1. In order to increase the yield strength of steel, steel bars are heated to a critical temperature in an oven for a specified amount of time, quenched in water and then cooled in the air. The strength of the bar is then measured by subjecting it to testing that destroys the bar. An experiment is performed to determine the effect of different factors on the strength of steel. One factor is the temperature of the oven which has two levels 1500 and 1600 degrees C. The second is the time the steel bar is heated at that temperature, which has three levels 10 minutes, 20 minutes and 30 minutes.

a) What are the response, conditions and experimental material?
b) How many treatment combinations are there?
c) If we have 4 replications of each treatment combination in a completely randomized design, what is the size of the difference in temperature level means that can be detected with Alpha = 0.05 and Beta = 0.05?
d) If we have 4 replications of each treatment combination in a completely randomized design, what is the size of the difference in heating time means that can be detected with Alpha = 0.05 and Beta = 0.05?

e) For a completely randomized design the treatments will be assigned at random to the bars. How long will it take to run the experiment as a completely randomized design?
f) If you are going to do a randomized complete block design why can’t you form blocks by reusing?
g) You can use a randomized complete block design by sorting the steel bars according to their initial strength (measured non-destructively). Give a partial analysis of variance table for a randomized complete block design using four blocks.
h) Using a randomized complete block design will not reduce the time it takes to run the experiment because one steel bar at a time is heated at the assigned temperature for the assigned time. To reduce the time it takes to run the experiment three steel bars are heated in the oven at a randomly assigned temperature, one bar, chosen at random, is removed after 10 minutes; a second bar, chosen at random, is removed after 20 minutes and the third bar is removed after 30 minutes. Explain why this is split plot (repeated measures) design. In your explanation, you must answer the following questions. Assume you have 24 steel bars to use in the experiment.
   i. What are the “whole plots”?
   ii. What is the “whole plot” factor?
   iii. How will random assignment be used for the whole plot factor? Be specific.
   iv. What are the “sub plots”?
   v. What is the “sub plot” factor?
   vi. How will random assignment be used for the sub plot factor? Be specific.
i) 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.
A psychology experiment is conducted on the effects of anxiety and muscular tension on four different types of memory. There are 4 treatments (A, B, C, and D) with different degrees of anxiety and muscular tension. Twelve students are chosen at random from all students at a large university who have given their consent to participate in psychology experiments. Treatments are assigned at random to the students. Three students are assigned A, three students are assigned B, three students are assigned C and three students are assigned D. Each student performs four types of memory trials in random order. The random order is different for each student. For each memory trial the number of memory errors is recorded for each student.

a) What is the response?
b) What are the experimental units?
c) What is the whole plot?
d) What is the whole plot, between subjects, factor?
e) What is the sub plot?
f) What is the sub plot, within subjects, factor?
g) A JMP data table is posted on the course web site. Use JMP 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. Turn in the computer output with your assignment.
h) Are there some treatment effects that are different from zero? Report the appropriate F- and P-values to support your answer.
i) Compute the HSD for comparing treatment means. Use the HSD to see which treatments means are statistically different from other treatment means?
j) Are there some memory trial effects that are different from zero? Report the appropriate F- and P-values to support your answer.
k) Compute the HSD for comparing memory trial means. Use the HSD to see which memory trial means are statistically different from other memory trial means?
l) Is there a statistically significant interaction between treatment and memory trial? Report the appropriate F- and P-values to support your answer.
m) Comment on the residuals given on the next page. Remember that there are two sets of residuals; one set for the whole plot and one set for the subplot. Tell me what you see in the various plots (residuals vs. factor levels, Normal quantile plot, box plot and histogram) and indicate what this tells you about the Fisher condition equal standard deviations and normally distributed errors.
Memory Errors for Different Treatments and Memory Trials

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<tr>
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Whole Plot Residuals

Subplot Residuals