EXPERIMENTAL STATISTICS 7015 **NAME** ______________________

November 18, 2010 **EXAM 2** **All sections : Geaghan**

READ CAREFULLY. Give an answer in the form of a number or numeric expression where possible. Show calculations for possible partial credit. Tables of the t distribution are available on a separate sheet. Use a **critical value of** α=0.05 where needed and not specified in a particular question.

1) 2 points each – Circle T for a true statement below or F for a false statement.

T (F) a) Tests of mean differences using Tukey's adjustment are more powerful than Fisher's protected LSD.

T (F) b) Tests of mean differences using Scheffé's adjustment are more powerful than Tukey's.

(T) F c) Interactions between treatments and blocks are usually used as an error term.

(T) F d) Tests of mean differences using Fisher's LSD are the most likely to make a TYPE I error.

(T) F e) Tests of mean differences using Scheffé's adjustment are the most likely to make a TYPE II error.

(T) F f) Tests of mean differences using Fisher's Protected LSD have an "α" probability of error on every single test.

T (F) g) Tests of mean differences using Dunnett's adjustment are suitable for data dredging.

T (F) h) Tests of mean differences between a control and the other treatment levels is best done with a Bonferroni adjustment.

(T) F i) Quantitative levels of a treatment are normally considered to be fixed effects.

(T) F j) All analysis of variance experiments will have at least one random variance component.

T (F) k) If subjects are randomly chosen from a population of males and randomly chosen from a population of females then "GENDER" is a random treatment effect.

T (F) l) Getting an analysis of variance with more replicates (i.e. larger n) is an important step to reducing the TYPE I (α) error rate.

(T) F m) The Satterthwaite approximation can be used to estimate the degrees of freedom when variances are not equal in the two sample t-test and in analysis of variance.

2) 3 points – In a CRD the deviation of a treatment level mean from the overall mean (i.e. $(\bar{Y}_i - \bar{\bar{Y}})$) is called which of the following?

a) a residual

(b)) an effect

c) a probit

d) a deviance

3) 3 points – Which of the tests of homogeneity below are based on the comparison of a full model to a reduced model, where the reduced model is some subset or restriction of the full model?

a) Levene's test

b) O'Brien's test

c) Brown and Forsythe's

d) Bartlett's test

4) 3 points – Techniques for the analysis of differences among more than 3 means and other modern statistical techniques were developed by which of the following?

a) Carlo Emilio Bonferroni

b) Ronald Aylmer Fisher

c) Barack Obama

d) James P Geaghan

5) 3 points – One test of homogeneity of variance can be done in SAS as either "Absolute values" or as "Squared values". Which test below has these characteristics?

a) Levene's test

b) O'Brien's test

c) Brown and Forsythe's

d) Bartlett's test

6) 3 points – Post hoc test like Tukey's and Scheffé's are used instead of the LSD for which of the following reasons?

a) they reduce Type I (α) error rate inflation

b) they reduce Type II (α) error rate inflation

c) they increase power

d) they are easier to interpret

7) 3 points – Both Tukey's and Scheffé's adjustments are said to have which of the following?

a) comparisonwise error rate

b) familywise error rate

c) experimentwise error rate

d) samplewise error rate

8) 2 points each – A student of horticulture is trying to develop better techniques for rooting cuttings of fig trees. He has 12 fit trees available (a potential source of variation, but not of interest). He takes 6 cuttings from each tree randomly assigns one cutting from each tree to each of the 6 treatment levels. The 6 treatment levels are rooting power applied in low, medium or high concentrations and each rooting power is applied in either water or ginger ale as a solute. All 6 combinations of the 3 rooting power levels and the 2 solutes are of interest. The variable of primary interest is a quantitative measure of "vigor" based on the development of root hairs and leaf buds measured on each cutting.

a) What is the experimental design for this experiment?

(a) CRD (b) RBD (c) LSD

b) What is the treatment arrangement for this experiment?

(a) single factor (b) factorial (c) nested

c) Does it seem to you that the treatments are fixed or random?

(a) fixed (b) random

d) What is the experimental unit for this experiment?

(a) vigor (b) root power (c) solute (d) cutting (e) trees

e) What is the sampling unit for this experiment?

(a) vigor (b) root power (c) solute (d) cutting (e) trees

f) If the design is RBD, what are the blocks?

(a) vigor (b) root power (c) solute (d) cutting (e) trees

g) How many denominator degrees of freedom are available for testing the treatments?

Enter the correct value here: 55

9) 3 points – The usual F test in an Analysis of Variance has which of the following characteristics.

a) It is a one tailed test against the lower tail of the F distribution.

b) It is a one tailed test against the upper tail of the F distribution.

c) It is a two tailed F test.

d) It can be any of the above tests, depending on the null and alternative hypotheses.

10) 3 points – Contrasts are said to be orthogonal if which of the following is true?

a) all of the contrasts sum to zero

b) the cross product between each pair of contrasts sums to zero

c) all values in the contrast are integers (not fractions)

d) the sum of the sum of squares of the contrasts is equal to the sum of squares of the treatment

11) 3 points – Which of the models below is a fully nested model at every level?

a) $Y_{ijkl} = \mu + \tau_i + \beta_{ij} + \gamma_{ijk} + \varepsilon_{ijkl}$.

b) $Y_{ijk} = \mu + \tau_i + \beta_j + \gamma_{ij} + \varepsilon_{ijk}$.

c) $Y_{ijkl} = \mu + \tau_i + \beta_j + \gamma_k + \varepsilon_{ijk}$.

d) $Y_{ijk} = \mu + \tau_i + \beta_j + \varepsilon_{ij}$.

12) 3 points – Which of the sources of variation below are least likely to be RANDOM effects in an experiment.

a) variation between years

b) variation between sexes

c) variation between trees

d) variation between people

13) 3 points each – The questions below refer to SAS output. The program and the output is provided separately. **Be sure to turn in your output with your exam!**

Two separate analyses have been provided: (1) PROC MIXED with homogeneous variance and (2) GLM which can only be done with homogenous variance but HOV tests are provided.

Choose the best and most appropriate of the 2 analyses (mixed or glm) to answer the questions below. Note that the investigators have calculated all pairwise tests AND a number of contrasts. Decide which post-ANOVA technique is appropriate for this situation and use it wherever possible unless another option is specifically requested.

Also note that computations have been requested for 3 different adjustments (Tukey, Scheffé and Bonferroni) and, of course, PROC MIXED automatically provides LSD tests for pairwise differences.

a) Do there appear to be significant differences among the levels of the treatment(s).

Circle one: YES NO P value (4 decimals) = <0.0001

b) There are several contrasts included with the analysis (see computer program). One or more of these contrasts may be pairwise tests of differences between treatment level means? Circle all letters below that correspond to contrasts that do pairwise tests of treatment level means.

Circle all that apply: A B C D E

c) In addition to the contrasts, there are several range tests provided. Since the investigators are interested in all pairwise comparisons among means and also interested in the contrasts, which would be the best choice of the multiple range tests provided?

Circle one: LSD Tukey's Scheffé's Bonferroni's

d) Give a confidence interval for the mean of treatment number A03.

P(70.2968 ≤ μ ≤ 75.4425) = 0.95

e) If the investigators has said that their **only** interest was in "all pairwise tests", would they conclude that treatment level "A04" significantly different from level "A06"?

Circle one: (YES) NO P value required here (4 decimals) = 0.0002

f) How many observations, or values of the dependent variable "Y_i", are "averaged" together in each of the 8 treatment means or LSMeans (assuming the design is balanced)?

Number = 20

g) 2 points each – Does the assumption of normality ~~of variance~~ appear to have been met? Use the "best" available statistic to determine this.

Circle one: YES (NO) P value (4 decimals) = <0.0001

14) 2 points each – From the output, provide a P value for the test of the hypotheses given below. Give the most detail possible, providing **4 decimals for each P value**.

a) For the test of the means of each strain

$H_0: \mu_{A01} = \mu_{A02} = \mu_{A03} = \mu_{A04} = \mu_{A05} = \mu_{A06} = \mu_{A07} = \mu_{A08}$ P value < **0.** 0 0 0 1

b) For the test of

$H_0: \mu_{A01} + \mu_{A03} + \mu_{A05} + \mu_{A07} = \mu_{A02} + \mu_{A04} + \mu_{A06} + \mu_{A08}$ P value = **0.** 1 7 8 0

c) For the test $H_0: \mu_{A04} = \mu_{A08}$ using a Tukey adjustment. P value = **0.** 0 2 1 9

d) For the test $H_0: \mu_{A04} = \mu_{A08}$ using a Scheffé adjustment. P value = **0.** 1 3 6 9

e) For the test $H_0: \mu_{A04} = \mu_{A08}$ using LSD P value = **0.** 0 0 1 0

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```
dm'log;clear;output;clear';
*******************************************;
*** Exam 3 Example                      ***;
*******************************************;
OPTIONS LS=105 PS=512 nocenter nodate nonumber nolabel FORMCHAR="|----|+|---+=|-/\<>*";
TITLE1 'Exam 3 Problem';

DATA ONE;  INFILE CARDS MISSOVER;
   INPUT Treatment $ BLOCK rep Y_Value;
CARDS; RUN;

;
PROC MIXED DATA=ONE; CLASSES Treatment;
   MODEL Y_Value = Treatment / outp=resids;
   random block block*treatment;
   LSMEANS Treatment / adjust=Tukey cl;
   LSMEANS Treatment / adjust=Scheffe cl;
   LSMEANS Treatment / adjust=Bon cl;
   *** order of treatment levels =>          A1  A2  A3  A4  A5  A6  A7  A8;
   contrast 'A) odd vrs even'        treatment -1   1  -1   1  -1   1  -1   1;
   contrast 'B) low vrs high'        treatment -1  -1  -1  -1   1   1   1   1;
   contrast 'C) one & two vrs others' treatment -3  -3   1   1   1   1   1   1;
   contrast 'D) one vrs two'         treatment -1   1   0   0   0   0   0   0;
   contrast 'E) one vrs others'      treatment -7   1   1   1   1   1   1   1;
 ods output diffs=ppp lsmeans=mmm;
 **ods listing exclude diffs lsmeans;
run;
%include 'C:\pdmix800.sas';
%pdmix800(ppp,mmm,alpha=0.05,sort=yes);
RUN; QUIT;

PROC UNIVARIATE DATA=resids NORMAL PLOT; VAR resid; RUN;

PROC GLM DATA=ONE; CLASSES Treatment;
  MODEL Y_Value = Treatment block block*treatment/ SS3;
  MEANS Treatment / TUKEY scheffe duncan;
RUN; QUIT;


Exam 3 Problem

The Mixed Procedure

 Model Information
Data Set                     WORK.ONE
Dependent Variable           Y_Value
Covariance Structure         Variance Components
Estimation Method            REML
Residual Variance Method     Profile
Fixed Effects SE Method      Model-Based
Degrees of Freedom Method    Containment
```

```
Class Level Information
Class         Levels    Values
Treatment          8    A01 A02 A03 A04 A05 A06 A07 A08

Dimensions
Covariance Parameters            3
Columns in X                     9
Columns in Z                     9
Subjects                         1
Max Obs Per Subject            160

Number of Observations
Number of Observations Read              160
Number of Observations Used              160
Number of Observations Not Used            0

Iteration History
Iteration    Evaluations    -2 Res Log Like       Criterion
        0              1       945.51097585
        1              2       922.39363511      0.00000000
Convergence criteria met.


Covariance Parameter Estimates
Cov Parm            Estimate
BLOCK                 3.0591
BLOCK*Treatment            0
Residual             21.1251


Fit Statistics
-2 Res Log Likelihood          922.4
AIC (smaller is better)        926.4
AICC (smaller is better)       926.5
BIC (smaller is better)        922.4


Type 3 Tests of Fixed Effects
              Num     Den
Effect         DF      DF    F Value    Pr > F
Treatment       7     144      25.68    <.0001


Contrasts                     Num     Den
Label                          DF      DF    F Value    Pr > F
A) odd vrs even                 1     144       1.83    0.1780
B) low vrs high                 1     144      35.40    <.0001
C) one & two vrs others         1     144       2.37    0.1262
D) one vrs two                  1     144     101.80    <.0001
E) one vrs others               1     144      74.55    <.0001
```

Least Squares Means

Effect	Treatment	Estimate	Standard Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
Treatment	A01	79.8247	1.3017	144	61.32	<.0001	0.05	77.2518	82.3975
Treatment	A02	65.1597	1.3017	144	50.06	<.0001	0.05	62.5868	67.7325
Treatment	A03	72.8697	1.3017	144	55.98	<.0001	0.05	70.2968	75.4425
Treatment	A04	76.8897	1.3017	144	59.07	<.0001	0.05	74.3168	79.4625
Treatment	A05	64.6847	1.3017	144	49.69	<.0001	0.05	62.1118	67.2575
Treatment	A06	70.0697	1.3017	144	53.83	<.0001	0.05	67.4968	72.6425
Treatment	A07	70.6847	1.3017	144	54.30	<.0001	0.05	68.1118	73.2575
Treatment	A08	72.0097	1.3017	144	55.32	<.0001	0.05	69.4368	74.5825

Differences ofLeast Squares Means

Effect	Treatment	_Treatment	Estimate	Standard Error	DF	t Value	Pr > |t|	Adjustment	Adj P
Treatment	A01	A02	14.6650	1.4534	144	10.09	<.0001	Tukey-Kramer	<.0001
Treatment	A01	A03	6.9550	1.4534	144	4.79	<.0001	Tukey-Kramer	0.0001
Treatment	A01	A04	2.9350	1.4534	144	2.02	0.0453	Tukey-Kramer	0.4726
Treatment	A01	A05	15.1400	1.4534	144	10.42	<.0001	Tukey-Kramer	<.0001
Treatment	A01	A06	9.7550	1.4534	144	6.71	<.0001	Tukey-Kramer	<.0001
Treatment	A01	A07	9.1400	1.4534	144	6.29	<.0001	Tukey-Kramer	<.0001
Treatment	A01	A08	7.8150	1.4534	144	5.38	<.0001	Tukey-Kramer	<.0001
Treatment	A02	A03	-7.7100	1.4534	144	-5.30	<.0001	Tukey-Kramer	<.0001
Treatment	A02	A04	-11.7300	1.4534	144	-8.07	<.0001	Tukey-Kramer	<.0001
Treatment	A02	A05	0.4750	1.4534	144	0.33	0.7443	Tukey-Kramer	1.0000
Treatment	A02	A06	-4.9100	1.4534	144	-3.38	0.0009	Tukey-Kramer	0.0206
Treatment	A02	A07	-5.5250	1.4534	144	-3.80	0.0002	Tukey-Kramer	0.0051
Treatment	A02	A08	-6.8500	1.4534	144	-4.71	<.0001	Tukey-Kramer	0.0002
Treatment	A03	A04	-4.0200	1.4534	144	-2.77	0.0064	Tukey-Kramer	0.1121
Treatment	A03	A05	8.1850	1.4534	144	5.63	<.0001	Tukey-Kramer	<.0001
Treatment	A03	A06	2.8000	1.4534	144	1.93	0.0560	Tukey-Kramer	0.5352
Treatment	A03	A07	2.1850	1.4534	144	1.50	0.1349	Tukey-Kramer	0.8046
Treatment	A03	A08	0.8600	1.4534	144	0.59	0.5550	Tukey-Kramer	0.9989
Treatment	A04	A05	12.2050	1.4534	144	8.40	<.0001	Tukey-Kramer	<.0001
Treatment	A04	A06	6.8200	1.4534	144	4.69	<.0001	Tukey-Kramer	0.0002
Treatment	A04	A07	6.2050	1.4534	144	4.27	<.0001	Tukey-Kramer	0.0009
Treatment	A04	A08	4.8800	1.4534	144	3.36	0.0010	Tukey-Kramer	0.0219
Treatment	A05	A06	-5.3850	1.4534	144	-3.70	0.0003	Tukey-Kramer	0.0071
Treatment	A05	A07	-6.0000	1.4534	144	-4.13	<.0001	Tukey-Kramer	0.0016
Treatment	A05	A08	-7.3250	1.4534	144	-5.04	<.0001	Tukey-Kramer	<.0001
Treatment	A06	A07	-0.6150	1.4534	144	-0.42	0.6728	Tukey-Kramer	0.9999
Treatment	A06	A08	-1.9400	1.4534	144	-1.33	0.1841	Tukey-Kramer	0.8840
Treatment	A07	A08	-1.3250	1.4534	144	-0.91	0.3635	Tukey-Kramer	0.9845

Treatment	A01	A02	14.6650	1.4534	144	10.09	<.0001	Scheffe	<.0001
Treatment	A01	A03	6.9550	1.4534	144	4.79	<.0001	Scheffe	0.0030
Treatment	A01	A04	2.9350	1.4534	144	2.02	0.0453	Scheffe	0.7693
Treatment	A01	A05	15.1400	1.4534	144	10.42	<.0001	Scheffe	<.0001
Treatment	A01	A06	9.7550	1.4534	144	6.71	<.0001	Scheffe	<.0001
Treatment	A01	A07	9.1400	1.4534	144	6.29	<.0001	Scheffe	<.0001
Treatment	A01	A08	7.8150	1.4534	144	5.38	<.0001	Scheffe	0.0004
Treatment	A02	A03	-7.7100	1.4534	144	-5.30	<.0001	Scheffe	0.0005
Treatment	A02	A04	-11.7300	1.4534	144	-8.07	<.0001	Scheffe	<.0001
Treatment	A02	A05	0.4750	1.4534	144	0.33	0.7443	Scheffe	1.0000
Treatment	A02	A06	-4.9100	1.4534	144	-3.38	0.0009	Scheffe	0.1313
Treatment	A02	A07	-5.5250	1.4534	144	-3.80	0.0002	Scheffe	0.0511
Treatment	A02	A08	-6.8500	1.4534	144	-4.71	<.0001	Scheffe	0.0038
Treatment	A03	A04	-4.0200	1.4534	144	-2.77	0.0064	Scheffe	0.3709
Treatment	A03	A05	8.1850	1.4534	144	5.63	<.0001	Scheffe	0.0001
Treatment	A03	A06	2.8000	1.4534	144	1.93	0.0560	Scheffe	0.8106
Treatment	A03	A07	2.1850	1.4534	144	1.50	0.1349	Scheffe	0.9427
Treatment	A03	A08	0.8600	1.4534	144	0.59	0.5550	Scheffe	0.9998
Treatment	A04	A05	12.2050	1.4534	144	8.40	<.0001	Scheffe	<.0001
Treatment	A04	A06	6.8200	1.4534	144	4.69	<.0001	Scheffe	0.0040
Treatment	A04	A07	6.2050	1.4534	144	4.27	<.0001	Scheffe	0.0147
Treatment	A04	A08	4.8800	1.4534	144	3.36	0.0010	Scheffe	0.1369
Treatment	A05	A06	-5.3850	1.4534	144	-3.70	0.0003	Scheffe	0.0643
Treatment	A05	A07	-6.0000	1.4534	144	-4.13	<.0001	Scheffe	0.0218
Treatment	A05	A08	-7.3250	1.4534	144	-5.04	<.0001	Scheffe	0.0012
Treatment	A06	A07	-0.6150	1.4534	144	-0.42	0.6728	Scheffe	1.0000
Treatment	A06	A08	-1.9400	1.4534	144	-1.33	0.1841	Scheffe	0.9700
Treatment	A07	A08	-1.3250	1.4534	144	-0.91	0.3635	Scheffe	0.9970

Treatment	A01	A02	14.6650	1.4534	144	10.09	<.0001	Bonferroni	<.0001
Treatment	A01	A03	6.9550	1.4534	144	4.79	<.0001	Bonferroni	0.0001
Treatment	A01	A04	2.9350	1.4534	144	2.02	0.0453	Bonferroni	1.0000
Treatment	A01	A05	15.1400	1.4534	144	10.42	<.0001	Bonferroni	<.0001
Treatment	A01	A06	9.7550	1.4534	144	6.71	<.0001	Bonferroni	<.0001
Treatment	A01	A07	9.1400	1.4534	144	6.29	<.0001	Bonferroni	<.0001
Treatment	A01	A08	7.8150	1.4534	144	5.38	<.0001	Bonferroni	<.0001
Treatment	A02	A03	-7.7100	1.4534	144	-5.30	<.0001	Bonferroni	<.0001
Treatment	A02	A04	-11.7300	1.4534	144	-8.07	<.0001	Bonferroni	<.0001
Treatment	A02	A05	0.4750	1.4534	144	0.33	0.7443	Bonferroni	1.0000
Treatment	A02	A06	-4.9100	1.4534	144	-3.38	0.0009	Bonferroni	0.0263
Treatment	A02	A07	-5.5250	1.4534	144	-3.80	0.0002	Bonferroni	0.0059

Treatment	A02	A08	-6.8500	1.4534	144	-4.71	<.0001	Bonferroni	0.0002
Treatment	A03	A04	-4.0200	1.4534	144	-2.77	0.0064	Bonferroni	0.1798
Treatment	A03	A05	8.1850	1.4534	144	5.63	<.0001	Bonferroni	<.0001
Treatment	A03	A06	2.8000	1.4534	144	1.93	0.0560	Bonferroni	1.0000
Treatment	A03	A07	2.1850	1.4534	144	1.50	0.1349	Bonferroni	1.0000
Treatment	A03	A08	0.8600	1.4534	144	0.59	0.5550	Bonferroni	1.0000
Treatment	A04	A05	12.2050	1.4534	144	8.40	<.0001	Bonferroni	<.0001
Treatment	A04	A06	6.8200	1.4534	144	4.69	<.0001	Bonferroni	0.0002
Treatment	A04	A07	6.2050	1.4534	144	4.27	<.0001	Bonferroni	0.0010
Treatment	A04	A08	4.8800	1.4534	144	3.36	0.0010	Bonferroni	0.0282
Treatment	A05	A06	-5.3850	1.4534	144	-3.70	0.0003	Bonferroni	0.0084
Treatment	A05	A07	-6.0000	1.4534	144	-4.13	<.0001	Bonferroni	0.0017
Treatment	A05	A08	-7.3250	1.4534	144	-5.04	<.0001	Bonferroni	<.0001
Treatment	A06	A07	-0.6150	1.4534	144	-0.42	0.6728	Bonferroni	1.0000
Treatment	A06	A08	-1.9400	1.4534	144	-1.33	0.1841	Bonferroni	1.0000
Treatment	A07	A08	-1.3250	1.4534	144	-0.91	0.3635	Bonferroni	1.0000

Exam 3 Problem

Effect=Treatment ADJUSTMENT=Bonferroni(P<0.05) bygroup=3

Obs	Treatment	Estimate	StdErr	Alpha	Lower	Upper	MSGROUP
1	A01	79.8247	1.3017	0.05	77.2518	82.3975	A
2	A04	76.8897	1.3017	0.05	74.3168	79.4625	AB
3	A03	72.8697	1.3017	0.05	70.2968	75.4425	BC
4	A08	72.0097	1.3017	0.05	69.4368	74.5825	C
5	A07	70.6847	1.3017	0.05	68.1118	73.2575	C
6	A06	70.0697	1.3017	0.05	67.4968	72.6425	C
7	A02	65.1597	1.3017	0.05	62.5868	67.7325	D
8	A05	64.6847	1.3017	0.05	62.1118	67.2575	D

Effect=Treatment ADJUSTMENT=Scheffe(P<0.05) bygroup=2

Obs	Treatment	Estimate	StdErr	Alpha	Lower	Upper	MSGROUP
9	A01	79.8247	1.3017	0.05	77.2518	82.3975	A
10	A04	76.8897	1.3017	0.05	74.3168	79.4625	AB
11	A03	72.8697	1.3017	0.05	70.2968	75.4425	BC
12	A08	72.0097	1.3017	0.05	69.4368	74.5825	BC
13	A07	70.6847	1.3017	0.05	68.1118	73.2575	CD
14	A06	70.0697	1.3017	0.05	67.4968	72.6425	CDE
15	A02	65.1597	1.3017	0.05	62.5868	67.7325	DE
16	A05	64.6847	1.3017	0.05	62.1118	67.2575	E

Effect=Treatment ADJUSTMENT=Tukey-Kramer(P<0.05) bygroup=1

Obs	Treatment	Estimate	StdErr	Alpha	Lower	Upper	MSGROUP
17	A01	79.8247	1.3017	0.05	77.2518	82.3975	A
18	A04	76.8897	1.3017	0.05	74.3168	79.4625	AB
19	A03	72.8697	1.3017	0.05	70.2968	75.4425	BC
20	A08	72.0097	1.3017	0.05	69.4368	74.5825	C
21	A07	70.6847	1.3017	0.05	68.1118	73.2575	C
22	A06	70.0697	1.3017	0.05	67.4968	72.6425	C
23	A02	65.1597	1.3017	0.05	62.5868	67.7325	D
24	A05	64.6847	1.3017	0.05	62.1118	67.2575	D

Exam 3 Problem

The UNIVARIATE Procedure
Variable: Resid

Moments

N	160	Sum Weights	160
Mean	0	Sum Observations	0
Std Deviation	4.47958028	Variance	20.0666395
Skewness	-0.8220281	Kurtosis	-0.6166932
Uncorrected SS	3190.59568	Corrected SS	3190.59568
Coeff Variation	.	Std Error Mean	0.35414192

Basic Statistical Measures

Location		Variability	
Mean	0.000000	Std Deviation	4.47958
Median	1.369866	Variance	20.06664
Mode	0.989799	Range	16.36013
		Interquartile Range	5.84277

Note: The mode displayed is the smallest of 6 modes with a count of 2.

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	0	Pr > |t|	1.0000
Sign	M	32	Pr >= |M|	<.0001
Signed Rank	S	843	Pr >= |S|	0.1516

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.86399	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.217217	Pr > D	<0.0100
Cramer-von Mises	W-Sq	1.746196	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	9.385752	Pr > A-Sq	<0.0050

Return this computer output **NAME ______________________________**

```
Extreme Observations
------Lowest-----        -----Highest----
   Value      Obs          Value      Obs
-9.92993      107         5.8502      102
-9.42993       50         5.9602       24
-9.04493       89         6.0502      105
-8.94493      129         6.3952        2
-8.82993       47         6.4302       65
```

```
   Stem Leaf  Boxplot
      6 0144                               4     |
      5 1234566889                        10     |
      4 45566799                           8     |
      3 0000012334445566667789            22 +-----+
      2 00000122333334567778              20 |     |
      1 000111222223334445555556777778    30 *-----*
      0 112455566667788899                18 |  +  |
     -0 6322110                            7 |     |
     -1 2                                  1 |     |
     -2                                      +-----+
     -3                                          |
     -4 64                                 2     |
     -5 775200                             6     |
     -6 98888777661                       11     |
     -7 96543111                           8     |
     -8 9876422111                        10     |
     -9 940                                3     |
        ----+----+----+----+----+----+
```

```
                       Normal Probability Plot
     6.5+                                      ++     * * *
        |                                    ++*******
        |                                 ++***
        |                              ******
        |                           ****
        |                      ******+
        |                    **** +++
        |                   **  ++
    -1.5+                  *  ++
        |                   ++
        |                 ++
        |              +++ *
        |            ++   **
        |          ++  ***
        |        ++ ****
        |     *******
    -9.5+* *+*
         +----+----+----+----+----+----+----+----+----+----+
             -2        -1         0        +1        +2
```

Exam 3 Problem

The GLM Procedure

Class Level Information

Class	Levels	Values
Treatment	8	A01 A02 A03 A04 A05 A06 A07 A08

Number of Observations Read	160
Number of Observations Used	160

Dependent Variable: Y_Value

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	15	4433.565937	295.571062	13.36	<.0001
Error	144	3186.249000	22.126729		
Corrected Total	159	7619.814937			

R-Square	Coeff Var	Root MSE	Y_Value Mean
0.581847	6.997322	4.703906	67.22438

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treatment	7	649.2045000	92.7435000	4.19	0.0003
BLOCK	1	633.1461125	633.1461125	28.61	<.0001
BLOCK*Treatment	7	3.6413875	0.5201982	0.02	1.0000

Duncan's Multiple Range Test for Y_Value
NOTE: This test controls the Type I comparisonwise error rate, not the experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	144
Error Mean Square	22.12673

Number of Means	2	3	4	5	6	7	8
Critical Range	2.940	3.095	3.197	3.273	3.332	3.379	3.419

Means with the same letter are not significantly different.

Dunnett Grouptings

	Mean	N	Treatment
A	75.525	20	A01
A	72.590	20	A04
B	68.570	20	A03
B	67.710	20	A08
B	66.385	20	A07
B	65.770	20	A06
C	60.860	20	A02
C	60.385	20	A05

Exam 3 Problem

The GLM Procedure

Tukey's Studentized Range (HSD) Test for Y_Value
NOTE: This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	144
Error Mean Square	22.12673
Critical Value of Studentized Range	4.35014
Minimum Significant Difference	4.5756

Means with the same letter are not significantly different.

Tukey Grouping		Mean	N	Treatment
	A	75.525	20	A01
B	A	72.590	20	A04
B	C	68.570	20	A03
	C	67.710	20	A08
	C	66.385	20	A07
	C	65.770	20	A06
	D	60.860	20	A02
	D	60.385	20	A05

Scheffe's Test for Y_Value
NOTE: This test controls the Type I experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	144
Error Mean Square	22.12673
Critical Value of F	2.07373
Minimum Significant Difference	5.6674

Means with the same letter are not significantly different.

Scheffe Grouping			Mean	N	Treatment
	A		75.525	20	A01
B	A		72.590	20	A04
B	C		68.570	20	A03
B	C		67.710	20	A08
D	C		66.385	20	A07
D	C	E	65.770	20	A06
D		E	60.860	20	A02
		E	60.385	20	A05