EXPERIMENTAL STATISTICS 7005 NAME ________________________________

November 18, 2010 EXAM 3 All sections : Geaghan

Read Carefully. Give an answer in the form of a number or numeric expression where possible. Use a value of 0.05 for α if not specified. t-tables are NOT provided, it you need a t-value use "2".

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

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

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

(T) F c) The F test of treatments in the usual Analysis of Variance is a one tailed test.

(T) F d) Tests of mean difference using Fishers LSD are the most likely to make a TYPE I error.

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

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

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

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

T (F) i) The assumption of normality is no longer needed if PROC MIXED is used instead of PROC GLM.

T (F) j) Welch's test is one of the tests of homogeneity of variance provided by PROC GLM.

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

T (F) l) 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) m) 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 n) 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 – 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

3) 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

4) 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

5) 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

a) they reduce Type II (β) error rate inflation

c) they increase power

d) they are easier to interpret

6) 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

7) 3 points each – An instructor teaching a high school class wants to know if the students are all understanding the material equally. In particular, he wants to know if the males and females are scoring equally in his exams and he wants to know if the upper classmen are scoring higher than the lower level classes. He has both boys and girls from the senior and junior classes, but only girls from the sophomore class.
Write three contrasts below; (1) one contrast comparing the mean of all boys to all girls, (2) one contrast comparing the mean of all seniors to all juniors and (3) one contrast comparing the mean of the sophomore girls versus the mean of the junior and senior girls combined.

Treatments → **Contrasts ↓**	**Senior Boys**	**Senior Girls**	**Junior Boys**	**Junior Girls**	**Sophomore Girls**
a) All Boys versus all Girls	-3	2	-3	2	2
b) All Seniors versus all Juniors	-1	-1	1	1	0
c) Sophmore girls versus all other girls	0	1	0	1	-2

8) 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

9) For each experiment described below name the most appropriate type of analysis and any additional questions where applicable.

a) 3 points each – A Veterinary Medicine student saw an advertisement for a dog food called "Kibbles and Bits" claiming that "Bits" make the difference in the desirability of dog food (to dogs). He decides to test this hypothesis. He has 30 dogs of similar size currently housed in the facility where he works. He prepares 3 diets; (1) Kibbles & Bits, (2) Kibbles **without** Bits and he uses (3) Purina Dog Chow as a control, He randomly assigns 10 dogs to each diet and measures the mean weight of food consumed in 30 minutes. What type of analysis should he use to see if mean consumption differs among the 3 diets?

a) Type of analysis (circle one) a) CRD b) RBD

b) What is the treatment variable (circle one) a) Diets b) Dogs c) Consumed d) 30 minutes

c) How many degrees of freedom would the treatment mean square have? d.f. = 2

The student decided to try some contrasts among the diet means. Fill in the appropriate contrast indicated below.

Contrast (3 points each)	A) Kibbles with Bits	B) Kibbles without Bits	C) Purina Dog Chow
d) "Kibbles with Bits versus Kibbles without Bits" Means compared: A versus B with C excluded	-1	1	0
e) "Anything with Kibbles versus Purina Dog Chow" Means compared: A and B versus C	-1	-1	2

10) 3 points – A librarian is studying the book usage by college professors. The variable of interest is the mean number of books check out by male and female faculty during the fall semester. He also wants to compare the usage by Assistant Professors, Associate Professors and Full Professors. What type of analysis would be used for this experiment?

Answer: CRD factorial (2 x 3)

Do not write in this space

11) The questions below refer to SAS output. The program is given above and the output is provided separately. Be sure to turn in your output with your exam!

Three separate analyses have been provided: (1) PROC MIXED with heterogeneous variance, (2) PROC MIXED with homogeneous variance and (3) GLM which can only be done with homogenous variance but HOV tests are provided.

Choose the best and most appropriate of the 3 models to answer the questions pertaining to the SAS output. Also 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. 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) 3 points – Do there appear to be significant differences among the levels of the treatment(s).

Circle one: (YES) NO P value (4 decimals) = 0.0237

b) 3 points – There are several contrasts included with the analysis (**see computer program**). One or more of these contrasts test pairwise differences in treatment level means? Circle all letters below that correspond to contrasts that do pairwise tests of treatment means.

Circle all that apply: A B C (D) E

c) 3 points – In addition to the contrasts, there are several range tests provided. If 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) 4 points – Give a confidence interval for the mean of treatment number A3.

$$P(\ 64.2989 \le \mu \le 69.3411\ ) = 0.95$$

e) 3 points – Give a linear model for this analysis?

$$Y_{ij} = \mu + \tau_i + \varepsilon_{ij}$$

f) 4 points – If the investigators said that their **only** interest was in "all pairwise tests", would they conclude that treatment level "A4" significantly different from level "A6"?

Circle one: (YES) NO **P value required here (4 decimals) =** 0.0446

g) 3 points – How many replicates are there for each treatment? 10

h) 4 points – Does the assumption of homogeneity of variance appear to have been met? Use the "best" available statistic to determine this.

Circle one: (YES) NO P value (4 decimals) = 0.5467 or 0.5767

```
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 $ Y_Value;
CARDS; RUN;
;
ROC MIXED DATA=ONE; CLASSES Treatment;
   MODEL Y_Value = Treatment / outp=resids;
   repeated / group = Treatment;
run;

PROC MIXED DATA=ONE; CLASSES Treatment;
   MODEL Y_Value = Treatment / outp=resids;
   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 / SS3;
  MEANS Treatment / TUKEY scheffe duncan;
  MEANS Treatment / HOVTEST=BARTLETT HOVTEST=BF
        HOVTEST=LEVENE HOVTEST=OBRIEN WELCH;
RUN; QUIT;
```

Exam 3 Problem : Example with Separate Variances

The Mixed Procedure

Model Information

Data Set	WORK.ONE
Dependent Variable	Y_Value
Covariance Structure	Variance Components
Group Effect	Treatment
Estimation Method	REML
Residual Variance Method	None
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Between-Within

Exam 3 Problem : Example with Separate Variances

Class Level Information

Class	Levels	Values
Treatment	8	A1 A2 A3 A4 A5 A6 A7 A8

Dimensions

Covariance Parameters	8
Columns in X	9
Columns in Z	0
Subjects	80
Max Obs Per Subject	1

Number of Observations

Number of Observations Read	80
Number of Observations Used	80
Number of Observations Not Used	0

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	422.34896310	
1	1	416.42442399	0.00000000

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Group	Estimate
Residual	Treatment A1	20.5943
Residual	Treatment A2	15.3001
Residual	Treatment A3	8.6307
Residual	Treatment A4	6.8667
Residual	Treatment A5	22.5427
Residual	Treatment A6	24.2604
Residual	Treatment A7	16.9512
Residual	Treatment A8	12.8090

Fit Statistics

-2 Res Log Likelihood	416.4
AIC (smaller is better)	432.4
AICC (smaller is better)	434.7
BIC (smaller is better)	451.5

Null Model Likelihood Ratio Test

DF	Chi-Square	Pr > ChiSq
7	5.92	0.5486

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Treatment	7	72	3.78	0.0015

Exam 3 Problem : Example with Homogeneous Variance

The Mixed Procedure

Model Information

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

Class Level Information

Class	Levels	Values
Treatment	8	A1 A2 A3 A4 A5 A6 A7 A8

Dimensions

Covariance Parameters	1
Columns in X	9
Columns in Z	0
Subjects	1
Max Obs Per Subject	80

Number of Observations

Number of Observations Read	80
Number of Observations Used	80
Number of Observations Not Used	0

Covariance Parameter Estimates

Cov Parm	Estimate
Residual	15.9944

Fit Statistics

-2 Res Log Likelihood	422.3
AIC (smaller is better)	424.3
AICC (smaller is better)	424.4
BIC (smaller is better)	426.6

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Treatment	7	72	2.49	0.0237

Contrasts

Label	Num DF	Den DF	F Value	Pr > F
A) odd vrs even	1	72	3.55	0.0636
B) low vrs high	1	72	8.04	0.0059
C) one & two vrs others	1	72	2.41	0.1249
D) one vrs two	1	72	1.57	0.2145
E) one vrs others	1	72	0.00	0.9446

Exam 3 Computer Output – Return with exam **Name** ______________________________

Exam 3 Problem : Example with Homogeneous Variance

Least Squares Means

Effect	Treatment	Estimate	Standard Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
Treatment	A1	65.7100	1.2647	72	51.96	<.0001	0.05	63.1889	68.2311
Treatment	A2	63.4700	1.2647	72	50.19	<.0001	0.05	60.9489	65.9911
Treatment	A3	66.8200	1.2647	72	52.84	<.0001	0.05	64.2989	69.3411
Treatment	A4	62.1000	1.2647	72	49.10	<.0001	0.05	59.5789	64.6211
Treatment	A5	67.5400	1.2647	72	53.40	<.0001	0.05	65.0189	70.0611
Treatment	A6	67.7600	1.2647	72	53.58	<.0001	0.05	65.2389	70.2811
Treatment	A7	66.4700	1.2647	72	52.56	<.0001	0.05	63.9489	68.9911
Treatment	A8	66.4700	1.2647	72	52.56	<.0001	0.05	63.9489	68.9911

Differences ofLeast Squares Means

Effect	Treatment	_Treatment	Estimate	Standard Error	DF	t Value	Pr > |t|	Adjustment	Adj P
Treatment	A1	A2	2.2400	1.7885	72	1.25	0.2145	Tukey	0.9129
Treatment	A1	A3	-1.1100	1.7885	72	-0.62	0.5368	Tukey	0.9985
Treatment	A1	A4	3.6100	1.7885	72	2.02	0.0473	Tukey	0.4771
Treatment	A1	A5	-1.8300	1.7885	72	-1.02	0.3096	Tukey	0.9694
Treatment	A1	A6	-2.0500	1.7885	72	-1.15	0.2555	Tukey	0.9440
Treatment	A1	A7	-0.7600	1.7885	72	-0.42	0.6722	Tukey	0.9999
Treatment	A1	A8	-0.7600	1.7885	72	-0.42	0.6722	Tukey	0.9999
Treatment	A2	A3	-3.3500	1.7885	72	-1.87	0.0651	Tukey	0.5735
Treatment	A2	A4	1.3700	1.7885	72	0.77	0.4462	Tukey	0.9943
Treatment	A2	A5	-4.0700	1.7885	72	-2.28	0.0258	Tukey	0.3212
Treatment	A2	A6	-4.2900	1.7885	72	-2.40	0.0190	Tukey	0.2579
Treatment	A2	A7	-3.0000	1.7885	72	-1.68	0.0978	Tukey	0.7015
Treatment	A2	A8	-3.0000	1.7885	72	-1.68	0.0978	Tukey	0.7015
Treatment	A3	A4	4.7200	1.7885	72	2.64	0.0102	Tukey	0.1592
Treatment	A3	A5	-0.7200	1.7885	72	-0.40	0.6885	Tukey	0.9999
Treatment	A3	A6	-0.9400	1.7885	72	-0.53	0.6008	Tukey	0.9995
Treatment	A3	A7	0.3500	1.7885	72	0.20	0.8454	Tukey	1.0000
Treatment	A3	A8	0.3500	1.7885	72	0.20	0.8454	Tukey	1.0000
Treatment	A4	A5	-5.4400	1.7885	72	-3.04	0.0033	Tukey	0.0616
Treatment	A4	A6	-5.6600	1.7885	72	-3.16	0.0023	Tukey	0.0446
Treatment	A4	A7	-4.3700	1.7885	72	-2.44	0.0170	Tukey	0.2370
Treatment	A4	A8	-4.3700	1.7885	72	-2.44	0.0170	Tukey	0.2370
Treatment	A5	A6	-0.2200	1.7885	72	-0.12	0.9024	Tukey	1.0000
Treatment	A5	A7	1.0700	1.7885	72	0.60	0.5515	Tukey	0.9988
Treatment	A5	A8	1.0700	1.7885	72	0.60	0.5515	Tukey	0.9988
Treatment	A6	A7	1.2900	1.7885	72	0.72	0.4731	Tukey	0.9961

Treatment	A6	A8	1.2900	1.7885	72	0.72	0.4731	Tukey	0.9961
Treatment	A7	A8	-183E-15	1.7885	72	-0.00	1.0000	Tukey	1.0000

Treatment	A1	A2	2.2400	1.7885	72	1.25	0.2145	Scheffe	0.9785
Treatment	A1	A3	-1.1100	1.7885	72	-0.62	0.5368	Scheffe	0.9997
Treatment	A1	A4	3.6100	1.7885	72	2.02	0.0473	Scheffe	0.7684
Treatment	A1	A5	-1.8300	1.7885	72	-1.02	0.3096	Scheffe	0.9935
Treatment	A1	A6	-2.0500	1.7885	72	-1.15	0.2555	Scheffe	0.9872
Treatment	A1	A7	-0.7600	1.7885	72	-0.42	0.6722	Scheffe	1.0000
Treatment	A1	A8	-0.7600	1.7885	72	-0.42	0.6722	Scheffe	1.0000
Treatment	A2	A3	-3.3500	1.7885	72	-1.87	0.0651	Scheffe	0.8307
Treatment	A2	A4	1.3700	1.7885	72	0.77	0.4462	Scheffe	0.9990
Treatment	A2	A5	-4.0700	1.7885	72	-2.28	0.0258	Scheffe	0.6390
Treatment	A2	A6	-4.2900	1.7885	72	-2.40	0.0190	Scheffe	0.5723
Treatment	A2	A7	-3.0000	1.7885	72	-1.68	0.0978	Scheffe	0.8981
Treatment	A2	A8	-3.0000	1.7885	72	-1.68	0.0978	Scheffe	0.8981
Treatment	A3	A4	4.7200	1.7885	72	2.64	0.0102	Scheffe	0.4421
Treatment	A3	A5	-0.7200	1.7885	72	-0.40	0.6885	Scheffe	1.0000
Treatment	A3	A6	-0.9400	1.7885	72	-0.53	0.6008	Scheffe	0.9999
Treatment	A3	A7	0.3500	1.7885	72	0.20	0.8454	Scheffe	1.0000
Treatment	A3	A8	0.3500	1.7885	72	0.20	0.8454	Scheffe	1.0000
Treatment	A4	A5	-5.4400	1.7885	72	-3.04	0.0033	Scheffe	0.2527
Treatment	A4	A6	-5.6600	1.7885	72	-3.16	0.0023	Scheffe	0.2065
Treatment	A4	A7	-4.3700	1.7885	72	-2.44	0.0170	Scheffe	0.5478
Treatment	A4	A8	-4.3700	1.7885	72	-2.44	0.0170	Scheffe	0.5478
Treatment	A5	A6	-0.2200	1.7885	72	-0.12	0.9024	Scheffe	1.0000
Treatment	A5	A7	1.0700	1.7885	72	0.60	0.5515	Scheffe	0.9998
Treatment	A5	A8	1.0700	1.7885	72	0.60	0.5515	Scheffe	0.9998
Treatment	A6	A7	1.2900	1.7885	72	0.72	0.4731	Scheffe	0.9993
Treatment	A6	A8	1.2900	1.7885	72	0.72	0.4731	Scheffe	0.9993
Treatment	A7	A8	-183E-15	1.7885	72	-0.00	1.0000	Scheffe	1.0000

Treatment	A1	A2	2.2400	1.7885	72	1.25	0.2145	Bonferroni	1.0000
Treatment	A1	A3	-1.1100	1.7885	72	-0.62	0.5368	Bonferroni	1.0000
Treatment	A1	A4	3.6100	1.7885	72	2.02	0.0473	Bonferroni	1.0000
Treatment	A1	A5	-1.8300	1.7885	72	-1.02	0.3096	Bonferroni	1.0000
Treatment	A1	A6	-2.0500	1.7885	72	-1.15	0.2555	Bonferroni	1.0000
Treatment	A1	A7	-0.7600	1.7885	72	-0.42	0.6722	Bonferroni	1.0000
Treatment	A1	A8	-0.7600	1.7885	72	-0.42	0.6722	Bonferroni	1.0000
Treatment	A2	A3	-3.3500	1.7885	72	-1.87	0.0651	Bonferroni	1.0000

Treatment	A2	A4	1.3700	1.7885	72	0.77	0.4462	Bonferroni	1.0000
Treatment	A2	A5	-4.0700	1.7885	72	-2.28	0.0258	Bonferroni	0.7237
Treatment	A2	A6	-4.2900	1.7885	72	-2.40	0.0190	Bonferroni	0.5334
Treatment	A2	A7	-3.0000	1.7885	72	-1.68	0.0978	Bonferroni	1.0000
Treatment	A2	A8	-3.0000	1.7885	72	-1.68	0.0978	Bonferroni	1.0000
Treatment	A3	A4	4.7200	1.7885	72	2.64	0.0102	Bonferroni	0.2852
Treatment	A3	A5	-0.7200	1.7885	72	-0.40	0.6885	Bonferroni	1.0000
Treatment	A3	A6	-0.9400	1.7885	72	-0.53	0.6008	Bonferroni	1.0000
Treatment	A3	A7	0.3500	1.7885	72	0.20	0.8454	Bonferroni	1.0000
Treatment	A3	A8	0.3500	1.7885	72	0.20	0.8454	Bonferroni	1.0000
Treatment	A4	A5	-5.4400	1.7885	72	-3.04	0.0033	Bonferroni	0.0919
Treatment	A4	A6	-5.6600	1.7885	72	-3.16	0.0023	Bonferroni	0.0637
Treatment	A4	A7	-4.3700	1.7885	72	-2.44	0.0170	Bonferroni	0.4761
Treatment	A4	A8	-4.3700	1.7885	72	-2.44	0.0170	Bonferroni	0.4761
Treatment	A5	A6	-0.2200	1.7885	72	-0.12	0.9024	Bonferroni	1.0000
Treatment	A5	A7	1.0700	1.7885	72	0.60	0.5515	Bonferroni	1.0000
Treatment	A5	A8	1.0700	1.7885	72	0.60	0.5515	Bonferroni	1.0000
Treatment	A6	A7	1.2900	1.7885	72	0.72	0.4731	Bonferroni	1.0000
Treatment	A6	A8	1.2900	1.7885	72	0.72	0.4731	Bonferroni	1.0000
Treatment	A7	A8	-183E-15	1.7885	72	-0.00	1.0000	Bonferroni	1.0000

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

Obs	Treatment	Estimate	StdErr	Alpha	Lower	Upper	MSGROUP
9	A6	67.7600	1.2647	0.05	65.2389	70.2811	A
10	A5	67.5400	1.2647	0.05	65.0189	70.0611	A
11	A3	66.8200	1.2647	0.05	64.2989	69.3411	A
12	A8	66.4700	1.2647	0.05	63.9489	68.9911	A
13	A7	66.4700	1.2647	0.05	63.9489	68.9911	A
14	A1	65.7100	1.2647	0.05	63.1889	68.2311	A
15	A2	63.4700	1.2647	0.05	60.9489	65.9911	A
16	A4	62.1000	1.2647	0.05	59.5789	64.6211	A

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

Obs	Treatment	Estimate	StdErr	Alpha	Lower	Upper	MSGROUP
17	A6	67.7600	1.2647	0.05	65.2389	70.2811	A
18	A5	67.5400	1.2647	0.05	65.0189	70.0611	AB
19	A3	66.8200	1.2647	0.05	64.2989	69.3411	AB
20	A8	66.4700	1.2647	0.05	63.9489	68.9911	AB
21	A7	66.4700	1.2647	0.05	63.9489	68.9911	AB
22	A1	65.7100	1.2647	0.05	63.1889	68.2311	AB
23	A2	63.4700	1.2647	0.05	60.9489	65.9911	AB
24	A4	62.1000	1.2647	0.05	59.5789	64.6211	B

Exam 3 Problem : Example with Homogeneous Variance

The UNIVARIATE Procedure
Variable: Resid

Moments

N	80	Sum Weights	80
Mean	0	Sum Observations	0
Std Deviation	3.81800531	Variance	14.5771646
Skewness	0.73834537	Kurtosis	-0.4680077
Uncorrected SS	1151.596	Corrected SS	1151.596
Coeff Variation	.	Std Error Mean	0.42686597

Basic Statistical Measures

Location		Variability	
Mean	0.00000	Std Deviation	3.81801
Median	-1.21500	Variance	14.57716
Mode	-3.40000	Range	14.76000
		Interquartile Range	5.21000

Note: The mode displayed is the smallest of 4 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	-9	Pr >= |M|	0.0567
Signed Rank	S	-140	Pr >= |S|	0.5053

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.921803	Pr < W	0.0001
Kolmogorov-Smirnov	D	0.139157	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.356387	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	2.173195	Pr > A-Sq	<0.0050

```
Stem Leaf  Boxplot                        Normal Probability Plot
   8 9                        1     |         8.5+                                              +++*
   7 233579                   6     |            |                                       *****+*
   6 046                        3     |            |                                     **  +++
   5 178                      3     |            |                                   **  ++
   4                                |            |                                    +++
   3 024579                   6     |            |                                 ***
   2 125                      3  +-----+         |                               **
   1 1238                     4  |     |      1.5+                            ++**
   0 45567                    5  |  +  |         |                         +++**
  -0 7543321                  7  |     |         |                       ++****
  -1 9999775554410           13  *-----*         |                    +*****
  -2 9877655320              10  +-----+         |                  ****
  -3 774444311                9     |            |             ******
  -4 6654110                  7     |            |        ******+
  -5 953                      3     |        -5.5+ *   * *  ++
     ----+----+----+----+                        +----+----+----+----+----+----+----+----+----+----
                                                      -2        -1         0        +1        +2
```

Exam 3 Problem : Analysis of Variance with PROC GLM

The GLM Procedure

Class Level Information

Class	Levels	Values
Treatment	8	A1 A2 A3 A4 A5 A6 A7 A8

Number of Observations Read	80
Number of Observations Used	80

Dependent Variable: Y_Value

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	279.339500	39.905643	2.49	0.0237
Error	72	1151.596000	15.994389		
Corrected Total	79	1430.935500			

R-Square	Coeff Var	Root MSE	Y_Value Mean
0.195215	6.078654	3.999299	65.79250

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Treatment	7	279.3395000	39.9056429	2.49	0.0237

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	72
Error Mean Square	15.99439

Number of Means	2	3	4	5	6	7	8
Critical Range	3.565	3.751	3.874	3.964	4.033	4.089	4.135

Means with the same letter are not significantly different.

Duncan Grouping			Mean	N	Treatment
	A		67.760	10	A6
	A		67.540	10	A5
B	A		66.820	10	A3
B	A		66.470	10	A8
B	A		66.470	10	A7
B	A	C	65.710	10	A1
B		C	63.470	10	A2
		C	62.100	10	A4

Exam 3 Problem : Analysis of Variance with PROC GLM

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	72
Error Mean Square	15.99439
Critical Value of Studentized Range	4.41490
Minimum Significant Difference	5.5835

Means with the same letter are not significantly different.

Tukey Grouping		Mean	N	Treatment
	A	67.760	10	A6
B	A	67.540	10	A5
B	A	66.820	10	A3
B	A	66.470	10	A8
B	A	66.470	10	A7
B	A	65.710	10	A1
B	A	63.470	10	A2
B		62.100	10	A4

Scheffe's Test for Y_Value

NOTE: This test controls the Type I experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	72
Error Mean Square	15.99439
Critical Value of F	2.13966
Minimum Significant Difference	6.9218

Means with the same letter are not significantly different.

Scheffe Grouping	Mean	N	Treatment
A	67.760	10	A6
A	67.540	10	A5
A	66.820	10	A3
A	66.470	10	A8
A	66.470	10	A7
A	65.710	10	A1
A	63.470	10	A2
A	62.100	10	A4

Exam 3 Problem : Analysis of Variance with PROC GLM

The GLM Procedure

Levene's Test for Homogeneity of Y_Value Variance
ANOVA of Squared Deviations from Group Means

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Treatment	7	2279.8	325.7	1.05	0.4056
Error	72	22364.9	310.6		

O'Brien's Test for Homogeneity of Y_Value Variance
ANOVA of O'Brien's Spread Variable, W = 0.5

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Treatment	7	2814.5	402.1	0.93	0.4898
Error	72	31170.2	432.9		

Brown and Forsythe's Test for Homogeneity of Y_Value Variance
ANOVA of Absolute Deviations from Group Medians

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Treatment	7	18.9995	2.7142	0.30	0.9503
Error	72	644.6	8.9524		

Bartlett's Test for Homogeneity of Y_Value Variance

Source	DF	Chi-Square	Pr > ChiSq
Treatment	7	5.6876	0.5767

Welch's ANOVA for Y_Value

Source	DF	F Value	Pr > F
Treatment	7.0000	3.34	0.0091
Error	30.7198		

The GLM Procedure

Level of Treatment	N	-----------Y_Value----------- Mean	Std Dev
A1	10	65.7100000	4.53809799
A2	10	63.4700000	3.91153565
A3	10	66.8200000	2.93779963
A4	10	62.1000000	2.62043253
A5	10	67.5400000	4.74791182
A6	10	67.7600000	4.92548926
A7	10	66.4700000	4.11718620
A8	10	66.4700000	3.57896633