

ST512

Fall Quarter, 2005

Exam 3

Name: \_\_\_\_\_

Directions: Answer questions as directed. Show work where appropriate to justify answers or to receive partial credit.

1. (40 pts) 25 men are randomly sampled from a population of interest and diastolic blood pressure is measured on each of 16 occasions. Let  $y_{ij}$  denote the measurement for subject  $i$  and occasion  $j$ . Summary statistics are given below.

$$\bar{y}_{+++} = 91.7, \quad \sum_{i=1}^{25} \sum_{j=1}^{16} (\bar{y}_{i+} - 91.7)^2 = 11529, \quad \sum_i \sum_j (\bar{y}_{ij} - \bar{y}_{i+})^2 = 19541$$

Consider a model with subject effects  $A_i$  assumed i.i.d.  $N(0, \sigma_1^2)$  and errors  $E_{ij}$  assumed i.i.d.  $N(0, \sigma_2^2)$ , independent of  $\{A_i\}$ .

- (a) Estimate all variance components for this model.

- (b) Use the normal approximation to the chisquare distribution ( $\chi_n^2 \approx N(\mu = n, \sigma^2 = 2n)$ ) to report an approximate 95% confidence interval for the variance component quantifying day-to-day variability (or variability not due to subject).

- (c) Estimate the intraclass correlation coefficient and give two interpretations of this parameter estimate.

- (d) Estimate the mean diastolic blood pressure among males. Report a 95% confidence interval for this parameter.

2. (30 pts) An experiment investigates the effect of row spacing on soybean yields. The design uses five row spacings (18,24,30,36 or 42 inches apart) in a randomized complete block design with 6 plots. SAS code and output appropriate for this experiment, which is described in Steel, Torrie and Dickey (1997) appear at the end of this exam under the title "SOYBEAN PROBLEM".
- (a) Report the  $F$ -ratio and associated degrees of freedom for a test that row spacing has no effect on yield.
- (b) Report Tukey's minimum significant difference (to control experimentwise error at  $\alpha = .05$ ) for all pairwise comparisons among row spacing means.
- (c) The coefficients for the linear polynomial contrast are  $(-2, -1, 0, 1, 2)$ . Obtain the  $F$ -ratio and associated degrees of freedom for a test of lack of fit in a model in which yield is linearly related to row spacing.

3. (30 pts) An experiment investigates the effects of two factors on corn yield. Three levels of nitrogen (56, 112, and 168 *lbs/ha*) and two types of irrigation (furrow, sprinkler) are used in a balanced  $3 \times 2$  randomized design with a total of  $N = 24$  plots. SAS code and output appropriate for this problem appears on a page entitled “CORNYIELDS PROBLEM” at the end of the exam.
- (a) Report the  $F$ -ratio and  $p$ -value for a test that any effects of nitrogen on yield are constant across irrigation types.
- (b) For each level of nitrogen, estimate the simple effect of irrigation type. Report a standard error and  $p$ -value for a test of no simple effect in each case.
- (c) For sprinkler irrigation, is the effect of nitrogen nonlinear? Report the quadratic (nonlinear) polynomial contrast for nitrogen (with coefficients  $(1, -2, 1)$ ) when sprinkler irrigation is used. Report the standard error.

- (d) Does the nonlinearity of the response to nitrogen vary across irrigation types? The quadratic polynomial contrast for furrow-irrigated corn is  $\hat{\theta}_{quad, furrow} = 2$ . Report the difference between the quadratic contrasts for furrow and sprinkler irrigated corn. Report the standard error for this difference.
- (e) Draw a conclusion about the effects of nitrogen and irrigation type on yield, characterizing the nature of their interaction. Sketch a plot if it helps.

SOYBEAN PROBLEM  
(taken from Steel, Torrie, and Dickey, 1997)

```
proc glm;
  class block spacing ;
  model y=spacing block;
  estimate "linear" spacing -2 -1 0 1 2;
  means spacing /tukey;
run;
```

The SAS System 1  
The GLM Procedure

Class	Levels	Values
block	6	1 2 3 4 5 6
spacing	5	18 24 30 36 42

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	?	133.0333333			
Error	??	63.9333333			
Corrected Total	??	196.9666667			

Source	DF	Type I SS	Mean Square	F Value	Pr > F
spacing	4	126.4666667			
block	5	6.5666667			

Parameter	Estimate	Standard Error	t Value	Pr >  t
linear	-12.6666667	2.30819795	-5.49	<.0001

Tukey's Studentized Range (HSD) Test for y

Alpha	0.05
Error Degrees of Freedom	??
Error Mean Square	??
Critical Value of Studentized Range	4.23186
Minimum Significant Difference	??

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	spacing
A	35.167	6	18
B	31.833	6	24
B	30.333	6	30
B	30.000	6	42
B	29.500	6	36

# CORNIELDS PROBLEM

```

proc glm order=dat;
  class irrig nit;
  model yield=irrig|nit;
  lsmeans irrig*nit/slice=nit;
  estimate "furrow: quad nit " nit 1 -2 1 irrig*nit 1 -2 1;

```

The SAS System  
The GLM Procedure

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Class	Levels	Values
irrig	2	furrow sprinkler
nit	3	56 112 168

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	4539.333333	907.866667	26.53	<.0001
Error	18	616.000000	34.222222		
Corrected Total	23	5155.333333			

Source	DF	Type I SS	Mean Square	F Value	Pr > F
irrig	1	912.666667	912.666667	26.67	<.0001
nit	2	3057.333333	1528.666667	44.67	<.0001
irrig*nit	2	569.333333	284.666667	8.32	0.0028

### Least Squares Means

irrig	nit	yield LSMEAN
furrow	56	160.000000
furrow	112	171.000000
furrow	168	184.000000
sprinkler	56	164.000000
sprinkler	112	197.000000
sprinkler	168	191.000000

### irrig\*nit Effect Sliced by nit for yield

nit	DF	Sum of Squares	Mean Square	F Value	Pr > F
56	1	32.000000	32.000000	0.94	0.3464
112	1	1352.000000	1352.000000	39.51	<.0001
168	1	98.000000	98.000000	2.86	0.1078

Parameter	Estimate	Standard Error	t Value	Pr >  t
furrow: quad nit	2.00000000	7.16472842	0.28	0.7833