ST512

Fall Semester, 2006

Quiz 4

Name:_____

Directions: Answer questions as directed. Please show work. You do not need to carry out any arithmetic that is obvious for the grader. For example, if the correct answer is $62.1 + 2.6 + 28.1 + 30.3$, then you needn't carry out the addition to get 123.1 unless you'll need it for some subsequent calculation.

There are 4 problems, worth 25 points each, on 5 pages. After the problems, there are three pages of SAS output pertaining to problems 2, 3 and 4 ("BARLEY PROBLEM", "WHEAT PROBLEM" and "COOKIES PROBLEM") and then one page for a t-table.

1. A study investigates variability of blood pressure measurements among $n = 25$ randomly sampled males. Each subject made 16 visits to a clinic and systolic blood pressures were measured once on each visit, for a total of 400 measurements. Consider a one-factor random effects model for this study.

   (a) The variance component estimates for subject and visit obtained by setting observed mean squares to expected mean squares and solving are $\hat{\sigma}_S^2 = 218.7$ and $\hat{\sigma}^2 = 203.2$, respectively. Complete an ANOVA table appropriate for the model.

   (b) The sample mean systolic blood pressure among all measurements was $\bar{y}_{++} = 150.6$. Report a 95% confidence interval for the mean systolic blood pressure in the population from which this sample was taken.

   (c) Estimate the coefficient of variation for blood pressure measurements.

   (d) Report the F-ratio and associated degrees of freedom for a test that the variance component for patient is 0: $H_0 : \sigma_S^2 = 0$.

2. An experiment measured yields on five barley varieties randomized to six locations so that each variety was observed once in each location. Pertinent SAS code and output are given at the end of the exam under the title "BARLEY PROBLEM." Treat variety effects as fixed.

   (a) Precede each of the following True/False questions with "Regardless of whether locations are regarded as fixed or random, ..."

      i. the F-test of equality of variety means is the same. (True/False)

      ii. the standard error for any contrast among sample variety means is the same. (True/False)

      iii. the standard error for any single sample variety mean is the same. (True/False) Prove or disprove this claim (iii).

   (b) For the following two problems, assume random location effects:

      i. Consider the observed difference between M and T, $\bar{y}_{4+} - \bar{y}_{1+}$. Obtain a 95% confidence interval for the parameter estimated by this difference.

      ii. Consider the average of the five variety (population) means. Propose and report an estimate (and standard error) for this quantity.

3. An experiment with wheat investigates the effects of irrigation (A) and fertilizer (B). The design first randomized 10 fields to the two irrigation methods (furrow and sprinkler) and then splits each field into three subplots which are randomized to the three fertilizer rates ('1x','2x' and '3x'). Some analysis of the yield data from the experiment can be found in the SAS code and output entitled "WHEAT PROBLEM."

   (a) Write out an appropriate mixed effects statistical model for data from this experiment which allows for fixed main effects and interactions for factors A and B. You don't need to specify the sum-to-zero constraints, but you do need to identify variance components and specify limits of any subscripts (i, j, k) you use.

   (b) Note that $SS[fert] = 11.27$. Use it to construct the F-ratio for a test of no fertilizer effect. Also, partition $SS[fert]$ into linear and quadratic contrast sums of squares, assuming $1x, 2x, 3x$ correspond to equally spaced fertilizer rates.

(c) Complete the table of estimated main effects below. Beneath the table, provide expressions for each standard error.

Effect	Estimate	standard error	confidence interval
Main effect of irrigation			
Difference between fertilizers $1x$ and $2x$			

4. An experiment investigates the effects of two factors on the taste of chocolate chip cookies: mixing temperature of ingredients and chocolate chip quality. Six batches of cookies are prepared; three with ingredients (eggs and butter) that have been mixed at room temperature and three with refrigerated ingredients. These batches are randomized to three different ovens, so that each oven gets two batches, one of each mixing temperature. Each batch will be divided into halves and one cup of premium chocolate chips will be added to one half-batch and one cup of low-cost chocolate chips to the other. Cookies are given to random consumers, whose taste ratings are summarized for each half-batch, resulting in 12 ratings measurements. SAS code and output pertaining to this problem may be found on the page entitled "COOKIES PROBLEM."

   (a) Draw a diagram of three ovens and six batches. Indicate treatment combinations for all 12 observations. Indicate the name of this experimental design.

   (b) Test for an interaction between temperature and chip quality using level $\alpha = .05$.

   (c) Report 95% confidence intervals for the main effects of both experimental factors.

```
proc glm data=one;
   class loc variety;
   model yield =loc variety;
   means variety;
run;
```


The GLM Procedure

Class	Levels	Values
loc	6	C D GR M UF W
variety	5	M P S T V

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
loc	5	17829.84667	3565.96933	21.89	<.0001
variety	4	2756.62467	689.15617	4.23	0.0121
Error	20	3257.74333	162.88717		
Corrected Total	29	23844.21467			

R-Square	Coeff Var	Root MSE	yield Mean
0.863374	11.70391	12.76273	109.0467

Level of variety	N	yield Mean	yield Std Dev
M	6	102.583333	25.9640842
P	6	109.750000	21.3401734
S	6	102.033333	26.0269604
T	6	127.400000	36.6710785
V	6	103.466667	32.6467558

The Mixed Procedure

Class	Levels	Values
field	5	1 2 3 4 5
irr	2	furrow sprinkler
fert	3	1x 2x 3x

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square
irr	1	2116.800000	2116.800000
fert	2	11.266667	5.633333
irr*fert	2	0.200000	0.100000
field(irr)	8	627.333333	78.416667
Residual	16	15.866667	0.991667

Covariance Parameter Estimates

Cov Parm	Estimate
field(irr)	25.8083
Residual	0.9917

Least Squares Means

Effect	irr	fert	Estimate	Standard Error	DF	t Value	Pr > |t|
irr	furrow		50.7333	2.2864	8	22.19	<.0001
irr	sprinkler		67.5333	2.2864	8	29.54	<.0001
fert		1x	58.4000	1.6371	16	35.67	<.0001
fert		2x	59.9000	1.6371	16	36.59	<.0001
fert		3x	59.1000	1.6371	16	36.10	<.0001

The GLM Procedure

Class	Levels	Values
oven	3	1 2 3
chips	2	low-cost premium
temp	2	refrig room

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	697.5833333	99.6547619	21.35	0.0051
Error	4	18.6666667	4.6666667		
Corrected Total	11	716.2500000			

R-Square	Coeff Var	Root MSE	taste Mean
0.973938	2.594891	2.160247	83.25000

Source	DF	Type III SS	Mean Square	F Value	Pr > F
chips	1	30.0833333	30.0833333	6.45	0.0641
temp	1	252.0833333	252.0833333	54.02	0.0018
chips*temp	1	0.7500000	0.7500000	0.16	0.7090
oven	2	398.0000000	199.0000000	42.64	0.0020
oven*temp	2	16.6666667	8.3333333	1.79	0.2791

Least Squares Means

chips	temp	taste LSMEAN
low-cost	refrig	77.3333333
low-cost	room	86.0000000
premium	refrig	80.0000000
premium	room	89.6666667

Table of critical values ($t(df, \alpha)$) from t-distributions:

df	$\alpha = 0.2$	$\alpha = 0.15$	$\alpha = 0.1$	$\alpha = 0.05$	$\alpha = 0.025$	$\alpha = 0.01$	$\alpha = 0.005$	$\alpha = 0.001$
1	1.37638	1.96261	3.07768	6.31375	12.7062	31.8205	63.6567	318.309
2	1.06066	1.38621	1.88562	2.91999	4.3027	6.9646	9.9248	22.327
3	0.97847	1.24978	1.63774	2.35336	3.1824	4.5407	5.8409	10.215
4	0.94096	1.18957	1.53321	2.13185	2.7764	3.7469	4.6041	7.173
5	0.91954	1.15577	1.47588	2.01505	2.5706	3.3649	4.0321	5.893
6	0.90570	1.13416	1.43976	1.94318	2.4469	3.1427	3.7074	5.208
7	0.89603	1.11916	1.41492	1.89458	2.3646	2.9980	3.4995	4.785
8	0.88889	1.10815	1.39682	1.85955	2.3060	2.8965	3.3554	4.501
9	0.88340	1.09972	1.38303	1.83311	2.2622	2.8214	3.2498	4.297
10	0.87906	1.09306	1.37218	1.81246	2.2281	2.7638	3.1693	4.144
11	0.87553	1.08767	1.36343	1.79588	2.2010	2.7181	3.1058	4.025
12	0.87261	1.08321	1.35622	1.78229	2.1788	2.6810	3.0545	3.930
13	0.87015	1.07947	1.35017	1.77093	2.1604	2.6503	3.0123	3.852
14	0.86805	1.07628	1.34503	1.76131	2.1448	2.6245	2.9768	3.787
15	0.86624	1.07353	1.34061	1.75305	2.1314	2.6025	2.9467	3.733
16	0.86467	1.07114	1.33676	1.74588	2.1199	2.5835	2.9208	3.686
17	0.86328	1.06903	1.33338	1.73961	2.1098	2.5669	2.8982	3.646
18	0.86205	1.06717	1.33039	1.73406	2.1009	2.5524	2.8784	3.610
19	0.86095	1.06551	1.32773	1.72913	2.0930	2.5395	2.8609	3.579
20	0.85996	1.06402	1.32534	1.72472	2.0860	2.5280	2.8453	3.552
21	0.85907	1.06267	1.32319	1.72074	2.0796	2.5176	2.8314	3.527
22	0.85827	1.06145	1.32124	1.71714	2.0739	2.5083	2.8188	3.505
23	0.85753	1.06034	1.31946	1.71387	2.0687	2.4999	2.8073	3.485
24	0.85686	1.05932	1.31784	1.71088	2.0639	2.4922	2.7969	3.467
25	0.85624	1.05838	1.31635	1.70814	2.0595	2.4851	2.7874	3.450
26	0.85567	1.05752	1.31497	1.70562	2.0555	2.4786	2.7787	3.435
27	0.85514	1.05673	1.31370	1.70329	2.0518	2.4727	2.7707	3.421
28	0.85465	1.05599	1.31253	1.70113	2.0484	2.4671	2.7633	3.408
29	0.85419	1.05530	1.31143	1.69913	2.0452	2.4620	2.7564	3.396
30	0.85377	1.05466	1.31042	1.69726	2.0423	2.4573	2.7500	3.385
40	0.85070	1.05005	1.30308	1.68385	2.0211	2.4233	2.7045	3.307
60	0.84765	1.04547	1.29582	1.67065	2.0003	2.3901	2.6603	3.232
80	0.84614	1.04320	1.29222	1.66412	1.9901	2.3739	2.6387	3.195
100	0.84523	1.04184	1.29007	1.66023	1.9840	2.3642	2.6259	3.174
200	0.84342	1.03913	1.28580	1.65251	1.9719	2.3451	2.6006	3.131
100000	0.84162	1.03644	1.28156	1.64487	1.9600	2.3264	2.5759	3.090