STAT 5200 Fall 2017 Midterm Exam

Directions: You have 70 minutes to complete the exam. You may use your calculator and a single page (both sides) of notes, but no laptops, cell phones, or other wireless-capable devices are allowed. Be concise with all your responses (no more than 1-2 sentences are needed for each question). You may use 3 decimal places in all calculations. The point-worth of each question is given, and the total points sum to 100.

Student Name: Solutions

SAS Output: Partial output and graphics from certain models using SAS procedures are provided in a separate handout, and are necessary for some of the questions on the exam. The SAS output and graphics are clearly identified by title or output number.

Data: An experiment was carried out to evaluate the effects of multiple factors on the growth of shrimp. Two **Temp**eratures were used in the experiment: 25° C and 35° C. Water **Salinity** is expressed as a percentage, and three levels were used (10, 25, and 40). Six 40-liter containers were randomly assigned to each combination of factor levels. For each container, 120 shrimp are randomly selected from a large batch of shrimp, weighed as a group, and then put in the container. After four weeks, the shrimp were harvested from the containers, weighed again as a group, and then the *average* of the 120 shrimps' weight **Gain** (in mg) in each container was recorded. The six combinations of factor levels were referred to as the six **Condition**s, summarized as follows:

Temp:	25	35	25	35	25	35
Salinity:	10	10	25	25	40	40
Condition:	1	2	3	4	5	6

Question 1: (9 points) The researchers were not lazy – they could have weighed individual [and tagged] shrimp (before and after the four weeks in their respective containers) and recorded individual weight gain. Referring to principles of experimental design, why was it appropriate to use the average of the 120 shrimps' weight gain in each container instead of the individual shrimp's weight gain?

Shrimp were measurement units.

Containers were $\underbrace{\text{experimental units.}}_{+9}$

(may also refer to inflated sample size if use shrimp as experimental unit)

Question 2: (7 Points) The SAS code below produces 'SAS Output 1'. What inference, if any, can be made about the effect of Condition factor level on mean Gain, based on this output? If no valid inference can be made, specifically explain why.

```
proc glm data=shrimp plots=diagnostics;
     class Condition;
     model Gain = Condition;
run;
```

+3 { Nothing - no valid inference can be made

+2 { Model assumptions not met

+2 { (Clear problems with constant variance)

-may also mention possible non-normality

(-4 if ignore violations and conclude Condition affects Gain)

Question 3: (6 Points) The SAS code below produces 'SAS Output 2'. What should be done based on this result? (Be specific.)

```
proc transreg data=shrimp;
  model boxcox(Gain / lambda=-1 to 1 by 0.05) = class(Condition);
run;
```

+6 { Transform response variable to log(Gain)

(or any $\text{sign}(\lambda)\cdot \text{Gain}^{\lambda}$ for $-.2 \le \lambda \le .5$)

and re-fit model

(+3 if only say to transform response

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Question 4: After acting on the suggestion of SAS Output 2 (Question 3 above), the variable newGain is defined, and the model is fit again using the following SAS code, and 'SAS Output 3' results.

```
proc glm data=shrimp plots=diagnostics;
    class Condition;
    model newGain = Condition;
    means Condition / LSD Bon Tukey REGWQ;
    lsmeans Condition / pdiff;
run;
```

a) (4 points) What is the value of the test statistic for testing the null hypothesis "mean newGain is the same for all Condition levels"?

$$\underbrace{F = \frac{MS_{model}}{MS_{error}}}_{+2 \text{ ratio}} \approx \underbrace{\frac{2.518}{0.035} \approx 71.943}_{+2}$$

Depending on rounding, 71.297 to 71.943 okay; do not need to show work.

b) (3 points) What is the sampling distribution for this test statistic?

$F_{5,30}$ (-1 for each missing piece)

c) (4 points) What is the conclusion of this test of significance, in the context of this application?

Condition means are not all equal

(+2 if only "reject null" or if have no context – must refer to Gain, newGain, or Condition; +2 if conclude Condition means are all unequal)

d) (6 points) Can you trust this conclusion? Why or why not?

$\underbrace{\text{Yes}}_{+2}$ – $\underbrace{\text{model assumptions are met}}_{+4}$

Question 5: (4 points) Is the design of this shrimp study balanced? Explain briefly.

+2 { Yes

+2 { The same # of exp. units (6 containers) were used at each factor level combination

(-1 if say yes because same # shrimp (msmnt units))

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Question 6: (14 points) Refer to the code (previous page) and output (attached) for 'SAS Output 3'. The LSMEANS statement (which does not depend on the MEANS statement) produces the table below of raw, unadjusted p-values. We are interested in all pairwise comparisons of Condition level means, and we want to control the strong family-wise error rate at α=.05 while maintaining the highest statistical power. Based on this interest and using the appropriate table in 'SAS Output 3', cross out the raw, unadjusted p-values below for the pairwise comparisons that are **not** statistically significant after appropriately accounting for multiple comparisons. (Here, LSMEAN number is the same as Condition number. Calling only p-values in this table greater than .05 'not significant' would just control the per-comparison error rate at α=.05, which is not our objective.)

REGWQ

cross out p where LSMEANS share letter grouping

Least Squares Means for effect Condition Pr > |t| for H0: LSMean(i)=LSMean(j) Dependent Variable: newGain						
i/j	1	2	3	4	5	6
1		<.0001	<.0001	<.0001	<.0001	<.0001
2			~~0.3085~~	~~0.0310~~	~~0.0490~~	0.0003
3				0.0035	0.0071	<.0001
4					~~0.7773~~	~~0.0380~~
5						~~0.0312~~
6						

−2 for each missing or extra cross-out if method (like Tukey or Bonferroni) is not clear

−10 (not FWER) • LSD approach would cross out all $p \geq 0.05$

−2 for either of these (less power than REGWQ) • Tukey (HSD) would be same as REGWQ, and also cross out .0071 • Bonferroni would be same as REGWQ, and also cross out .0071 and .0035

Question 7: (14 points) Let μ_i be the population mean newGain value of Condition i. Define a contrast ψ in terms of the μ_i's, such that "H_0: ψ = 0" corresponds to a test of whether the mean newGain value is any different in the lowest Salinity level than in the highest two Salinity levels, averaging over both Temperatures.

+6 correct understanding: H_0: mean at lowest Salinity = mean at highest two Salinities

+4 express H_0 in terms of μ_i's: $H_0: \frac{\mu_1 + \mu_2}{2} = \frac{\mu_3 + \mu_4 + \mu_5 + \mu_6}{4}$ [−3 if only highest one]

+1 rewrite: $H_0: 2\mu_1 + 2\mu_2 = \mu_3 + \mu_4 + \mu_5 + \mu_6$

+3 write contrast: $\psi = 2\mu_1 + 2\mu_2 - \mu_3 - \mu_4 - \mu_5 - \mu_6$ (or $k \cdot \psi$ for any $k \neq 0$)

(+6 for any $\Sigma w_i \mu_i$ or even generic def. of contrast)

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Question 8: The SAS code below produces 'SAS Output 4', which also includes one additional interaction plot.

```
proc glm data=shrimp plots=diagnostics;
     class Temp Salinity;
     model newGain = Temp|Salinity;
     lsmeans Temp*Salinity;
run;
```

a) (14 points) Write out the appropriate effects parameterization model corresponding to this SAS code. Define any symbols (parameters or letters) you use, and specify the range of any subscripts you use. Also specify model assumptions, referring to a specific part of the model.

+5 $\{ \; Y_{ijk} = \mu + T_i + S_j + TS_{ij} + \varepsilon_{ijk}$

+5 { Y_{ijk}: newGain; μ: overall or pop. mean; T_i: Temp effect; S_j: Salinity effect; TS_{ij}: interaction; ε_{ijk}: random or residual error

+2 { $i=1,2$ $\quad j=1,2,3$ $\quad k=1,\dots,6$

+2 { ε_{ijk}'s iid $N(0,\sigma^2)$

b) (8 points) What does the interaction term mean in this model?

The effect of Temp (on newGain) depends on Salinity

[Could switch 'Temp' & 'Salinity'; okay if don't mention newGain; okay to say 'could depend'; −3 if omit "effect"]

c) (6 points) Would you expect the interaction term to be statistically significant here? Explain briefly, referring to specific elements of 'SAS Output 4'.

+2 { Yes

+4 { Lines in interaction plots not parallel
-or- $F_{TS} > F_S$ (with same DF), so TS p-val < S p-val < .0001

Question 9: (1 point) What topic(s) did you study most that did not appear on this exam?

(anything)

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