

STATISTICS 402 - Assignment 6
Due February 23, 2009

1. An engineer wishes to design a battery that will function for a long time in a variety of temperatures. The engineer has three different plate materials to use in building the battery. Once the battery goes into production and is shipped to customers, the engineer has no control over the temperatures that the battery may be exposed to. However, the engineer can manipulate the temperature in the laboratory for testing the lifetime of prototype batteries. To test the lifetime, a battery is placed in a chamber where the temperature is maintained at a specified level. The battery is hooked to a circuit that has a voltage meter and a timer. When the voltage drops below a specified threshold the timer stops giving you the lifetime of the battery in hours. The engineer builds prototype batteries with each of the three types of plate material. All other components of the batteries e.g. casings, terminals, design, etc. are the same. Batteries are tested at three temperature levels: -10 C , 20 C , and 50 C . Several batteries will be tested at each combination of temperature and plate material. The testing of the batteries will be done in a completely randomized order.
 - a) Identify the response, conditions and experimental units.
 - b) Give an example of an outside variable that is controlled in the study. How is it controlled?
 - c) How many treatment combinations are there? List all the treatment combinations.
 - d) If the experimenter wishes to detect a difference in means for the three different plate materials as small as 1.0 standard deviations with $\text{Alpha}=0.05$ and $\text{Beta}=0.10$, how many batteries are needed?
 - e) With the number of batteries you found in d), how small a difference in means for the treatment combinations of plate material and temperature can be found with $\text{Alpha}=0.05$ and $\text{Beta}=0.10$?
 - f) The engineer comes to you for advice on randomization. She explains she can only afford to build and test 3 batteries for each combination of plate material and temperature. Explain to the experimenter how to use complete randomization to build and test the batteries. Do the randomization and turn in the randomized order.

2. The experiment described in problem 1 is run. The data are available on the course web site in the file BatteryLife.JMP. Download this file and use JMP to help with the analysis of the data.
 - a) Analyze and comment on the distribution of battery life.
 - b) Fit a model that includes Plate Material, Temperature and Plate*Temp interaction effects. Give the value of R^2 and the value of the estimate of the error standard deviation, σ .
 - c) Test the hypothesis that there are no differences among the population treatment means. Be sure to include the F statistic, P-value, decision, reason for the decision and a conclusion.

- d) Test the hypothesis that the plate material effects are all zero. Be sure to include the F statistic, P-value, decision, reason for the decision and a conclusion.
- e) Where are the statistically significant differences among the plate material means? Use the LSD (Student's t) multiple comparisons procedure.
- f) Test the hypothesis that the temperature effects are all zero. Be sure to include the F statistic, P-value, decision, reason for the decision and a conclusion.
- g) Where are the statistically significant differences among the means for the different temperatures? Use the HSD (Tukey-Kramer) multiple comparisons procedure.
- h) Is a linear contrast on temperature statistically significant? If it is, what does this indicate?
- i) Test the hypothesis that the interaction effects are all zero. Be sure to include the F statistic, P-value, decision, reason for the decision and a conclusion.
- j) Construct and comment on the interaction plot.
- k) Construct plots of residuals versus plate material and residuals versus temperature in the experiment. Comment on the plots.
- l) Analyze the distribution of residuals. Comment on what the analysis of residuals says about the conditions necessary for statistical analysis.

Remember to turn in copies of your JMP output with your assignment.