

STATISTICS 402 - Assignment 9
Due April 17, 2009

1. You are asked to help design an experiment involving the effect of exam aids on the performance of students on the second exam in an introductory statistics course. The four treatments are (1) no exam aids, (2) calculator only, (3) formula sheet only and (4) calculator and formula sheet. An additional factor (individual versus group work in recitation) is also of interest. For this experiment, 200 students in a large lecture introductory statistics course have agreed to participate. The students are divided, at random, into 10 recitation sections of 20 students each. Half of the recitation sections, selected at random, will do individual work on problems similar to the ones that will appear on the exam. The other half of the recitation sections will work in small groups on problems similar to the ones that will appear on the exam. Each recitation section will be divided, at random, into 4 groups of 5 students for the exam. Within each recitation section the groups will be randomly assigned to the four treatments: (1) no exam aids, (2) calculator only, (3) formula sheet only and (4) calculator and formula sheet for the exam. Exam score will be the response.
 - a. Explain why this is a split plot/repeated measures design. In this explanation be sure to address the following:
 - i. What are the “whole plots”?
 - ii. What is the “whole plot,” between subjects, factor?
 - iii. What are the “sub plots”?
 - iv. What is the “sub plot,” within subjects factor?
 - b. Construct a partial ANOVA table indicating sources of variation and degrees of freedom. Also indicate how to construct the appropriate F tests for determining the statistical significance of the model effects.
 - c. In this experiment, we have not accounted for individual differences in students’ aptitude for statistics, study and exam taking skills. Where does this variability in students end up in the ANOVA table? Explain briefly.
2. In order to increase the strength, refine the grain and homogenize the structure of steel, steel is heated above a critical temperature, quenched in water and then air-cooled. An experiment is performed to determine the effect of temperature and heat treatment time on the strength of steel. Two temperatures and three times are selected. The experiment is performed by heating the oven to a randomly selected temperature and inserting 3 specimens. After 10 minutes one specimen is chosen at random and removed, after another 10 minutes a second specimen is chosen at random and removed, and after another 10 minutes the third specimen is removed. Then the temperature is reset and the process is repeated. Each temperature is replicated 4 times in a completely random order.

On the next page are the data arising from this split plot (repeated measures) design. The run gives the randomized order of the temperature settings.

Temperature				Temperature			
1500° F				1600° F			
Time				Time			
Run	10 min	20 min	30 min	Run	10 min	20 min	30 min
3	52	56	61	7	89	91	62
8	50	52	59	2	72	80	69
1	58	64	71	4	73	81	69
6	48	54	59	5	88	92	64

- What is the response?
- What are the experimental units?
- What is the whole plot, between subjects, factor?
- What is the sub plot, within subjects, factor?
- Use the computer program of your choice to analyze these data keeping in mind that this is a split plot (repeated measures) design. Be sure to include plots of main effects and an interaction plot as well as an analysis of the distribution of residuals. Turn in the computer output with your assignment.
- Are the two temperatures significantly different in terms of mean strength? Report the appropriate F- and P- values to support your answer.
- Are there significant differences among the times? Report the appropriate F- and P-values to support your answer.
- Compute the LSD for comparing mean strengths for the three times. What, if any, times have statistically significant differences?
- Is there a statistically significant linear relationship between time and strength? Support your answer with an appropriate linear contrast and test of hypothesis.
- Comment on the interaction plot. Be sure to tell me what you see (be specific) and what this means.
- Is there a statistically significant interaction between time and temperature? Report the appropriate F- and P-values to support your answer.
- Comment on the distribution of residuals. Tell me what you see in the various plots (Normal quantile plot, box plot and histogram) and indicate what this tells you about the condition of normally distributed errors.