Math 3080 § 1. **Precambrian Iron Data: Tukey's Honest** Name: Example
Treibergs **Significant Differences in ANOVA** March 17, 2010

Data File Used in this Analysis:

```
# M3080 - 1             Precambrian Iron Data          March 12     2010
# treibergs
#
# From Devore "Probability and Statistics for Engineering and the
# Sciences, 5th ed."
#
#  from "Origins of Precambrian Iron Formations." Econ. Geology (1964)
#
# Total iron in four types of formations
#  1 = carbonate
#  2 = silicate
#  3 = magnetite
#  4 = hematite
#
"Fe"     "formation_group"
20.5     1
28.1     1
27.8     1
27       1
28       1
25.2     1
25.3     1
27.1     1
20.5     1
31.3     1
26.3     2
24       2
26.2     2
20.2     2
23.7     2
34       2
17.1     2
26.8     2
23.7     2
24.9     2
29.5     3
34       3
27.5     3
29.4     3
27.9     3
26.2     3
29.9     3
29.5     3
30       3
35.6     3
36.5     4
44.2     4
```

```
34.1     4
30.3     4
31.4     4
33.1     4
34.1     4
32.9     4
36.3     4
25.5     4
```

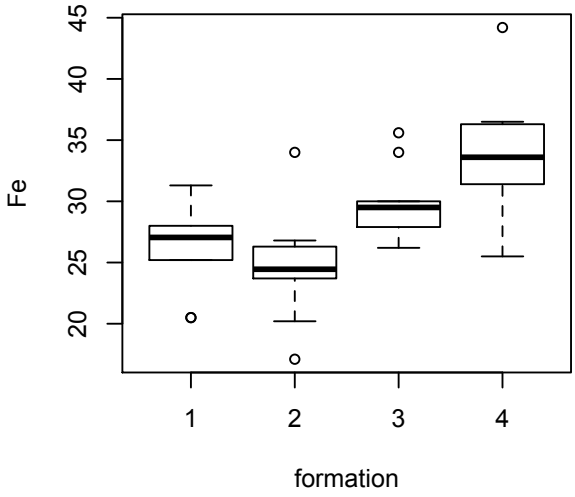
R Session:

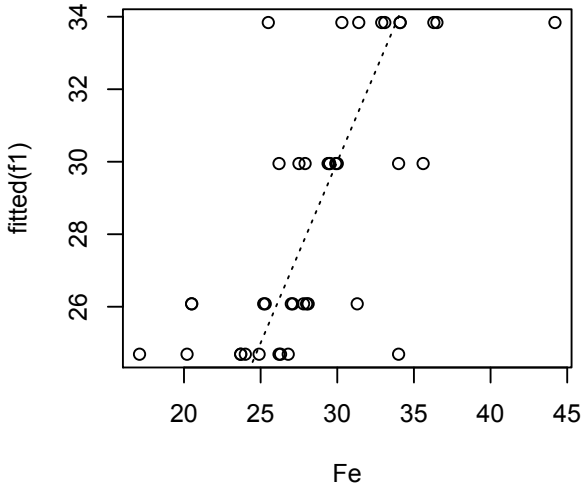
```
R version 2.10.1 (2009-12-14)
Copyright (C) 2009 The R Foundation for Statistical Computing
ISBN 3-900051-07-0

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

  Natural language support but running in an English locale

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
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("M3081DataPrecambrian.txt", header=TRUE); tt
     Fe formation_group
1  20.5               1
2  28.1               1
3  27.8               1
4  27.0               1
5  28.0               1
6  25.2               1
7  25.3               1
8  27.1               1
9  20.5               1
10 31.3               1
11 26.3               2
12 24.0               2
13 26.2               2
14 20.2               2
15 23.7               2
16 34.0               2
```

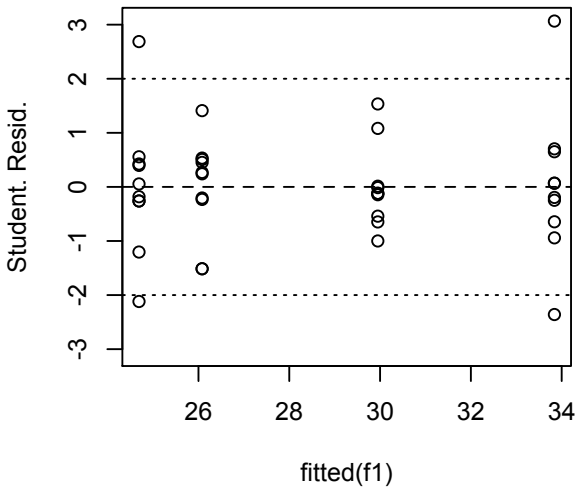
```
17 17.1               2
18 26.8               2
19 23.7               2
20 24.9               2
21 29.5               3
22 34.0               3
23 27.5               3
24 29.4               3
25 27.9               3
26 26.2               3
27 29.9               3
28 29.5               3
29 30.0               3
30 35.6               3
31 36.5               4
32 44.2               4
33 34.1               4
34 30.3               4
35 31.4               4
36 33.1               4
37 34.1               4
38 32.9               4
39 36.3               4
40 25.5               4
> attach(tt)
> formation <- factor(formation_group)

>#==============================SUMMARY STATS BY FACTOR==========
> tapply(Fe,formation,summary)

$`1`
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  20.50   25.22   27.05   26.08   27.95   31.30

$`2`
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  17.10   23.70   24.45   24.69   26.28   34.00

$`3`
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  26.20   28.28   29.50   29.95   29.98   35.60

$`4`
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  25.50   31.78   33.60   33.84   35.75   44.20
```

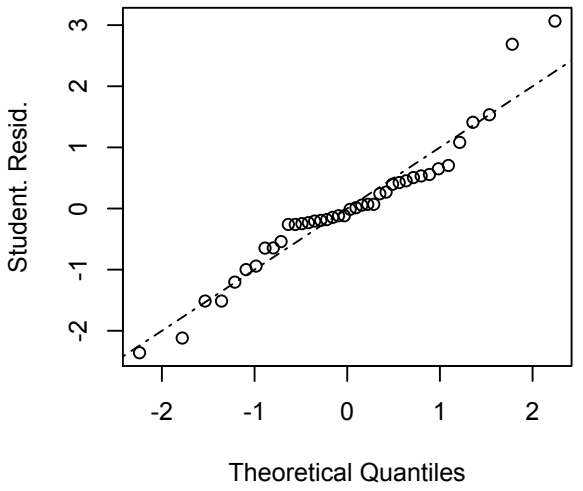
```
>#==================RUN ANOVA====================================

> f1 <- aov(Fe ~ formation);summary(f1)
            Df Sum Sq Mean Sq F value    Pr(>F)
formation    3 509.12 169.707  10.849 3.199e-05 ***
Residuals   36 563.13  15.643
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1

> print(f1)
Call:
   aov(formula = Fe ~ formation)

Terms:
                formation Residuals
Sum of Squares    509.122   563.134
Deg. of Freedom         3        36

Residual standard error: 3.955074
Estimated effects may be unbalanced


>#==============================PRINT MEANS AND EFFECTS=========
> model.tables(f1,"means")
Tables of means
Grand mean

28.64

 formation
formation
    1     2     3     4
26.08 24.69 29.95 33.84

> model.tables(f1,"effects",se=TRUE)
Tables of effects

 formation
formation
    1     2     3     4
-2.56 -3.95  1.31  5.20

Standard errors of effects
        formation
            1.251
replic.        10
```

```
>#============================DRAW DIAGNOSTIC PLOTS==================

> layout(matrix(1:4,ncol=2))
> plot(rstudent(f1),fitted(f1),
  ylab="Student. Resid.",ylim=max(abs(rstudent(f1)))*c(-11));
> plot(rstudent(f1)~fitted(f1),ylab="Student. Resid.",
  ylim=max(abs(rstudent(f1)))*c(-1,1));abline(h=c(0,-2,2),lty=c(2,3,3))
> plot(fitted(f1)~Fe);abline(0,1,lty=3)
> qqnorm(rstudent(f1),ylab="Student. Resid.");abline(0,1,lty=4)
> layout(1)
```

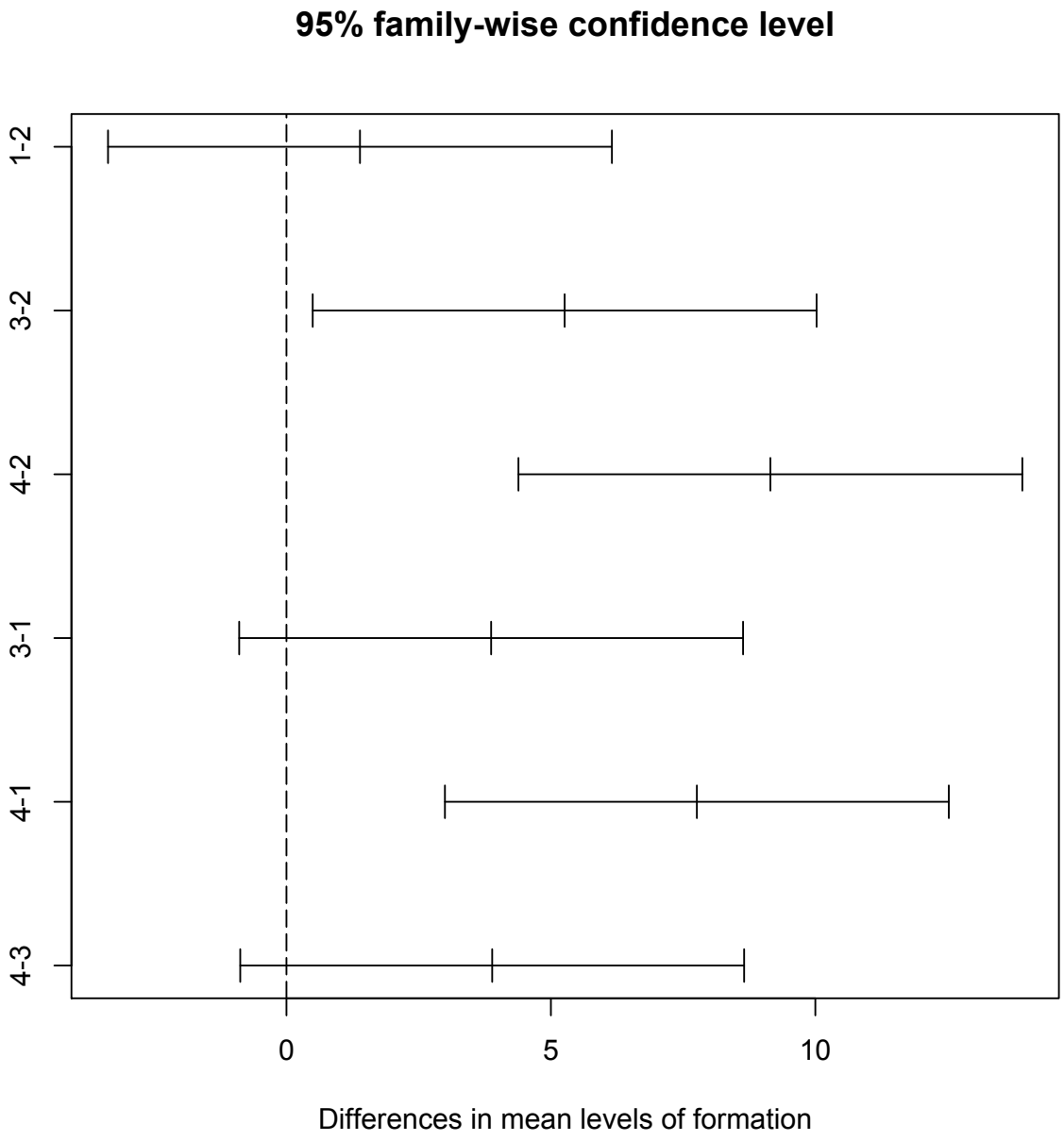








```
>#==================TUKEY'S HONEST SIGNIFICANT DIFFERENCES==============


> TukeyHSD(f1,ordered=TRUE)
  Tukey multiple comparisons of means
    95% family-wise confidence level
    factor levels have been ordered

Fit: aov(formula = Fe ~ formation)

$formation
    diff        lwr      upr     p adj
1-2 1.39 -3.3736803  6.15368 0.8603728
3-2 5.26  0.4963197 10.02368 0.0256750
4-2 9.15  4.3863197 13.91368 0.0000507
3-1 3.87 -0.8936803  8.63368 0.1459622
4-1 7.76  2.9963197 12.52368 0.0005352
4-3 3.89 -0.8736803  8.65368 0.1427984

>#=============DRAW SIMULTANEOUS CI BARS FOR MEANS DIFFERENCES===
> plot(TukeyHSD(f1,ordered=TRUE))
> abline(v=0,lty=5)

>#==============FIND TUKEY HSD AND CI'S "BY HAND"=============

> qT <- qtukey(.95,4,36);qT
[1] 3.808798

> seHSD <- 3.955074*qT/sqrt(10);seHSD
[1] 4.76368

> means <- tapply(Fe,formation,mean)

> sort(means)
    2     1     3     4
24.69 26.08 29.95 33.84


> c(means[1]-means[2]-seHSD,means[1]-means[2]+seHSD)
       1        1
-3.37368  6.15368

> c(means[3]-means[2]-seHSD,means[3]-means[2]+seHSD)
         3          3
 0.4963198 10.0236802

> c(means[4]-means[2]-seHSD,means[4]-means[2]+seHSD)
       4        4
 4.38632 13.91368
>
```


95% family-wise confidence level
1-2
3-2
4-2
3-1
4-1
4-3
0
5
10
Differences in mean levels of formation