Homework Assignment#3

1. **(Page 294, Q-10)** A manufacturer of concrete bridge supports is interested in determining the effect of varying the sand content of concrete on the strength of the supports. Five supports are made for each of five different amounts of sand in the concrete mix and each support tested for compression resistance. The results are as shown in the following table.

Percent Sand	Compression Resistance (10,000 psi)				
15	7	7	10	15	9
20	17	12	11	18	19
25	14	18	18	19	19
30	20	24	22	19	23
35	7	10	11	15	11

   a. Perform the analysis to determine whether there is an effect due to changing the sand content.
   b. Prior to the experiment, the researchers planned to compare the average of the means in the groups (20, 25, 30) with the mean in the "low sand" group (15), and with the mean in the "high sand" group (35). Test these two contrasts separately.

Solution:

a.

CODE:

```
TITLE 'CONCRETE';
DATA PS;
INPUT PS $ CR @@;
DATALINES;
15 7 15 7 15 10 15 15 15 9
20 17 20 12 20 11 20 18 20 19
25 14 25 18 25 18 25 19 25 19
30 20 30 24 30 22 30 19 30 23
35 7 35 10 35 11 35 15 35 11
;

PROC GLM DATA = PS;
CLASS PS;
MODEL CR = PS;
LSMEANS PS/CL;
RUN;
```

NULL HYPOTHESIS: H0 : mu15 = mu20 = mu25 = mu30 = mu35
ALTERNATIVE HYPOTHESIS: H1: At least one mean is not equal to another

OUTPUT:

CONCRETE

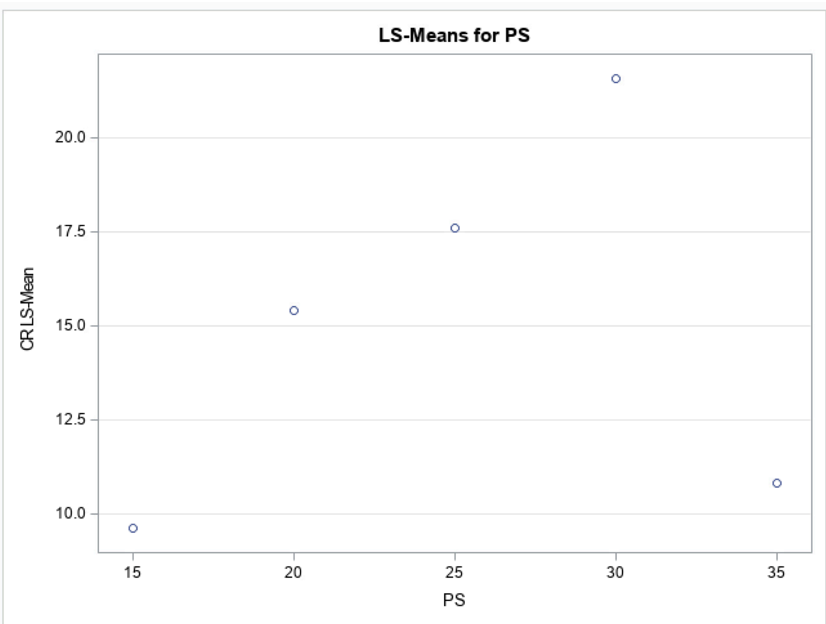
The GLM Procedure

Dependent Variable: CR

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	486.4000000	121.6000000	14.87	<.0001
Error	20	163.6000000	8.1800000		
Corrected Total	24	650.0000000			

Here, we can see that P value is less than level of significance alpha=0.05. Hence we reject the null hypothesis.
Therefore, we can say that the strength is not same for all the amount of sand in the concrete mix

b.



When we compare means of (20,25,30) with mean 15, we can say it has a linear contrast from the plot, But When we compare means of (20,25,30) with mean 35, we can say it has a cubic contrast

2. A study was conducted to compare the effect of four manganese rates (from $MnSO_4$) and four copper rates (from $CuSO_4\ 5H_2O$) on the yield of soybeans. A large field was subdivided into 32 separate plots. Two plots were randomly assigned to each of the 16 factor–level combinations (treatments) and the treatments were applied to the designated plot. Soybeans were then planted over the entire field in rows 3 feet apart. The yields from the 32 plots are given here (in kilograms/hectare).

	Mn			
Cu	20	50	80	110
1	1,558 1,578	2,003 2,033	2,490 2,470	2,830 2,810
3	1,590 1,610	2,020 2,051	2,620 2,632	2,860 2,841
5	1,558 1,550	2,003 2,010	2,490 2,690	2,830 2,910
7	1,328 1,427	2,010 2,031	2,887 2,832	2,960 2,941

a. Identify the design for this experiment.
b. Write an appropriate statistical model for this experiment.
c. Construct a profile plot and describe what this plot says about the effect of Mn and Cu on soybean yield.
d. Using a proper analysis, test for an interaction between the effect of Mn and Cu on soybean yield. Use $\alpha = 0.05$.

e. What level of Mn appears to produce the highest yield?

f. What combination of Cu-Mn appears to produce the highest yield?

Solution:

a. Manganese and copper both rates are at four levels. Hence there are 16 treatments. And for each treatment there are two replications. The design is complete randomised by a 4X4 factorial experiment
b. CODE:

```
5 110 2830
5 110 2910
7 20 1328
7 20 1427
7 50 2010
7 50 2031
7 80 2887
7 80 2832
7 110 2960
7 110 2941
;
run;
proc GLM data = Anagave;
class CU MN;
model Val = CU MN CU*MN;
LSMEANS CU MN CU*MN/CL;
run;
```

```
3 110 2841
5 20 1558
5 20 1550
5 50 2003
5 50 2010
5 80 2490
5 80 2690
5 110 2830
5 110 2910
7 20 1328
7 20 1427
7 50 2010
7 50 2031
7 80 2887
7 80 2832
7 110 2960
7 110 2941
.
```

METALS

The GLM Procedure

Dependent Variable: Val

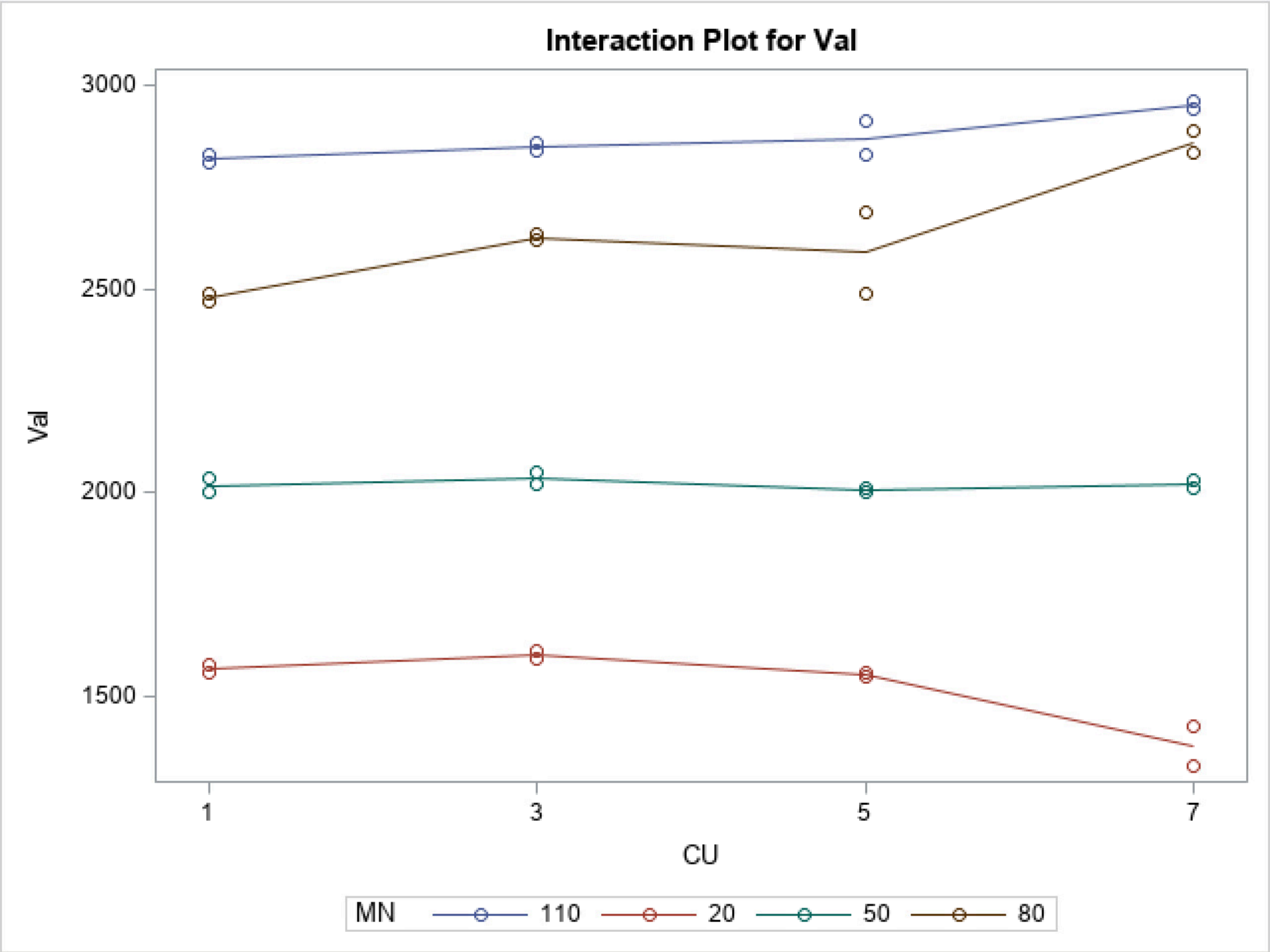
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	15	9167706.719	611180.448	305.08	<.0001
Error	16	32053.500	2003.344		
Corrected Total	31	9199760.219			

R-Square	Coeff Var	Root MSE	Val Mean
0.996516	1.976839	44.75873	2264.156

Source	DF	Type I SS	Mean Square	F Value	Pr > F
CU	3	28199.344	9399.781	4.69	0.0155
MN	3	8935108.094	2978369.365	1486.70	<.0001
CU*MN	9	204399.281	22711.031	11.34	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
CU	3	28199.344	9399.781	4.69	0.0155
MN	3	8935108.094	2978369.365	1486.70	<.0001
CU*MN	9	204399.281	22711.031	11.34	<.0001

c.



The profile plot says that there is a clear differences in the mean of yield of soybean between the four MN rates is different across the four rates of CU.

Hence, We can conclude that interaction between MN and CU rates is significant

d. From the above analysis in b. Output, we can see that p value is less than level of significance so there is a significant effect of MN and CU on the soybean field

e. From the given data, the mean for MN is highest at 2,872.8 at MN rate is 110
Hence, MN = 110 appears to produce highest yield

f. From the given data, the mean yield for interaction of MN and CU is highest at 2,960 when MN is at 110 and Cu is at 7
Hence, The combination MN=110 and CU =7 appears to produce highest yield

3. The percent of coarse material in a concrete mix affects its strength as well as surface texture. The data in the table below are collected from an experiment in which the percent of coarse material is the treatment. One of the surface measures on the cast samples is shown in the data table below.

Percent of Coarse Material

10	15	20	25	30	35
75.1812	81.1239	68.4632	80.8145	92.9998	88.2814
74.9768	89.1028	87.3696	77.4699	87.8600	95.0287
80.8406	83.9878	78.0501	89.7534	84.8251	88.9217
83.9138	81.3299	86.3880	87.9809	82.3168	89.8271
74.3493	75.7019	83.0716	82.4643	83.1374	82.0296
74.0673	78.7711	84.5145	82.6726	84.7963	79.8002
71.4454	77.6734	76.6751	86.7448	87.3592	79.8198
84.7586	77.0928	86.3444	84.3853	98.8903	95.7426

Use SAS to analyze this data and answer the following questions.

a. Conduct an ANOVA for these data.

b. Separate the treatment levels means using Tukey methods and $\alpha = 0.01$. Illustrate your findings in a summary plot.

c. Test the following research question: Is there a difference in mean surface texture when the percent of coarse material is in excess of 20?

d. Using $\alpha = 0.01$, write a brief but well written paragraph of your conclusions. As always, cite the test statistic and observed significance level where necessary. Include a table with the illustration requested in part b. Following your complete conclusions, include the final copy of your final SAS program, copy and paste the final log after the program, and finally copy and paste the final version of the Results Viewer. All of this will be assembled in a single document (MS Word or equivalent). Upload this document to Canvas by the due date indicated.

CODE:

```
TITLE 'percent of coarse materials';
  DATA Table;
  INPUT percent measure @@;
  DATALINES;
10 75.1812
10 74.9768
10 80.8406
10 83.9138
10 74.3493
10 74.0673
10 71.4454
10 84.7586
15 81.1239
15 89.1028
15 83.9878
15 81.3299
15 75.7019
15 78.7711
15 77.6734
15 77.0928
20 68.4632
20 87.3696
20 78.0501
20 86.388
20 83.0716
20 84.5145
20 76.6751
20 86.3444
25 80.8145
25 77.4699
25 89.7534
25 87.9809
25 82.4643
25 82.6726
25 86.7448
25 84.3853
30 92.9998
30 87.86
30 84.8251
30 82.3168
30 83.1374
30 84.7963
30 87.3592
30 98.8903
35 88.2814
35 95.0287
35 88.9217
35 89.8271
35 82.0296
35 79.8002
35 79.8198
35 95.7426
 PROC GLM DATA=Table;
    CLASS percent;
```

```
  MODEL measure = percent;
  LSMEANS percent /adjust = Tukey alpha = 0.01 linestable;
RUN;
```

a.

The GLM Procedure

Dependent Variable: measure

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	662.246260	132.449252	4.56	0.0021
Error	42	1220.466664	29.058730		
Corrected Total	47	1882.712924			

R-Square	Coeff Var	Root MSE	measure Mean
0.351751	6.486389	5.390615	83.10656

Source	DF	Type I SS	Mean Square	F Value	Pr > F
percent	5	662.2462597	132.4492519	4.56	0.0021

Source	DF	Type III SS	Mean Square	F Value	Pr > F
percent	5	662.2462597	132.4492519	4.56	0.0021

b.

Tukey Grouping for LS-Means of percent				
LS-means with the same letter are not significantly different.				
		measure LSMEAN	percent	LSMEAN Number
	A	87.77311	30	5
	A			
	A	87.43139	35	6
	A			
B	A	84.03571	25	4
B	A			
B	A	81.35956	20	3
B	A			
B	A	80.59795	15	2
B				
B		77.44163	10	1

c. No, there is no difference in mean surface texture when the percent of coarse material is in excess of 20

d. The presence of a marginally significant interaction term complicates the explanation, as it implies that the effect of a certain number depends on the measure . To proceed, we need to understand the intentions of the study.
now treating the problem as a One-way ANOVA with 6 groups, and
pairwise comparisons. Applying Tukey method to this problem gives the results summarized in the following table, we can see that they are not significantly different .

percent of coarse materials

The GLM Procedure

Class Level Information		
Class	**Levels**	**Values**
percent	6	10 15 20 25 30 35

Number of Observations Read	48
Number of Observations Used	48

percent of coarse materials

The GLM Procedure

Dependent Variable: measure

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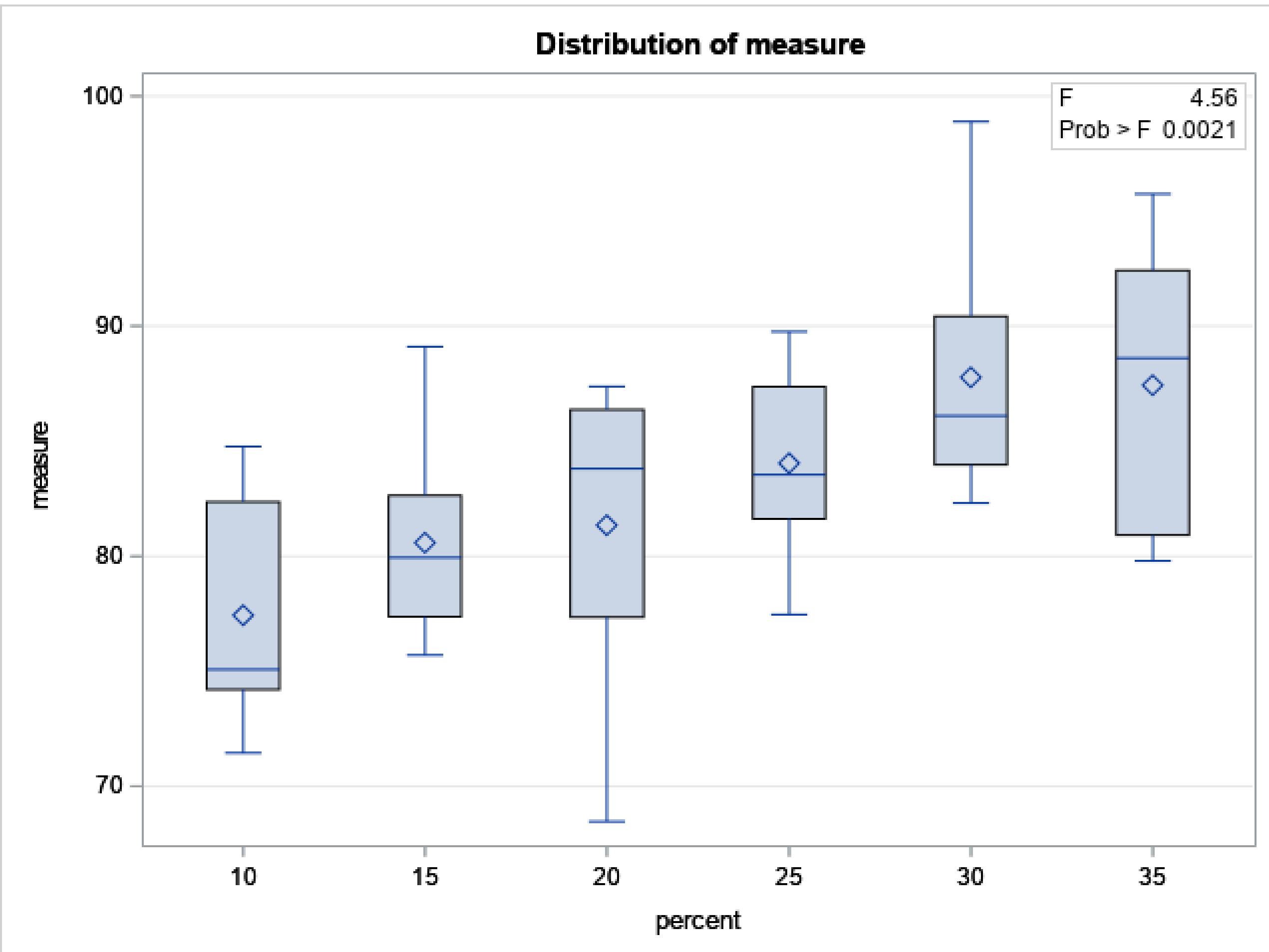


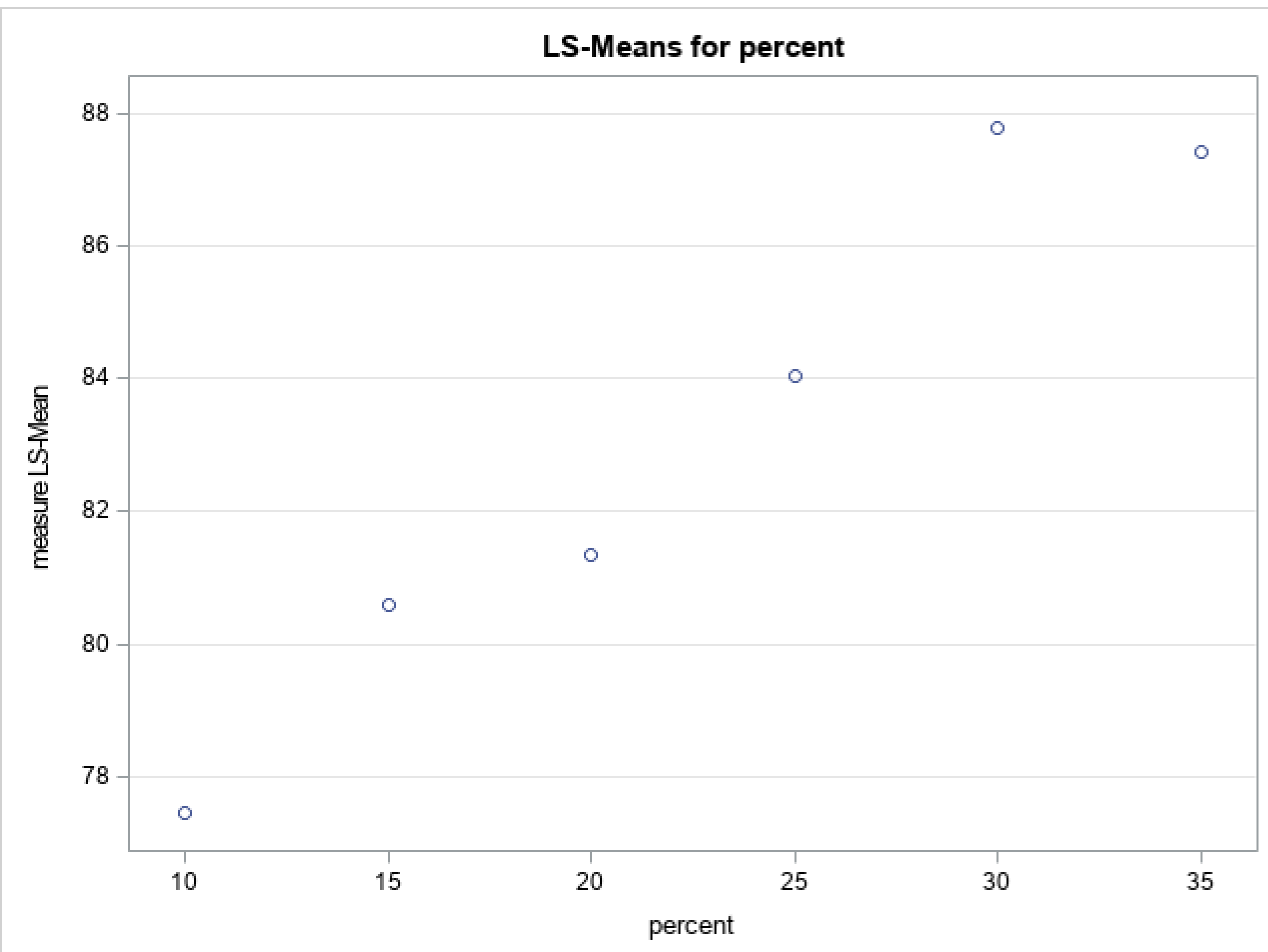
percent of coarse materials

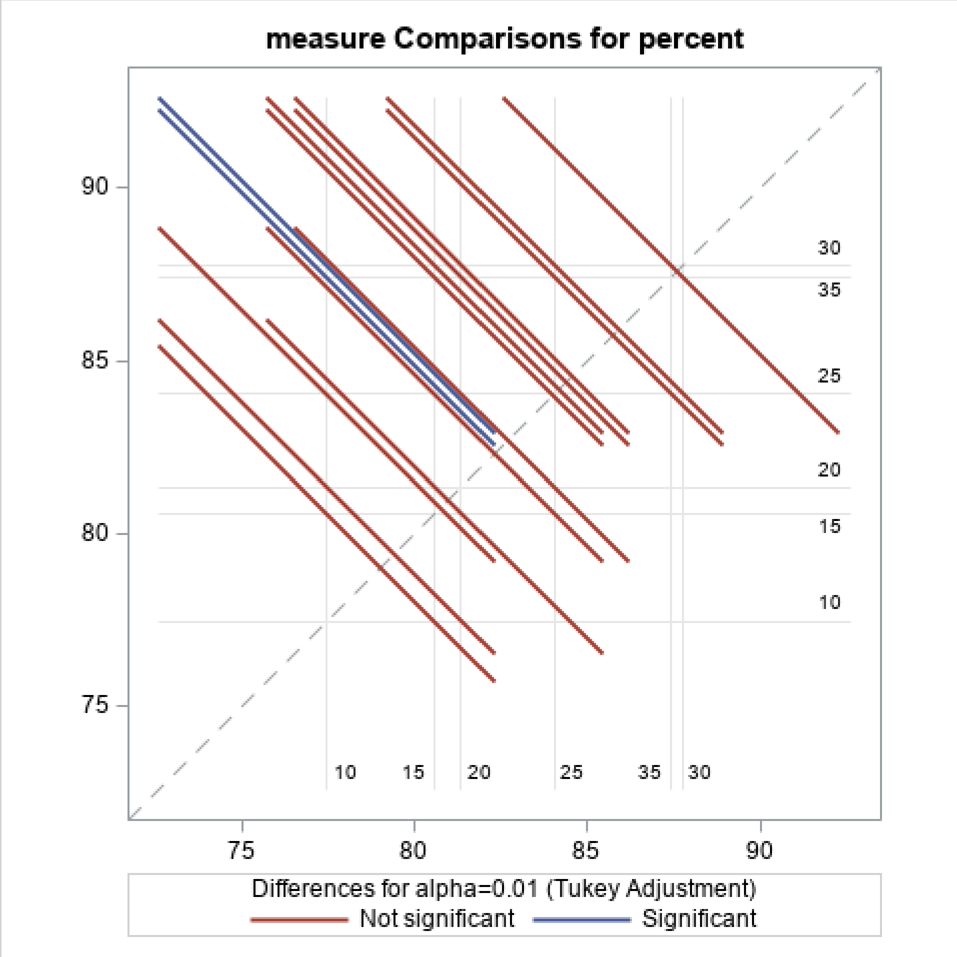
The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey

percent	measure LSMEAN	LSMEAN Number
10	77.4416250	1
15	80.5979500	2
20	81.3595625	3
25	84.0357125	4
30	87.7731125	5
35	87.4313875	6

Least Squares Means for effect percent
Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: measure

i/j	1	2	3	4	5	6
1		0.8479	0.6947	0.1640	0.0052	0.0075
2	0.8479		0.9997	0.7964	0.1049	0.1371
3	0.6947	0.9997		0.9177	0.1868	0.2363
4	0.1640	0.7964	0.9177		0.7346	0.8046
5	0.0052	0.1049	0.1868	0.7346		1.0000
6	0.0075	0.1371	0.2363	0.8046	1.0000	





Tukey Grouping for LS-Means of percent				
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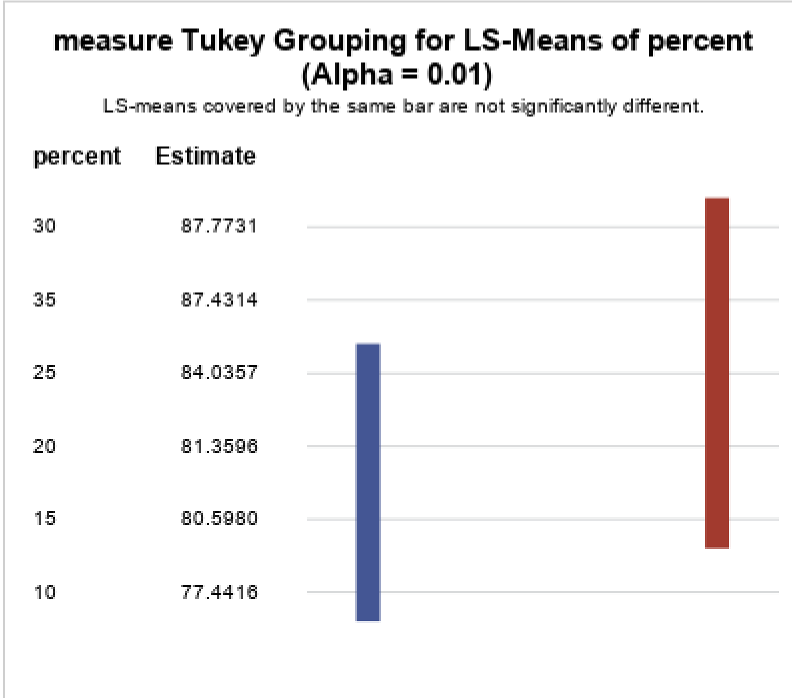
	A	87.77311	30	5
	A			
	A	87.43139	35	6
	A			
B	A	84.03571	25	4
B	A			
B	A	81.35956	20	3
B	A			
B	A	80.59795	15	2
B				
B		77.44163	10	1


measure Tukey Grouping for LS-Means of percent
(Alpha = 0.01)
LS-means covered by the same bar are not significantly different.
percent
Estimate
30
87.7731
35
87.4314
25
84.0357
20
81.3596
15
80.5980
10
77.4416