Master's Comprehensive Exam

EXPERIMENTAL DESIGN

February 10, 2007

Instructions:
Do 5 problems out of the 8 problems given below.

1. During the winter, a farmer conducts an experiment in order to test if different sorts of onions have an effect on germination and growth of seedlings. He has seeds of three sorts of onions (yellow, red, and white), and two windows in the basement of his house, one to the east and one to the south. The farmer decides to use the windows as blocks. He prepares six flower pots, two with each sort of onions, and places one pot of each sort of onions on each window sill. The order of pots on each window sill is randomized. In three weeks, the farmer records the height of the seedlings in each pot (in cm). The results are

Sort of Onions	Window to the East (Block 1)	Window to the South (Block 2)
Yellow	8	12
Red	3	8
White	25	15

   a. Write an appropriate statistical model with all specifications. Estimate all the parameters in the model.

   b. Draw an ANOVA table for the experiment and draw conclusions. Is it reasonable to block on the amount of sunlight the seedlings receive?

   c. Obtain confidence intervals for all pairwise comparisons between the treatment (onion) means; use the Tukey procedure and a 90% family confidence coefficient. Interpret your results.

2. A study compares four formulas (A, B, C, and D) that are fed to newborns, each for one week. The response variable is the mean increase in weight recorded as ounces per day. The data are

	Week			
Infant	1	2	3	4
1	D=0.4	B=1.3	A=1.2	C=0.8
2	B=0.2	A=0.6	C=1.1	D=1.1
3	A=1.1	C=1.3	D=1.0	B=1.3
4	C=1.0	D=1.4	B=0.9	A=1.1

a. State the statistical model with all specifications.

b. Specify the hypotheses and draw the ANOVA table for the experiment. Write down your conclusion.

c. Give a 95% CI for comparing formula A and formula B.

3. A mom wants to test whether different brands of laundry detergent and different washing temperatures affect how well her toddler's clothes are washed. She goes to a store and randomly picks three detergents. Then she prepares 18 loads of clothes, two for each treatment-treatment combination. She uses all available levels of temperature: cold, warm, and hot. Then she records on a seven-point scale her satisfaction level. The data are

	Temperature		
Detergent Type	Cold	Warm	Hot
Dreft	7	6	6
	6	6	5
Ivory Snow	5	5	4
	6	6	5
Mountain Green	5	6	6
	6	7	4

a. Write an appropriate statistical model and estimate all parameters.

b. Specify statistical hypotheses and perform the hypothesis tests. What is your conclusion?

c. Plot the main effect and the interaction plots. Interpret.

4. The surface finish of metal parts made on three machines is being studied. An experiment is conducted in which each machine is run by three different operators and two specimens from each operator are collected tested. Because of the location of the machines, different

operators are used on each machine, and the operators are chosen at random. The data are shown in the following table.

	Machine 1			Machine 2			Machine 3		
Operator	1	2	3	1	2	3	1	2	3
	79	94	46	92	85	76	36	40	62
	62	74	57	99	79	68	53	56	47

a. Write an appropriate statistical model for this experimental situation. State the model assumptions.

b. Draw an ANOVA table and perform hypothesis tests for the machine and operator effect.

c. Compute the 95% simultaneous CI for comparing Machine 2 and Machine 3 with the Tukey method.

5. A big fitness center is interested in determining whether aerobics, step, and cardio classes differ in weight reduction. Sixty overweight women are randomly allocated to the three classes, twenty women in each class. After an eight week session, the weight loss (in pounds) for each woman is recorded. The sum of squares of the observations is 7626.3. The mean weight losses are 10.5, 12.2, and 5.6, respectively.

a. Which design is appropriate for this experiment? Write down the model and state the model assumptions.

b. Estimate all the parameters in the model.

c. Conduct the analysis. What is your conclusion?

d. Use Duncan's procedure to compare pairs of treatment means.

6. An instructor wishes to test whether the way of administering a quiz affects the results. He prepares four quizzes: with open-end questions, with multiple choice questions, with computer-based open-end questions, and with compute-based multiple choice questions. The instructor suspects that time of the day may have an effect on students' performance. He decides to administer the quizzes in the morning classes, early afternoon classes, late

afternoon classes, and night classes. There are twelve sections of the same course available, so the instructor runs the design presented below and records the average scores in each section. The data are

	Time of the Day			
Type of Quiz	Morning	Early Afternoon	Late Afternoon	Night
Open-End Paper	78	58		78
Multiple-Choice Paper	67	67	82	78
Open-End Computer		74	84	
Multiple-Choice Computer	77		81	72

a. What is the type of the design the instructor runs?

b. Compute the ANOVA. Draw conclusion.

c. Could the instructor use a fewer number of classes? What is the minimum number of classes the instructor could use?

7. A food company is interested in finding out whether there is a difference in demand between the type of container (glass or plastic), and type of product (jam or preserve). The company manufactures 100 boxes for each treatment combination and records the percentage sold to wholesale buyers within one week. The experiment is repeated two times. The data are

	Type of Product	
Type of Container	Jam	Preserve
Glass	90	78
	95	84
Plastic	85	92
	76	97

a. Do the analysis. What is your conclusion?

b. Which factor combination would you recommend to the company?

c. Think of another factor the company might incorporate into the experiment. Which design would be used for the experiment then?

8. Rats were given one of three different diets at random, and the response measure was liver weight as a percentage of body weight. The response were

Treatment		
1	2	3
3.47	3.54	3.74
3.73	3.52	3.83
3.38	3.61	3.87
3.51		4.31

3.64

a. Write an appropriate statistical model with all specifications.

b. Provide point estimates of all the parameters in the model.

c. Compute an ANOVA table and do the analysis.

d. Give confidence intervals for all pairwise comparisons between the treatment means; use the Tukey procedure and a 90% family confidence coefficient. Interpret your results