STATISTICS 642 - ASSIGNMENT 7

DUE DATE: 8 am central, THURSDAY, March 31, 2022

Name (**Typed**) _____

Email Address (**Typed**) _____

Make this cover sheet the first page of your Solutions.

STATISTICS 642 - ASSIGNMENT #7

- Due 8 am central, THURSDAY, March 31, 2022
- Read Handouts 7 and 8
- Supplemental Reading: Chapters 6 & 7 in the Design& ANOVA Book
- **Submit for grading the following problems:**

1. (30 points) A study was conducted to investigate the effect of nitrogen fertility on nitrogen fixation by *Rhizobium* bacteria. The study included four crops: alfalfa, soybeans, guar, and mungbean. Twelve plants of each crop were inoculated with the *Rhizobium* bacteria and grown in a growth chamber with one of three amounts of nitrogen in the growth media: 0, 50, or 100 ppm N. Four growth chambers were randomly assigned to each of the 12 combinations of crop and and amount of nitrogen. The acetylene reduction was measured when the plants were at the flowering stage. Acetylene reduction reflects the amount of nitrogen that is fixed by the bacteria in the symbiotic relationship with the plant.

	Type of Crop			
Nitrogen	Alfalfa	Soybean	Guar	Mungbean
0	2.6, 1.1	6.5, 2.6	0.5, 0.9	0.8, 0.9
	0.9, 1.2	3.9, 4.3	0.7, 0.7	2.2, 1.2
50	1.5, 1.8	0.6, 0.6	0.3, 0.5	0.7, 0.7
	0.7, 2.2	0.3, 0.8	0.4, 0.4	0.5, 0.6
100	0.6, 1.3	0.5, 0.1	0.2, 0.1	0.3, 0.4
	1.9, 2.6	0.1, 0.3	0.1, 0.2	0.2, 0.2

- The SAS program ASSIGN7_P1_SP2022.sas has been placed in the HomeworkAssignments folder for use in answering the following questions:

a. Write a linear model (effects model) for this experiment. Make sure to identify terms in your model.

b. Do the three model conditions appear to be satisfied as seen through the data?

c. Construct a complete ANOVA table for the data.

d. Test all appropriate hypotheses about main effects and interactions between type of crop and amount of nitrogen.

e. Construct a profile plot of the treatment means to illustrate your conclusions from part (d.).

f. Group the four crops relative to their mean acetylene reduction.

2. (40 points) A manufacturer of fabric used in protective clothing designs an experiment to evaluate the durability of coated fabric. The fabric will be subjected to standard abrasive testing. The manufacturer wants to determine the effect of three factors on the durability of the fabric: Factor 1: two types of Filler ($F_1,\ F_2$), Factor 2: three Proportions of the filler (P = 25%, 50%, 75%), and Factor 3: two types of Surface treatment ($S_1,\ S_2$). Four replicate fabric specimens were tested for each of the 12 treatment combinations in a CRD. The data are the weight loss (mg) of the fabric specimens during the abrasion test.

Surface	Filler	Proportion	Weight Loss (mg)			
S1	F1	25	194	208	197	205
S1	F1	50	233	241	235	239
S1	F1	75	260	279	266	270
S1	F2	25	229	197	200	212
S1	F2	50	224	243	228	235
S1	F2	75	249	232	236	245
S2	F1	25	155	173	160	168
S2	F1	50	198	177	185	192
S2	F1	75	235	219	230	225
S2	F2	25	137	160	142	155
S2	F2	50	184	163	175	177
S2	F2	75	212	189	195	204

- The SAS program ASSIGN7__P2__SP2022.sas has been placed in the HomeworkAssignments folder for use in answering the following questions:

a. Write a linear model for the experiment and explain all terms in your model, including any constraints.

b. Check for any violations in your model conditions.

c. Display the AOV table.

d. Prepare a table of the least square estimates of cell and marginal means with their respective standard errors.

e. Is there a significant difference in the mean weight loss of the two types of Filler?

f. Is there a significant difference in the mean weight loss of the three Proportions of Filler?

g. Are there any trends in the mean weight loss as the proportion of filler increases.

h. Provide all relevant profile plots.

3. (10 points) For each of the following questions, select **ONE** letter from the list at the bottom of the page which is the **BEST** solution to each of the following situations.

   a. In an experiment having the levels of factor F_1-qualitative and the levels of factor F_2-quantitative, the $F_1 * F_2$ interaction was found to be significant. The experimenter wants to compare the mean responses across the levels of factor F_1, averaged over the levels of factor F_2.

   b. In an experiment having factors F_1 - quantitative and F_2 - qualitative, the $F_1 * F_2$ interaction was found to be significant. The experimenter wants to determine if there is an increasing relationship in the mean responses across the levels of factor F_1 at each level of factor F_2.

4. (12 points) A CRD factorial experiment involving three factors (F_1, F_2, F_3) was conducted. The experimenter ran the F-tests from the AOV table and then wanted to further investigate the relationships between the factors. For each of the following questions, select **ONE** letter from the list at the bottom of the page which is the **BEST** solution to each of the following situations.

   a. $F_1 * F_2 * F_3$ was not significant and $F_1 * F_3$, $F_2 * F_3$, F_2, F_3 were significant, but $F_1 * F_2$ was not significant. The experimenter wants to compare the levels of factor F_1, a quantitative factor.

   b. $F_1 * F_2 * F_3$ was significant, $F_1 * F_3$, $F_1 * F_2$ were not significant, but $F_2 * F_3$, F_1, F_2,and F_3 were significant. (levels of F_2, F_3 are qualitative, levels of F_1 is quantitative). The experimenter wants to evaluate trends in the levels of factor F_1.

   c. $F_1 * F_2 * F_3$ was not significant and $F_1 * F_3$, $F_2 * F_3$, $F_1 * F_2$ were significant, but F_1, F_2, F_3 were not significant. The experimenter wants to compare the levels of factor F_1 to a control treatment.

   d. $F_1 * F_2 * F_3$, $F_1 * F_2$, $F_1 * F_3$, and $F_2 * F_3$ were significant, but F_1, F_2, F_3 were not significant. The levels of F_2, F_3 are qualitative, levels of F_1 are quantitative. The experimenter wants to determine the level of factor F_1 which yields the smallest treatment mean.

TECHNIQUE:

A. Trend analysis in the levels of F_1 averaged over levels of both F_2 and F_3
B Trend analysis in the levels of F_1 separately at each level of F_2
C. Trend analysis in the levels of F_1 separately at each level of F_3
D. Trend analysis in the levels of F_1 at each combination of (F_2, F_3)
E. Dunnett's comparison technique applied to the levels of factor F_1 separately at each combination of $(F_2,\ F_3)$
F. Dunnett's comparison technique applied to the levels of factor F_1 averaged over the levels of $(F_2,\ F_3)$
G. Dunnett's comparison technique applied to the levels of factor F_1 separately at each level of F_2
H. Dunnett's comparison technique applied to the levels of factor F_1 separately at each level of F_3
I. Tukey's comparison technique applied to the levels of factor F_1 separately at each combination of $(F_2,\ F_3)$
J. Tukey's comparison technique applied to the levels of factor F_1 separately at each level of F_2
K. Tukey's comparison technique applied to the levels of factor F_1 separately at each level of F_3
L. Tukey's comparison technique applied to the levels of factor F_1 averaged over the levels of $(F_2,\ F_3)$
M. Hsu's comparison technique applied to the levels of factor F_1 averaged over the levels of $(F_2,\ F_3)$
N. Hsu's comparison technique applied to the levels of factor F_1 separately at each level of F_2
O. Hsu's comparison technique applied to the levels of factor F_1 separately at each level of F_3
P. Hsu's comparison technique applied toto the levels of factor F_1 separately at each combination of $(F_2,\ F_3)$
Q. Nothing new is learned beyond the results of the F-tests from the AOV table.
R. Comparison of marginal means is not appropriate.
S. None of the above methods are appropriate.

Problem 5. (8 points)

1. Provide a short but precise answer, **(Do Not Exceed 25 words/question.)** to the following: A study was conducted to investigate the effect of nitrogen fertility on nitrogen fixation by *Rhizobium* bacteria. The study included four crops: alfalfa, soybeans, guar, and mungbean. Two plants of each crop were inoculated with the *Rhizobium* bacteria and grown in a growth chamber with one of three amounts of nitrogen in the growth media: 0, 50, or 100 ppm N. Four growth chambers were randomly assigned to each of the 12 combinations of crop and and amount of nitrogen. The acetylene reduction was measured when the plants were at the flowering stage. Acetylene reduction reflects the amount of nitrogen that is fixed by the bacteria in the symbiotic relationship with the plant. The researcher evaluates the experiment as a CRD with a 4×3 factorial treatment structure with $r = 4$ reps per treatment. Describe any problems with the analysis or do you think the analysis is correct? Explain your answer.

2. A researcher wants to design a balanced experiment with r replications of two factors, F_1 at 5 fixed levels and F_2 at 2 fixed levels. What is the smallest value of r which would yield an F test of the main effect of factor F_1 with $\alpha = .05$ and power 0.80 to detect a difference of at least 6 units between any pair of factor F_1 means if the variance σ_e^2 is approximately 6.5.

   You do not need to justify your answers in the following two questions, just circle the best answer.

3. In a CRD with a quantitative factor F_1 at 4 levels and a qualitative factor F_2 at 2 levels, the researcher wants to know if there is a linear trend in the mean responses across the levels of F_1. The AOV table reveals a non-significant $F_1 * F_2$ interaction. Which of the following contrasts would address this question?

   A. $L = \mu_{11} + \mu_{21} + \mu_{31} + \mu_{41} - \mu_{12} - \mu_{22} - \mu_{32} - \mu_{42}$
   B. $L = \mu_{11} - \mu_{21} - \mu_{31} + \mu_{41} - \mu_{12} + \mu_{22} + \mu_{32} - \mu_{42}$
   C. $L = 3\mu_{11} + \mu_{21} - \mu_{31} - 3\mu_{41} - 3\mu_{12} - \mu_{22} + \mu_{32} + 3\mu_{42}$
   D. $L = -3\mu_{11} - \mu_{21} + \mu_{31} + 3\mu_{41} - 3\mu_{12} - \mu_{22} + \mu_{32} + 3\mu_{42}$
   E. none of the above

4. In a CRD with a qualitative factor A at 2 levels and a quantitative factor B at 3 levels, the researcher wants to know if the quadratic trend in the mean responses across the levels of factor B differ for the two levels of factor (A). Which of the following contrasts would address this question?

   A. $L = \mu_{31} - 2\mu_{32} + \mu_{33} + \mu_{21} - 2\mu_{22} + \mu_{23}$
   B. $L = \mu_{11} - 2\mu_{12} + \mu_{13} - \mu_{21} + 2\mu_{22} - \mu_{23}$
   C. $L = \mu_{11} - \mu_{12} - \mu_{13} - \mu_{21} + \mu_{22} + \mu_{23}$
   D. $L = \mu_{11} - \mu_{13} - \mu_{21} + \mu_{23}$
   E. None of the above would appropriate because Factor A has only 2 levels.