Math 3080 § 1. **Fly Ash Data: 2^3 Factorial with** Name: Example
Treibergs **One Replicate Per Cell ANOVA** April 7, 2010

Data File Used in this Analysis:

```
# Math 3080 - 1                Fly Ash Data                  April 17, 2010
# Treibergs
#
# from Devore "Probability and Statistics for Engineering and the Sciences,
# 5th ed.," (Duxbury 1999)
#
# Taken from "Fly Ash Binders in Stabilization of FGD Wastes,"
# (J. Environmental Engineering, 1998). A study of the influence of three
# factors that affect leaching characteristics of solid waste from combustion.
# Factor A = binder type
# Factor B = amount of water
# Factor C = land disposal scenario
# Response = effective concentration (mg/L) that decreases by 50% the light in
#            luminescence bioassay.
"Sample number"  "Factor A"  "Factor B"  "Factor C"  "Resonse EC50"
1  -1  -1  -1  23100
2   1  -1  -1  43000
3  -1   1  -1  71400
4   1   1  -1  76000
5  -1  -1   1  37000
6   1  -1   1  33200
7  -1   1   1  17000
8   1   1   1  16500
```

R Session:

```
R version 2.10.1 (2009-12-14)
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  Natural language support but running in an English locale

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Type 'q()' to quit R.

[R.app GUI 1.31 (5538) powerpc-apple-darwin8.11.1]
```

```
[Workspace restored from /Users/andrejstreibergs/.RData]

> tt <- read.table("M3081DataFlyAsh.txt",header=TRUE)
> tt
  Sample.number Factor.A Factor.B Factor.C Resonse.EC50
1             1       -1       -1       -1        23100
2             2        1       -1       -1        43000
3             3       -1        1       -1        71400
4             4        1        1       -1        76000
5             5       -1       -1        1        37000
6             6        1       -1        1        33200
7             7       -1        1        1        17000
8             8        1        1        1        16500
> attach(tt)
> A <- factor(Factor.A)
> B <- factor(Factor.B)
> C <- factor(Factor.C)
> Y <- Resonse.EC50

>#================================RUN ANOVA=======================
> f1<-aov(Y~A+B+C);anova(f1)
Analysis of Variance Table

Response: Y
          Df     Sum Sq    Mean Sq F value Pr(>F)
A          1   51005000   51005000  0.1071 0.7599
B          1  248645000  248645000  0.5220 0.5100
C          1 1507005000 1507005000  3.1636 0.1499
Residuals  4 1905425000  476356250
```

```
>#=========================LIST OF EFFECTS=======================
> model.tables(f1,"effects",se=TRUE)
Tables of effects

 A
A
   -1     1
-2525  2525

 B
B
   -1     1
-5575  5575

 C
C
    -1      1
 13725 -13725

Standard errors of effects
            A     B     C
        10913 10913 10913
replic.     4     4     4

>#===================================LIST OF MEANS===============
> model.tables(f1,"means",se=TRUE)
Tables of means
Grand mean

39650

 A
A
   -1     1
37125 42175

 B
B
   -1     1
34075 45225

 C
C
   -1     1
53375 25925

Standard errors for differences of means
            A     B     C
        15433 15433 15433
replic.     4     4     4
```

```
>#==============================BUILD CONTRASTS TABLE================
> L<-rep(1,times=8)
> LA <-Factor.A; LB <- Factor.B; LC <- Factor.C; LAB <- LA*LB; LAC <- LA*LC
> LBC <- LB*LC; LABC <- LA*LB*LC
> c1<- c("a","b","ab","c","ac","bc","abc","E","T")
> matrix(c(L,LA,LB,LAB,LC,LAC,LBC,LABC),ncol=8,dimnames=list(c("1",c1[1:7]),c("1",c1[1:7])))

    1  a  b ab  c ac bc abc
1   1 -1 -1  1 -1  1  1  -1
a   1  1 -1 -1 -1 -1  1   1
b   1 -1  1 -1 -1  1 -1   1
ab  1  1  1  1 -1 -1 -1  -1
c   1 -1 -1  1  1 -1 -1   1
ac  1  1 -1 -1  1  1 -1  -1
bc  1 -1  1 -1  1 -1  1  -1
abc 1  1  1  1  1  1  1   1

> muhat <- mean(Y)
> SST <- sum((Y-muhat)^2)
> SST
[1] 3712080000


>#=======HITTING OVERFLOW. TRY STANDARDIZING VARIABLES FIRST=========================
> s<-sd(Y)
> Z<- (Y-muhat)/s
>#============================RUN AOV=================================================
> f2 <- aov(Z~A+B+C);anova(f2)

Analysis of Variance Table

Response: Z
          Df Sum Sq Mean Sq F value Pr(>F)
A          1 0.0962 0.09618  0.1071 0.7599
B          1 0.4689 0.46888  0.5220 0.5100
C          1 2.8418 2.84181  3.1636 0.1499
Residuals  4 3.5931 0.89828
```

```
>#======================SUM SQUARES ARE SQUARES OF THE CONTRASTS====================

> CAC <- sum(LAC*Z); CBC <- sum(LBC*Z); CABC <- sum(LABC*Z); C <- sum(Z)
> CA <- sum(LA*Z);CB <- sum(LB*Z); CC <- sum(LC*Z); CAB <- sum(LAB*Z)
> C2 <- c(C,CA,CB,CAB,CC,CAC,CBC,CABC)
> c3 <- C2*C2/8
> matrix(c(c2,0,7,c3,0,SSZT),ncol=2,dimnames=list(c("1",c1),c("DF","SS")))
    DF          SS
1    1 9.629650e-35
a    1 9.618192e-02
b    1 4.688786e-01
ab   1 3.394323e-02
c    1 2.841812e+00
ac   1 1.955130e-01
bc   1 3.282122e+00
abc  1 8.154862e-02
E    0 0.000000e+00
T    7 7.000000e+00
> anova(f2)
Analysis of Variance Table

Response: Z
          Df Sum Sq Mean Sq F value Pr(>F)
A          1 0.0962 0.09618  0.1071 0.7599
B          1 0.4689 0.46888  0.5220 0.5100
C          1 2.8418 2.84181  3.1636 0.1499
Residuals  4 3.5931 0.89828

> matrix(c(c2[-1],0,7,c3[-1],0,SSZT),ncol=2,dimnames=list(c1,c("DF","SS")))
    DF         SS
a    1 0.09618192
b    1 0.46887863
ab   1 0.03394323
c    1 2.84181241
ac   1 0.19551303
bc   1 3.28212215
abc  1 0.08154862
E    0 0.00000000
T    7 7.00000000
```

```
>#====================================CONSTRUCT ANOVA TABLE "BY HAND"================

> SSe <- c3[4]+sum(c3[6:8]);SSe
[1] 3.593127
> FA <- c3[2]/MSe
> FB <- c3[3]/MSe
> FC <- c3[5]/MSe
> PA <- pf(FA,1,4)
> PA <- pf(FA,1,4,lower.tail=FALSE)
> PB <- pf(FB,1,4,lower.tail=FALSE)
> PC <- pf(FC,1,4,lower.tail=FALSE)


> matrix(c(1,1,1,4,7,c3[2:3],c3[5],SSe,SSZT,c3[2:3],c3[5],
  MSe,-1,FA,FB,FC,-1,-1,PA,PB,PC,-1,-1),ncol=5,
  dimnames=list(c(c1[1:2],c1[4],c2[7:8]),c("DF","SS","MS","F","Pr(>F)")))

    DF          SS          MS          F     Pr(>F)
a    1  0.09618192  0.09618192  0.1070732  0.7599095
b    1  0.46887863  0.46887863  0.5219728  0.5099832
c    1  2.84181241  2.84181241  3.1636092  0.1499193
E    4  3.59312704  0.89828176 -1.0000000 -1.0000000
T    7  7.00000000 -1.00000000 -1.0000000 -1.0000000



>#====================================COMPARE TO ANOVA TABLE OF AOV=================

> anova(f2)
Analysis of Variance Table

Response: Z
          Df Sum Sq Mean Sq F value Pr(>F)
A          1 0.0962 0.09618  0.1071 0.7599
B          1 0.4689 0.46888  0.5220 0.5100
C          1 2.8418 2.84181  3.1636 0.1499
Residuals  4 3.5931 0.89828
```