Homework 8

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```
fabric <- read.table(file="fabric.txt", header = T)
fabric$surface <- as.factor(fabric$surface)
fabric$filler<-factor(fabric$filler)
fabric$p <- factor(fabric$p)
fabric <- fabric %>% arrange(filler)
```

4)

a)

```
#estimate the linear model
cm <- lm(data = fabric, formula = y ~ surface + filler + p + surface:filler + surface:p + filler:p + su
cm$coefficients
```

```
##          (Intercept)             surface2              filler2
##                201.0                -37.0                 12.0
##                  p50                  p75     surface2:filler2
##                 36.0                 66.0                -27.5
##         surface2:p50         surface2:p75          filler2:p50
##                -12.5                  2.0                -15.5
##          filler2:p75 surface2:filler2:p50 surface2:filler2:p75
##                -44.5                -43.0                -28.5
```

```
c <- c(cm$coefficients)
#our estimate is just the combination of coefficients
c[1]+c[3]+c[4]+c[9]
```

```
## (Intercept)
##       233.5
```

```
#and the standard error is square root of mse/2
mse <- anova(cm)$'Mean Sq'[8]
se <- sqrt(mse/2)
se
```

```
## [1] 11.59202
```

```
#We can check our answer using the lsmeans package
lsmeans(cm, ~ surface + filler + p + surface:filler + surface:p + filler:p + surface:filler:p)[7]
```

```
##  surface filler p  lsmean       SE df lower.CL upper.CL
##  1       2      50  233.5 11.59202 12 208.2432 258.7568
##
## Confidence level used: 0.95
```

b)

```
#lsmeans are the averages of observations of for each filler type across proportion and treatment
lsmeans(cm, ~filler)
```

```
## NOTE: Results may be misleading due to involvement in interactions
```

```
##  filler   lsmean       SE df lower.CL upper.CL
##  1      214.7500 4.732424 12 204.4389 225.0611
##  2      181.0833 4.732424 12 170.7723 191.3944
##
## Results are averaged over the levels of: surface, p
## Confidence level used: 0.95
```

c)

```
#same as above, but now we just average across filler type
lsmeans(cm, ~surface+p)[2]
```

```
## NOTE: Results may be misleading due to involvement in interactions
```

```
##  surface p  lsmean       SE df lower.CL upper.CL
##  2       25 156.25 8.196798 12 138.3907 174.1093
##
## Results are averaged over the levels of: filler
## Confidence level used: 0.95
```

d)

```
#the standard error is just square root of (mse*(1/8 + 1/8)), and should match what we have above
sqrt(mse*(1/8+1/8))
```

```
## [1] 8.196798
```

e)

```
#we can compute the test statistic using the answer from b)
t = (214.75-181.08333333)/sqrt(mse*(1/12+1/12))
fst = t^2
fst
```

```
## [1] 25.30481
```

```
pf(fst, 1, 12, lower.tail = F)
```

```
## [1] 0.0002939847
```

```
#this should be close to the F statistic in the second line of the ANOVA table:
anova(cm)[2,]
```

```
## Analysis of Variance Table
##
## Response: y
```

```
##        Df Sum Sq Mean Sq F value   Pr(>F)
## filler  1 6800.7  6800.7  25.305 0.000294 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

f)

```
#Three-way interaction is added last, so we can just use the last line of the ANOVA table for our reduc
anova(cm)[7,]
```

```
## Analysis of Variance Table
##
## Response: y
##                   Df Sum Sq Mean Sq F value Pr(>F)
## surface:filler:p  2 478.58  239.29  0.8904  0.436
```

```
#Numerator df is 2, denominator df is 12
```

g)

```
#No f/p two way interaction also restricts the 3-way interaction to be 0 as well
#We can just add SS from the last 2 lines of ANOVA table to get our error SS reduction for F test:
redss <- anova(cm)[7,2]+anova(cm)[6,2]
numdf <- anova(cm)[7,1]+anova(cm)[6,1]
fstat <- (redss/numdf)/mse
fstat
```

```
## [1] 3.728062
```

```
pf(fstat,numdf,12,lower.tail=F)
```

```
## [1] 0.03398892
```

```
#above should match what we get with a reduced/full F test:
redmm <- lm(data=fabric, formula = y~surface+filler+p+p:surface+filler:surface)
anova(cm,redmm)
```

```
## Analysis of Variance Table
##
## Model 1: y ~ surface + filler + p + surface:filler + surface:p + filler:p +
##     surface:filler:p
## Model 2: y ~ surface + filler + p + p:surface + filler:surface
##   Res.Df    RSS Df Sum of Sq      F  Pr(>F)
## 1     12 3225.0
## 2     16 7232.7 -4   -4007.7 3.7281 0.03399 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```