tukey's, Bonferroni's and Scheffe's Methods:

R/

```r
#Tukey's HSD
Q <- qtukey(0.95, 3, 12-3)/sqrt(2)
Q
```

```
[1] 2.792006
```

```
Up_Tu <- PEs + Q * SE
Up_Tu
```

```
[1] 27.76248
```

```
Lo_Tu <- PEs - Q * SE
Lo_Tu
```

```
[1] 3.737524
```

```
# Bonferroni
g = 3 * (3 - 1)/2
dfe = 12 - 3
t_bf = qt(1 - (0.05/(2*g)), dfe)
t_bf
```

```
[1] 2.933324
```

```
Up_bf <- PEs + t_bf * SE
Up_bf
```

```
[1] 28.37049
```

```
Lo_bf <- PEs - t_bf * SE
Lo_bf
```

```
[1] 3.129508
```

```
# Scheffe
Sh <- sqrt((3 - 1) * qf(0.95, 3-1, dfe))
Sh
```

```
[1] 2.917703
```

```r
Up_sh <- PEs + Sh * SE
Up_sh
```

```
[1] 28.30328
```

```r
Lo_sh <- PEs - Sh * SE
Lo_sh
```

```
[1] 3.196718
```

Tukey's HSD 95% confidence interval = (3.74, 27.76)
Bonferroni's 95% confidence interval = (3.13, 28.37)
Scheffe's 95% confidence interval = (3.2, 28.3)

e.

Use Tukey's HSD to compare pairs of treatment means.

R/
When $|x_a - x_b| > Tukey's\ HSD$ we can conclude that there is a difference mean of a is different of the mean of b

```r
# Tukey's HSD for all the comparisons
T_HSD <- Q * SE
T_HSD
```

```
[1] 12.01248
```

```r
abs(x1 - x2) > T_HSD #Comparison for dosage 20g to dosage 30g
```

```
[1] FALSE
```

```r
abs(x1 - x3) > T_HSD #Comparison for dosage 20g to dosage 40g
```

```
[1] TRUE
```

```
abs(x2 - x3) > T_HSD #Comparison for dosage 30g to dosage 40g
```

```
[1] FALSE
```

For these comparisons, the only comparison in which the mean bioactivity of the new drug is significantly different, is when it is compared 20g and 40 g of dosage.

Problem 2

The tensile strength of Portland cement is being studied. Four different mixing techniques can be used economically. A completely randomized experiment was conducted, and the following data were collected.

Mixing Technique	Tensile Strength (lb/in^2)			
1	3129	3000	2865	2890
2	3200	3300	2975	3150
3	2800	2900	2985	3050
4	2600	2700	2600	2765

You are given the following information:

$\bar{Y}_{1.} = 2971.00$, $s(\bar{Y}_{1.}) = 56.65$ and, $MSE = 12825.7$
$\bar{Y}_{2.} = 2933.75$, $s(\bar{Y}_{2.}) = 56.65$
$\bar{Y}_{3.} = 2933.75$, $s(\bar{Y}_{3.}) = 56.65$
$\bar{Y}_{4.} = 2666.25$, $s(\bar{Y}_{4.}) = 56.65$

a.

Test the hypothesis that mixing techniques affect the strength of the cement. Test the hypothesis:

$$H_o : \mu_1 = \mu_2 = \mu_3 = \mu_3$$

$$H_a : At\ least\ one\ \mu_i \neq \mu_j\ ; for\ i \neq j$$