Homework 3 - Solutions

STAT 212 (Fall 2022)

Problem A

Problem 4, pg 368

(a)

R commands:

```
pc <- read.table("PorousCarbon.txt", header=TRUE)
pc_aov <- aov(values ~ as.factor(temp), data = pc)
thsd <- TukeyHSD(pc_aov, conf.level = .95)
```

	diff	lwr	upr	p adj
400-300	-0.19	-0.8414712	0.4614712	0.8373903
500-300	-0.77	-1.4214712	-0.1185288	0.0179499
600-300	-1.19	-1.8414712	-0.5385288	0.0004366
500-400	-0.58	-1.2314712	0.0714712	0.0900085
600-400	-1.00	-1.6514712	-0.3485288	0.0023107
600-500	-0.42	-1.0714712	0.2314712	0.2897872

We see that the 500-300, 600-300, and 600-400 pairs have p-values less than 0.05 and are significantly different.

Hand calculation:

```
sst <- sum((pc$values - mean(pc$values))^2)
sst
```

```
## [1] 6.521375
```

```
anova(pc_aov)
```

```
## Analysis of Variance Table
##
## Response: values
##                 Df Sum Sq Mean Sq F value    Pr(>F)
## as.factor(temp)  3 4.4474 1.48246  11.437 0.0002958 ***
## Residuals       16 2.0740 0.12962
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

$$SSTr = 4.4474$$
$$SST = 6.521375$$
$$k = 4$$
$$n_1 = n_2 = n_3 = n_4 = 5$$
$$MSE = \frac{SST - SSTr}{N - k}$$
$$= (6.521375 - 4.4474)/(20 - 4) = 0.1296234$$

The critical value, from the Q table, is

$$Q_{0.05,4,16} = 4.05$$

The margin of error is

$$Q_{0.05,4,16}\sqrt{\frac{MSE}{2}\left(\frac{1}{5} + \frac{1}{5}\right)} = 4.05\sqrt{\frac{0.1296234}{2}\frac{2}{5}} = 0.6520963$$

We detmermine significant differences by seeing which absolute estimated differences exceed this margin of error. These are 500-300, 600-300, and 600-400.
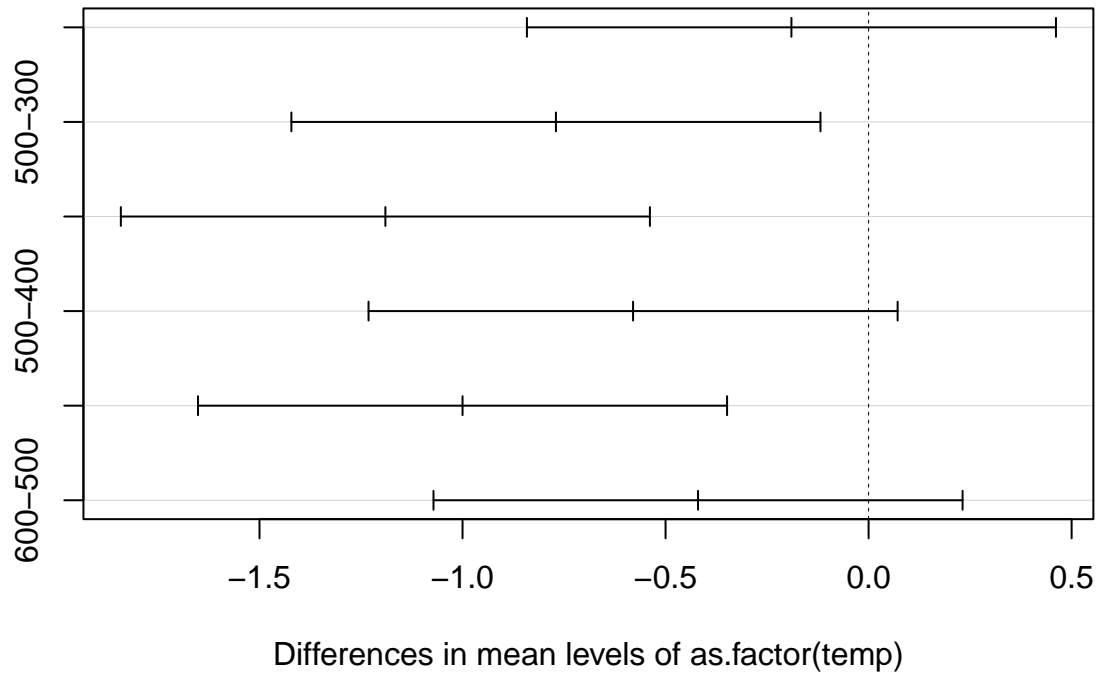
(c)

```
sort(thsd$`as.factor(temp)`[, 1])
```

```
## 600-300 600-400 500-300 500-400 600-500 400-300
##   -1.19   -1.00   -0.77   -0.58   -0.42   -0.19
```

The last three differences should be underlined.

```
plot(TukeyHSD(pc_aov))
```

95% family–wise confidence level

Differences in mean levels of as.factor(temp)

We see this in the plot, where these intervals do not contain 0, we reject the null that these differences are 0.