STATISTICS 642 - EXAM 2

April 6, 2020

Student's Name ____

Student's Email Address ______________________________________

INSTRUCTIONS FOR STUDENTS:

(1) The exam consists of 8 pages of questions including the title page and SAS code, 19 pages of SAS output, and 21 pages of STAT 642 Tables.

(2) You have exactly **70 minutes** to complete the exam and 20 minutes for downloading exam and uploading solutions.

(3) **Exam Period:** A period of 90 minutes Starting at 11:30 a.m. CDT April 6 and Concluding at 1:00 p.m. CDT April 6.

(4) You MUST upload your solutions to the exam by 1:00 p.m. CDT April 6.

(5) The exam will be proctored using Zoom. You will have two options for composing your solutions: you can print out the exam, put your solutions on the exam, then upload to eCampus. Alternatively, you can just write your solutions on paper, scan it into a single pdf file, then upload the pdf file to eCampus just as you would with homework solutions.

(6) Upload just your solutions, **Do Not upload the SAS Output.**

(7) Do not discuss or provide information to anyone concerning the questions on this exam or your solutions until I post the solutions to the exam.

(8) You may use the following:

- Calculator
- Summary Sheets - **6-pages,** 8.5"x11"**, (you may write/type/cut-paste anything on both sides of the six sheets**)
- The STAT 642 Exam Tables

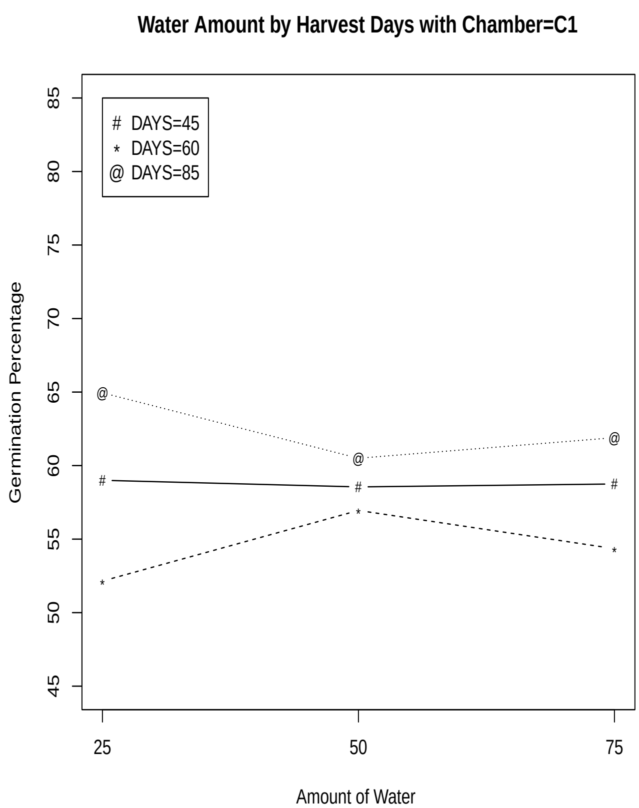
(9) Do not use any other written material except for your summary sheets and STAT 642 Exam Tables. Do not communicate with anyone during the exam. The solutions must be just your own work.

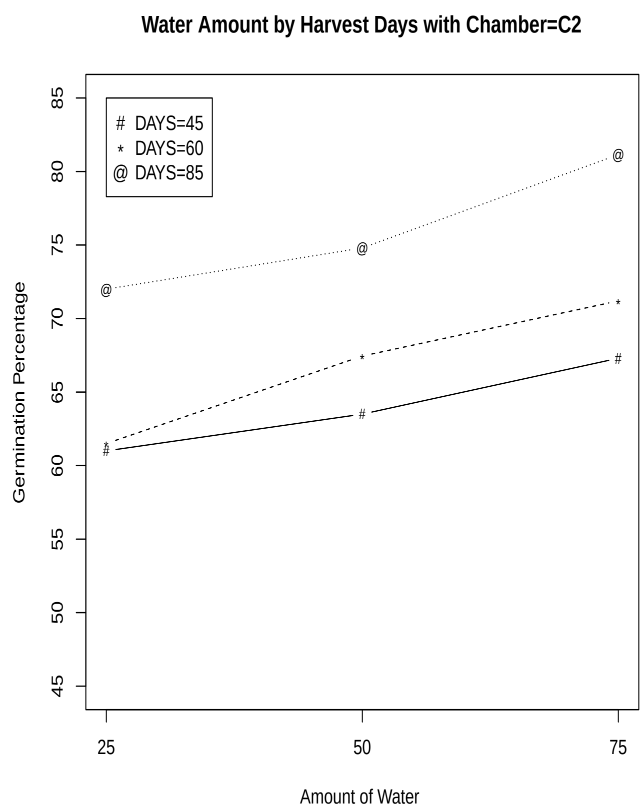
I attest that I spent no more than 70 minutes to complete the exam. I used only the materials described above. I did not receive assistance from anyone during the taking of this exam.

Student's Signature____

Problem I (64 points) Brewer's malt is produced by germinating barley, so brewers want to know what conditions are optimal for germination of their barley. Three factors were identified as possibly impacting the germination rate. The two types of growth chambers (C = C1, C2), number of days after harvest (D = 45, 60, 85), and amount of water used in germination (W = 25, 50, 75) ml of water. Barley seeds were divided into 72 lots of approximately 250 seeds. Four lots were randomly assigned to each of the 18 combinations of the three factors. The measured response is the percent of seeds that germinate. The data is given in the following table and reflects that some of the 18 treatments had less than 4 reps due to problems in one of the growth chambers.

		C1			C2		
	HarvestDays	45	60	85	45	60	85
	25	58.1, 58.9	52.2, 51.1	66.6, 64.3	60.2, 61.8	65.7, 60.3	71.1, 71.9
		59.1, 59.9	53.2, 52.1	65.6, 63.3		60.7, 59.3	72.1, 72.9
Water	50	57.8, 59.3	54.5, 58.4	61.3, 58.7	62.7, 63.3	67.5, 66.4	76.2, 72.4
		56.8, 60.3	55.5, 59.4	62.3, 59.7	63.7, 64.3	68.5, 67.4	77.2, 73.4
	75	58.8, 57.7	56.0, 51.7	60.2, 62.6	65.2, 69.4	72.1, 70.3	83.1, 80.2
		59.8, 58.7	57.0, 52.7	61.2, 63.6			82.1, 79.2





1. Based on the two plots given above and assuming the standard errors are very small, does there appear to be a three-way interaction between the three factors? Justify your answer.

Use the SAS output to answer the following questions.

2. Do the necessary conditions for testing hypotheses and constructing confidence intervals appear to be satisfied? Justify your answers.

   C_1- Normality:

   C_2- Equal Variance:

3. Group the three Harvest Days on the basis of their mean germination rate. Use $\alpha = .05$.

4. Construct a 95% confidence interval for the mean germination rate when the Water = 25 ml and the number of Harvest Days = 45

Problem II. **(36 points) Place your answer to each of the MULTIPLE CHOICE questions in the space provided. Make sure to use UPPER case letters: A, B, C, D, E and select ONLY one answer for each question.**

Name ____

(1.)__________

(2.)__________

(3.)__________

(4.)__________

(5.)__________

(6.)__________

(7.)__________

(8.)__________

(9.)__________

(1.) In a study to determine if there is a difference in the mean strength of cotton fibers produced by the thousands of fiber manufacturers located in North America, the researcher randomly selects 10 manufacturers to be included in the study. From each manufacturer, 20 samples of cotton fiber are randomly selected from their warehouse and a tensile strength measurement is determined for each sample. The researcher used Tukey's HSD procedure to determine which pairs of manufacturers had significantly different mean responses. What is a major criticism of the researcher's methodology?

A. Tukey's HSD procedure is too conservative to detect small differences in the means.
B. Tukey's HSD procedure will result in an inflated Type II error rate in the selection of pairs of differences.
C. Tukey's HSD procedure should only be used when the treatment levels have fixed effects.
D. Tukey's HSD procedure will result in an inflated Type I error rate in the selection of pairs of differences.
E. None of the above, the use of Tukey's HSD is an appropriate procedure.

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

(3.) After conducting a CRD with the factors A and B having 3 fixed levels each, the researcher conducts a residual analysis and determines there are a large number of outliers. Because a transformation of the data often leads to a situation where the conclusions are hard to interpret, the research would like you to suggest an alternative approach. Which one of the following methods would be a valid method to determine the existence of an **interaction** between the factors A and B?

A. Use the results from the ANOVA F-test because the F-test is robust to deviations from the normality condition.
B. Apply the multiple comparison procedure associated with the Kruskal-Wallis rank based procedure to the pairs of levels of factor A at each level of factor B.
C. Use the results from the transformed data because you can just invert the transformation to obtain results in the original scale.
D. Apply Tukey's HSD to the pairs of levels of factor A at each level of factor B.
E. None of the above would be valid.

(4.) A researcher is studying two Factors each having three levels. The initial design had five replications of each of the nine treatments, but because of problems that occurred during the experiment, only the following number of observations were observed for the nine treatments:

$n_{11} = 3, n_{12} = 5, n_{13} = 5, n_{21} = 4, n_{22} = 0, n_{23} = 4, n_{31} = 0, n_{32} = 3, n_{33} = 3.$

Which one of the following contrasts is an **estimable interaction** contrast?

A. $\mu_{11} - 2\mu_{12} + \mu_{13} - \mu_{21} + 2\mu_{22} - \mu_{23}$
B. $\mu_{11} - 2\mu_{12} + \mu_{13} + \mu_{31} - 2\mu_{32} + \mu_{33}$
C. $\mu_{11} - \mu_{13} - 2\mu_{21} + 2\mu_{23} + \mu_{31} - \mu_{33}$
D. $\mu_{11} - \mu_{13} - \mu_{21} + \mu_{23}$
E. None of the above contrasts are estimable.

(5.) An entomologist designs an experiment to evaluate the effectiveness of five Dose levels of a pesticide to control fire ants. She randomly selects 100 1-acre plots of land and randomly assigns 20 plots to each dose level. Next, she randomly selects 15 fire ant hills in each plot and records the weight, W, of fire ants killed after two weeks of treatment. The scientist runs the following code in SAS to analyze her data:

```
PROC GLM;

CLASS DOSE PLOT;

MODEL W = DOSE PLOT(DOSE);

RANDOM PLOT(DOSE)/TEST;

LSMEANS DOSE/PDIFF ADJUST=TUKEY;
```

She then uses the output from LSMEANS to group the five Doses according to the mean weight of fire ants killed. The conclusions reached using the SAS output will be incorrect because

A. the LS means are biased due to using the wrong df for the error term.

B. the calculation of $\widehat{SE}\,(\hat{\mu}_i)$ is incorrect, SAS only considers $\hat{\sigma}^2_{PLOT(DOSE)}$ and not $\hat{\sigma}^2_e$ in the calculation.

C. the calculation of $\widehat{SE}\,(\hat{\mu}_i)$ is incorrect, SAS only considers $\hat{\sigma}^2_e$ and not $\hat{\sigma}^2_{PLOT(DOSE)}$ in the calculation.

D. multiple comparisons should not be made because the PLOT factor has random levels.

E. There is no problem in the analysis because a Tukey adjustment was made to the p-values.

(6.) A three factor completely crossed experiment is run with Factor A-fixed levels, Factor B-fixed levels, Factor C-fixed levels. The following effects were significant: interaction between factor A and factor B, and the interaction between factor A and factor C. The following effects were not significant: main effect of A, main effect of B, main effect of C and the 3-way interaction between A, B, and C.

A. A comparison of the differences in the levels of Factor B can be conducted using Tukey's HSD on the means for the levels of Factor B averaged over the levels of Factors A and C.

B. A comparison of the differences in the levels of Factor B can be conducted using Tukey's HSD on the means for the levels of Factor B computed separately at each level of factors A and C.

C. A comparison of the differences in the levels of Factor B can be conducted using Tukey's HSD on the means for the levels of Factor B computed separately at each level of factor A.

D. A comparison of the differences in the levels of Factor B can be conducted using Tukey's HSD on the means for the levels of Factor B computed separately at each level of factor C.

E. None of the above

(7.) A Completely Randomized Design with $t = 4$ treatments, $r = 5$ reps/treatment, and $m = 7$ subsamples/rep was run. The researcher wanted to perform a multiple comparison procedure to pairwise group the 4 treatment means with an overall error rate of $\alpha_F = .05$. The form of HSD for this type of experiment is given by

A. HSD $= q(\alpha_o, t, \nu_2)\hat{\sigma}\sqrt{1/n}$ where $\alpha_o = .05$; $t = 4$; $\nu_2 = 16$; $\hat{\sigma}^2 = MS_{Rep(Trt)}$; $n = 5$

B. HSD $= q(\alpha_o, t, \nu_2)\hat{\sigma}\sqrt{1/n}$ where $\alpha_o = .05$; $t = 4$; $\nu_2 = 16$; $\hat{\sigma}^2 = MS_{Rep(Trt)}$; $n = 35$

C. HSD $= q(\alpha_o, t, \nu_2)\hat{\sigma}\sqrt{1/n}$ where $\alpha_o = .05/6$; $t = 4$; $\nu_2 = 30$; $\hat{\sigma}^2 = MS_{Sub(Rep)}$; $n = 5$

D. HSD $= q(\alpha_o, t, \nu_2)\hat{\sigma}\sqrt{1/n}$ where $\alpha_o = .05$; $t = 4$; $\nu_2 = 30$; $\hat{\sigma}^2 = MS_{Sub(Rep)}$; $n = 35$

E. Not enough information is given to answer the question

(8.) In a CRD 2×3 factorial design, the SAS output for the LSMEANS of the the Two Factors displayed the expression **NON-ESTIMABLE**. This means that the main effects of the two factors

A. have a significant interaction and hence we should not estimate main effects.

B. cannot be unbiasedly estimated using a linear combination of the data values.

C. have REML estimates but cannot be obtained in a finite number of iterations.

D. are confounded and hence cannot be uniquely estimated.

E. there must have been errors in your SAS code.

(9.) A researcher is designing a CRD experiment having 2 factors: Factor A with 3 fixed levels and Factor B with 3 fixed levels and 8 reps per treatment. The researcher wants to determine if this would be a sufficient number of reps in order that an $\alpha = .01$ F-test would have power of at least .80 to detect a difference of 25 units in the mean responses of at least two of the treatments. From past experiments, an estimate $\hat{\sigma}_e \approx 10$ is provided. What would be the power of the F-test?

A. $0 \leq Power \leq .6$

B. $.6 < Power \leq .7$

C. $.7 < Power \leq .8$

D. $.8 < Power \leq .9$

E. $.9 < Power \leq 1.0$

SAS Program for Problem I:

```
data raw;
array Y Y1-Y4;
INPUT C $ W $ D $ TRT $ Y1-Y4;
do over Y;
G = Y+50;
output;
end;

drop  Y1-Y4;
label W = 'Water' D = 'HarvestDays' C = 'Growth Chamber'
            G = 'Germination Rate';
cards;
C1   25 45 TRT01   58.1  58.9 59.1  59.9
C1   25 60 TRT02   52.2  51.1 53.2  52.1
C1   25 85 TRT03  66.6 64.3 65.6 63.3
C1   50 45 TRT04   57.8 59.3 56.8 60.3
C1   50 60 TRT05   54.5  58.4 55.5  59.4
C1   50 85 TRT06  61.3  58.7 62.3  59.7
C1   75 45 TRT07   58.8  57.7 59.8  58.7
C1   75 60 TRT08   56.0  51.7 57.0  52.7
C1   75 85 TRT09  60.2 62.6 61.2 63.6
C2   25 45 TRT10 60.2 61.8 . .
C2   25 60 TRT11 65.7 60.3 60.7 59.3
C2   25 85 TRT12 71.1 71.9 72.1 72.9
C2   50 45 TRT13 62.7 63.3 63.7 64.3
C2   50 60 TRT14 67.5 66.4 68.5 67.4
C2   50 85 TRT15 76.2 72.4 77.2 73.4
C2   75 45 TRT16 65.2 69.4 . .
C2   75 60 TRT17 72.1 70.3  . .
C2   75 85 TRT18 83.1 80.2 82.1 79.2

run;

proc glm order=data;
class C W D;
model G = C W D  C*W C*D W*D C*W*D/SS3;
lsmeans C|W|D/stderr pdiff adjust=tukey;
lsmeans C|W|D/stderr pdiff;
RUN;
proc glm;
class trt;
model G = TRT;
means TRT/hovtest=bf;
output out=ASSUMP r=RESID p=MEANS;
PROC PLOT; PLOT RESID*MEANS/VREF=0;
proc univariate def=5 plot normal; var RESID;
run;
proc sort data=ASSUMP;by C;
PROC PLOT DATA=ASSUMP;BY C;
PLOT MEANS*D=W;
run;
```

Class Level Information		
Class	**Levels**	**Values**
C	2	C1 C2
W	3	25 50 75
D	3	45 60 85

Number of Observations Read	72
Number of Observations Used	66

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	3629.859394	213.521141	75.27	<.0001
Error	48	136.160000	2.836667		
Corrected Total	65	3766.019394			

R-Square	Coeff Var	Root MSE	G Mean
0.963845	2.653614	1.684241	63.46970

Source	DF	Type III SS	Mean Square	F Value	Pr > F
C	1	1640.350476	1640.350476	578.27	<.0001
W	2	154.242877	77.121438	27.19	<.0001
D	2	1016.424658	508.212329	179.16	<.0001
C*W	2	184.082877	92.041438	32.45	<.0001
C*D	2	198.038082	99.019041	34.91	<.0001
W*D	4	82.163821	20.540955	7.24	0.0001
C*W*D	4	25.985146	6.496287	2.29	0.0733

SAS OUTPUT FOR Problem I - EXAM II - 2020

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

C	G LSMEAN	Standard Error	H0:LSMEAN=0	H0:LSMean1=LSMean2
			Pr > |t|	Pr > |t|
C1	58.5666667	0.2807068	<.0001	<.0001
C2	68.8777778	0.3241323	<.0001	

W	G LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
25	61.7666667	0.3713402	<.0001	1
50	63.6250000	0.3437942	<.0001	2
75	65.7750000	0.3969793	<.0001	3

Least Squares Means for effect W
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: G

i/j	1	2	3
1		0.0017	<.0001
2	0.0017		0.0005
3	<.0001	0.0005	

SAS OUTPUT FOR Problem I - EXAM II - 2020

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

C	W	G LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
C1	**25**	58.7000000	0.4861984	<.0001	1
C1	**50**	58.6666667	0.4861984	<.0001	2
C1	**75**	58.3333333	0.4861984	<.0001	3
C2	**25**	64.8333333	0.5614136	<.0001	4
C2	**50**	68.5833333	0.4861984	<.0001	5
C2	**75**	73.2166667	0.6276794	<.0001	6

Least Squares Means for effect C*W
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: G

i/j	1	2	3	4	5	6
1		1.0000	0.9945	<.0001	<.0001	<.0001
2	1.0000		0.9965	<.0001	<.0001	<.0001
3	0.9945	0.9965		<.0001	<.0001	<.0001
4	<.0001	<.0001	<.0001		<.0001	<.0001
5	<.0001	<.0001	<.0001	<.0001		<.0001
6	<.0001	<.0001	<.0001	<.0001	<.0001	

SAS OUTPUT FOR Problem I - EXAM II - 2020

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

D	G LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
45	61.3500000	0.3969793	<.0001	1
60	60.6000000	0.3713402	<.0001	2
85	69.2166667	0.3437942	<.0001	3

Least Squares Means for effect D Pr > |t| for H0: LSMean(i)=LSMean(j) Dependent Variable: G			
i/j	1	2	3
1		0.3594	<.0001
2	0.3594		<.0001
3	<.0001	<.0001	

C	D	G LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
C1	45	58.7666667	0.4861984	<.0001	1
C1	60	54.4833333	0.4861984	<.0001	2
C1	85	62.4500000	0.4861984	<.0001	3
C2	45	63.9333333	0.6276794	<.0001	4
C2	60	66.7166667	0.5614136	<.0001	5
C2	85	75.9833333	0.4861984	<.0001	6

ast Squares Means for effect C*D Pr > |t| for H0: LSMean(i)=LSMean(j) Dependent Variable: G						
i/j	1	2	3	4	5	6
1		<.0001	<.0001	<.0001	<.0001	<.0001
2	<.0001		<.0001	<.0001	<.0001	<.0001
3	<.0001	<.0001		0.4336	<.0001	<.0001
4	<.0001	<.0001	0.4336		0.0210	<.0001
5	<.0001	<.0001	<.0001	0.0210		<.0001
6	<.0001	<.0001	<.0001	<.0001	<.0001	

SAS OUTPUT FOR Problem I - EXAM II - 2020

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

W	D	G LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
25	**45**	60.0000000	0.7292976	<.0001	1
25	**60**	56.8250000	0.5954690	<.0001	2
25	**85**	68.4750000	0.5954690	<.0001	3
50	**45**	61.0250000	0.5954690	<.0001	4
50	**60**	62.2000000	0.5954690	<.0001	5
50	**85**	67.6500000	0.5954690	<.0001	6
75	**45**	63.0250000	0.7292976	<.0001	7
75	**60**	62.7750000	0.7292976	<.0001	8
75	**85**	71.5250000	0.5954690	<.0001	9

Least Squares Means for effect W*D
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: G

i/j	1	2	3	4	5	6	7	8	9
1		0.0363	<.0001	0.9732	0.3417	<.0001	0.1061	0.1786	<.0001
2	0.0363		<.0001	0.0003	<.0001	<.0001	<.0001	<.0001	<.0001
3	<.0001	<.0001		<.0001	<.0001	0.9860	<.0001	<.0001	0.0185
4	0.9732	0.0003	<.0001		0.8941	<.0001	0.4698	0.6441	<.0001
5	0.3417	<.0001	<.0001	0.8941		<.0001	0.9933	0.9995	<.0001
6	<.0001	<.0001	0.9860	<.0001	<.0001		0.0003	0.0001	0.0010
7	0.1061	<.0001	<.0001	0.4698	0.9933	0.0003		1.0000	<.0001
8	0.1786	<.0001	<.0001	0.6441	0.9995	0.0001	1.0000		<.0001
9	<.0001	<.0001	0.0185	<.0001	<.0001	0.0010	<.0001	<.0001	

SAS OUTPUT FOR Problem I - EXAM II - 2020

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

C	W	D	G LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
C1	25	45	59.0000000	0.8421203	<.0001	1
C1	25	60	52.1500000	0.8421203	<.0001	2
C1	25	85	64.9500000	0.8421203	<.0001	3
C1	50	45	58.5500000	0.8421203	<.0001	4
C1	50	60	56.9500000	0.8421203	<.0001	5
C1	50	85	60.5000000	0.8421203	<.0001	6
C1	75	45	58.7500000	0.8421203	<.0001	7
C1	75	60	54.3500000	0.8421203	<.0001	8
C1	75	85	61.9000000	0.8421203	<.0001	9
C2	25	45	61.0000000	1.1909380	<.0001	10
C2	25	60	61.5000000	0.8421203	<.0001	11
C2	25	85	72.0000000	0.8421203	<.0001	12
C2	50	45	63.5000000	0.8421203	<.0001	13
C2	50	60	67.4500000	0.8421203	<.0001	14
C2	50	85	74.8000000	0.8421203	<.0001	15
C2	75	45	67.3000000	1.1909380	<.0001	16
C2	75	60	71.2000000	1.1909380	<.0001	17
C2	75	85	81.1500000	0.8421203	<.0001	18

SAS OUTPUT FOR Problem I - EXAM II - 2020

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

Least Squares Means for effect C*W*D
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: G

i/j	1	2	3	4	5	6	7	8	9	10	11	12
1		<.0001	0.0010	1.0000	0.9526	0.9979	1.0000	0.0277	0.5866	0.9947	0.8034	<.0001
2	<.0001		<.0001	0.0003	0.0195	<.0001	0.0002	0.9169	<.0001	<.0001	<.0001	<.0001
3	0.0010	<.0001		0.0003	<.0001	0.0436	0.0005	<.0001	0.4995	0.4024	0.2920	<.0001
4	1.0000	0.0003	0.0003		0.9957	0.9692	1.0000	0.0746	0.3387	0.9615	0.5575	<.0001
5	0.9526	0.0195	<.0001	0.9957		0.2496	0.9855	0.7543	0.0135	0.3601	0.0348	<.0001
6	0.9979	<.0001	0.0436	0.9692	0.2496		0.9890	0.0006	0.9991	1.0000	1.0000	<.0001
7	1.0000	0.0002	0.0005	1.0000	0.9855	0.9890		0.0487	0.4431	0.9823	0.6731	<.0001
8	0.0277	0.9169	<.0001	0.0746	0.7543	0.0006	0.0487		<.0001	0.0040	<.0001	<.0001
9	0.5866	<.0001	0.4995	0.3387	0.0135	0.9991	0.4431	<.0001		1.0000	1.0000	<.0001
10	0.9947	<.0001	0.4024	0.9615	0.3601	1.0000	0.9823	0.0040	1.0000		1.0000	<.0001
11	0.8034	<.0001	0.2920	0.5575	0.0348	1.0000	0.6731	<.0001	1.0000	1.0000		<.0001
12	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	
13	0.0390	<.0001	0.9986	0.0135	0.0002	0.5284	0.0219	<.0001	0.9957	0.9542	0.9615	<.0001
14	<.0001	<.0001	0.8034	<.0001	<.0001	<.0001	<.0001	<.0001	0.0029	0.0061	0.0010	0.0348
15	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.6446
16	<.0001	<.0001	0.9734	<.0001	<.0001	0.0029	<.0001	<.0001	0.0477	0.0431	0.0227	0.1519
17	<.0001	<.0001	0.0093	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	1.0000
18	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001

Least Squares Means for effect C*W*D
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: G

i/j	13	14	15	16	17	18
1	0.0390	<.0001	<.0001	<.0001	<.0001	<.0001
2	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
3	0.9986	0.8034	<.0001	0.9734	0.0093	<.0001
4	0.0135	<.0001	<.0001	<.0001	<.0001	<.0001
5	0.0002	<.0001	<.0001	<.0001	<.0001	<.0001
6	0.5284	<.0001	<.0001	0.0029	<.0001	<.0001

SAS OUTPUT FOR Problem I - EXAM II - 2020

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

Least Squares Means for effect C*W*D
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: G

i/j	13	14	15	16	17	18
7	0.0219	<.0001	<.0001	<.0001	<.0001	<.0001
8	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
9	0.9957	0.0029	<.0001	0.0477	<.0001	<.0001
10	0.9542	0.0061	<.0001	0.0431	<.0001	<.0001
11	0.9615	0.0010	<.0001	0.0227	<.0001	<.0001
12	<.0001	0.0348	0.6446	0.1519	1.0000	<.0001
13		0.1230	<.0001	0.4696	0.0004	<.0001
14	0.1230		<.0001	1.0000	0.4928	<.0001
15	<.0001	<.0001		0.0006	0.5637	0.0003
16	0.4696	1.0000	0.0006		0.6687	<.0001
17	0.0004	0.4928	0.5637	0.6687		<.0001
18	<.0001	<.0001	0.0003	<.0001	<.0001	

SAS OUTPUT FOR Problem I - EXAM II - 2020

The GLM Procedure
Least Squares Means

C	G LSMEAN	Standard Error	H0:LSMEAN=0	H0:LSMean1=LSMean2
			Pr > |t|	Pr > |t|
C1	58.5666667	0.2807068	<.0001	<.0001
C2	68.8777778	0.3241323	<.0001	

W	G LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
25	61.7666667	0.3713402	<.0001	1
50	63.6250000	0.3437942	<.0001	2
75	65.7750000	0.3969793	<.0001	3

Least Squares Means for effect W
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: G

i/j	1	2	3
1		0.0006	<.0001
2	0.0006		0.0002
3	<.0001	0.0002	

Note: To ensure overall protection level, only probabilities associated with pre-planned comparisons should be used.

SAS OUTPUT FOR Problem I - EXAM II - 2020

The GLM Procedure
Least Squares Means

C	W	G LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
C1	25	58.7000000	0.4861984	<.0001	1
C1	50	58.6666667	0.4861984	<.0001	2
C1	75	58.3333333	0.4861984	<.0001	3
C2	25	64.8333333	0.5614136	<.0001	4
C2	50	68.5833333	0.4861984	<.0001	5
C2	75	73.2166667	0.6276794	<.0001	6

Least Squares Means for effect C*W
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: G

i/j	1	2	3	4	5	6
1		0.9615	0.5963	<.0001	<.0001	<.0001
2	0.9615		0.6300	<.0001	<.0001	<.0001
3	0.5963	0.6300		<.0001	<.0001	<.0001
4	<.0001	<.0001	<.0001		<.0001	<.0001
5	<.0001	<.0001	<.0001	<.0001		<.0001
6	<.0001	<.0001	<.0001	<.0001	<.0001	

Note: To ensure overall protection level, only probabilities associated with pre-planned comparisons should be used.

SAS OUTPUT FOR Problem I - EXAM II - 2020

The GLM Procedure
Least Squares Means

D	G LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
45	61.3500000	0.3969793	<.0001	1
60	60.6000000	0.3713402	<.0001	2
85	69.2166667	0.3437942	<.0001	3

Least Squares Means for effect D
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: G

i/j	1	2	3
1		0.1741	<.0001
2	0.1741		<.0001
3	<.0001	<.0001	

C	D	G LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
C1	45	58.7666667	0.4861984	<.0001	1
C1	60	54.4833333	0.4861984	<.0001	2
C1	85	62.4500000	0.4861984	<.0001	3
C2	45	63.9333333	0.6276794	<.0001	4
C2	60	66.7166667	0.5614136	<.0001	5
C2	85	75.9833333	0.4861984	<.0001	6

ast Squares Means for effect C*D
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: G

i/j	1	2	3	4	5	6
1		<.0001	<.0001	<.0001	<.0001	<.0001
2	<.0001		<.0001	<.0001	<.0001	<.0001
3	<.0001	<.0001		0.0678	<.0001	<.0001
4	<.0001	<.0001	0.0678		0.0018	<.0001
5	<.0001	<.0001	<.0001	0.0018		<.0001
6	<.0001	<.0001	<.0001	<.0001	<.0001	

SAS OUTPUT FOR Problem I - EXAM II - 2020

The GLM Procedure
Least Squares Means

W	D	G LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
25	45	60.0000000	0.7292976	<.0001	1
25	60	56.8250000	0.5954690	<.0001	2
25	85	68.4750000	0.5954690	<.0001	3
50	45	61.0250000	0.5954690	<.0001	4
50	60	62.2000000	0.5954690	<.0001	5
50	85	67.6500000	0.5954690	<.0001	6
75	45	63.0250000	0.7292976	<.0001	7
75	60	62.7750000	0.7292976	<.0001	8
75	85	71.5250000	0.5954690	<.0001	9

Least Squares Means for effect W*D
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: G

i/j	1	2	3	4	5	6	7	8	9
1		0.0015	<.0001	0.2817	0.0237	<.0001	0.0051	0.0098	<.0001
2	0.0015		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
3	<.0001	<.0001		<.0001	<.0001	0.3322	<.0001	<.0001	0.0007
4	0.2817	<.0001	<.0001		0.1694	<.0001	0.0388	0.0692	<.0001
5	0.0237	<.0001	<.0001	0.1694		<.0001	0.3853	0.5443	<.0001
6	<.0001	<.0001	0.3322	<.0001	<.0001		<.0001	<.0001	<.0001
7	0.0051	<.0001	<.0001	0.0388	0.3853	<.0001		0.8095	<.0001
8	0.0098	<.0001	<.0001	0.0692	0.5443	<.0001	0.8095		<.0001
9	<.0001	<.0001	0.0007	<.0001	<.0001	<.0001	<.0001	<.0001	

Note: To ensure overall protection level, only probabilities associated with pre-planned comparisons should be used.

SAS OUTPUT FOR Problem I - EXAM II - 2020

The GLM Procedure
Least Squares Means

C	W	D	G LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
C1	25	45	59.0000000	0.8421203	<.0001	1
C1	25	60	52.1500000	0.8421203	<.0001	2
C1	25	85	64.9500000	0.8421203	<.0001	3
C1	50	45	58.5500000	0.8421203	<.0001	4
C1	50	60	56.9500000	0.8421203	<.0001	5
C1	50	85	60.5000000	0.8421203	<.0001	6
C1	75	45	58.7500000	0.8421203	<.0001	7
C1	75	60	54.3500000	0.8421203	<.0001	8
C1	75	85	61.9000000	0.8421203	<.0001	9
C2	25	45	61.0000000	1.1909380	<.0001	10
C2	25	60	61.5000000	0.8421203	<.0001	11
C2	25	85	72.0000000	0.8421203	<.0001	12
C2	50	45	63.5000000	0.8421203	<.0001	13
C2	50	60	67.4500000	0.8421203	<.0001	14
C2	50	85	74.8000000	0.8421203	<.0001	15
C2	75	45	67.3000000	1.1909380	<.0001	16
C2	75	60	71.2000000	1.1909380	<.0001	17
C2	75	85	81.1500000	0.8421203	<.0001	18

SAS OUTPUT FOR Problem I - EXAM II - 2020

The GLM Procedure
Least Squares Means

Least Squares Means for effect C*W*D
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: G

i/j	1	2	3	4	5	6	7	8	9	10	11	12
1		<.0001	<.0001	0.7072	0.0916	0.2139	0.8346	0.0003	0.0187	0.1767	0.0411	<.0001
2	<.0001		<.0001	<.0001	0.0002	<.0001	<.0001	0.0709	<.0001	<.0001	<.0001	<.0001
3	<.0001	<.0001		<.0001	<.0001	0.0005	<.0001	<.0001	0.0136	0.0093	0.0057	<.0001
4	0.7072	<.0001	<.0001		0.1854	0.1081	0.8673	0.0009	0.0071	0.0995	0.0168	<.0001
5	0.0916	0.0002	<.0001	0.1854		0.0045	0.1372	0.0339	0.0001	0.0078	0.0004	<.0001
6	0.2139	<.0001	0.0005	0.1081	0.0045		0.1482	<.0001	0.2456	0.7332	0.4053	<.0001
7	0.8346	<.0001	<.0001	0.8673	0.1372	0.1482		0.0006	0.0110	0.1295	0.0253	<.0001
8	0.0003	0.0709	<.0001	0.0009	0.0339	<.0001	0.0006		<.0001	<.0001	<.0001	<.0001
9	0.0187	<.0001	0.0136	0.0071	0.0001	0.2456	0.0110	<.0001		0.5401	0.7384	<.0001
10	0.1767	<.0001	0.0093	0.0995	0.0078	0.7332	0.1295	<.0001	0.5401		0.7332	<.0001
11	0.0411	<.0001	0.0057	0.0168	0.0004	0.4053	0.0253	<.0001	0.7384	0.7332		<.0001
12	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	
13	0.0004	<.0001	0.2294	0.0001	<.0001	0.0152	0.0002	<.0001	0.1854	0.0930	0.0996	<.0001
14	<.0001	<.0001	0.0411	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0004
15	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0229
16	<.0001	<.0001	0.1137	<.0001	<.0001	<.0001	<.0001	<.0001	0.0006	0.0005	0.0002	0.0023
17	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.5859
18	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001

Least Squares Means for effect C*W*D
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: G

i/j	13	14	15	16	17	18
1	0.0004	<.0001	<.0001	<.0001	<.0001	<.0001
2	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
3	0.2294	0.0411	<.0001	0.1137	<.0001	<.0001
4	0.0001	<.0001	<.0001	<.0001	<.0001	<.0001
5	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
6	0.0152	<.0001	<.0001	<.0001	<.0001	<.0001
7	0.0002	<.0001	<.0001	<.0001	<.0001	<.0001

SAS OUTPUT FOR Problem I - EXAM II - 2020

The GLM Procedure
Least Squares Means

Least Squares Means for effect C*W*D
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: G

i/j	13	14	15	16	17	18
8	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
9	0.1854	<.0001	<.0001	0.0006	<.0001	<.0001
10	0.0930	<.0001	<.0001	0.0005	<.0001	<.0001
11	0.0996	<.0001	<.0001	0.0002	<.0001	<.0001
12	<.0001	0.0004	0.0229	0.0023	0.5859	<.0001
13		0.0017	<.0001	0.0122	<.0001	<.0001
14	0.0017		<.0001	0.9185	0.0133	<.0001
15	<.0001	<.0001		<.0001	0.0172	<.0001
16	0.0122	0.9185	<.0001		0.0249	<.0001
17	<.0001	0.0133	0.0172	0.0249		<.0001
18	<.0001	<.0001	<.0001	<.0001	<.0001	

Note: To ensure overall protection level, only probabilities associated with pre-planned comparisons should be used.

SAS OUTPUT FOR Problem I - EXAM II - 2020

The GLM Procedure

Class Level Information		
Class	**Levels**	**Values**
TRT	18	TRT01 TRT02 TRT03 TRT04 TRT05 TRT06 TRT07 TRT08 TRT09 TRT10 TRT11 TRT12 TRT13 TRT14 TRT15 TRT16 TRT17 TRT18

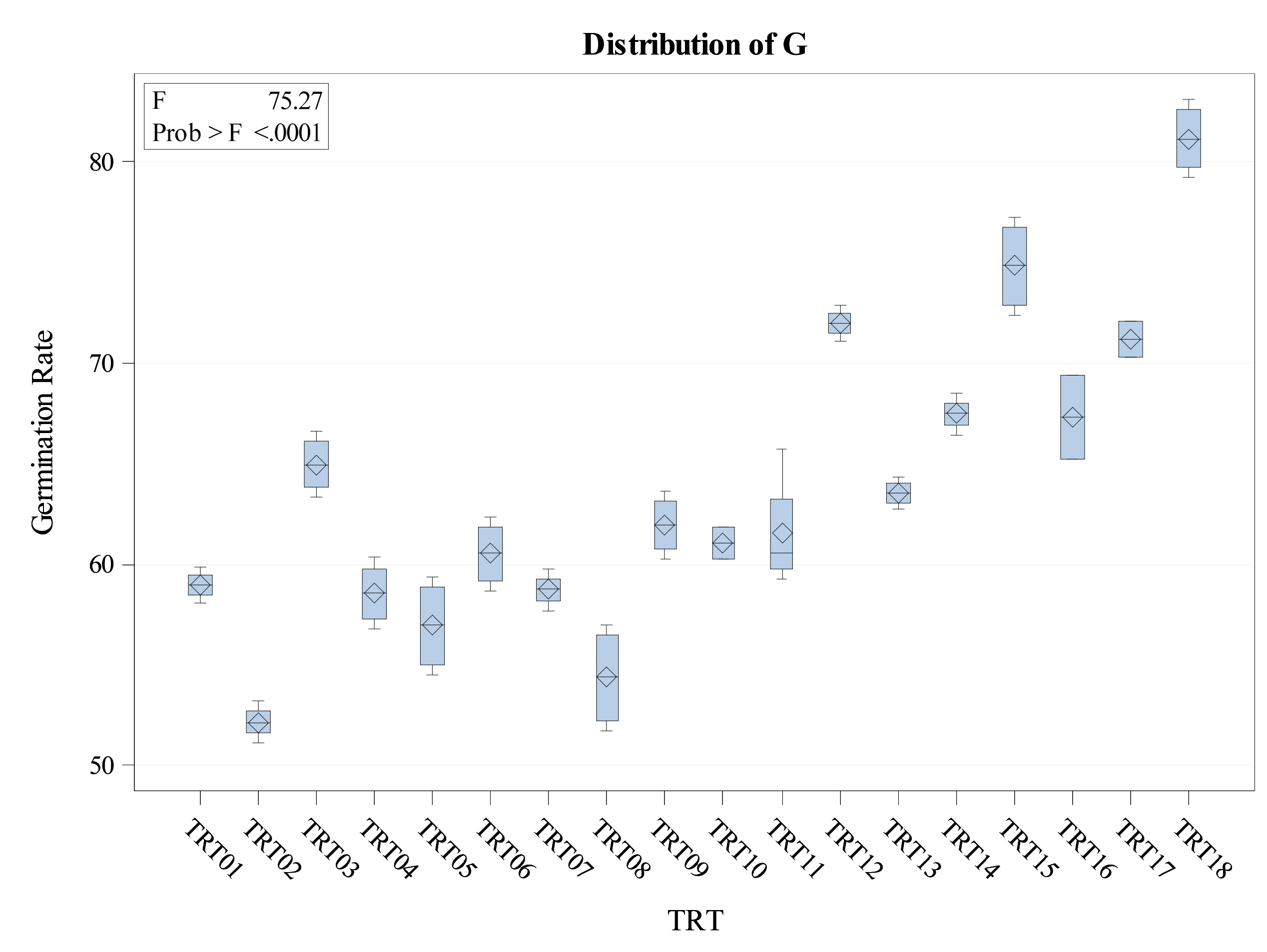
Number of Observations Read	72
Number of Observations Used	66

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	3629.859394	213.521141	75.27	<.0001
Error	48	136.160000	2.836667		
Corrected Total	65	3766.019394			

SAS OUTPUT FOR Problem I - EXAM II - 2020

The GLM Procedure

Dependent Variable: G   Germination Rate

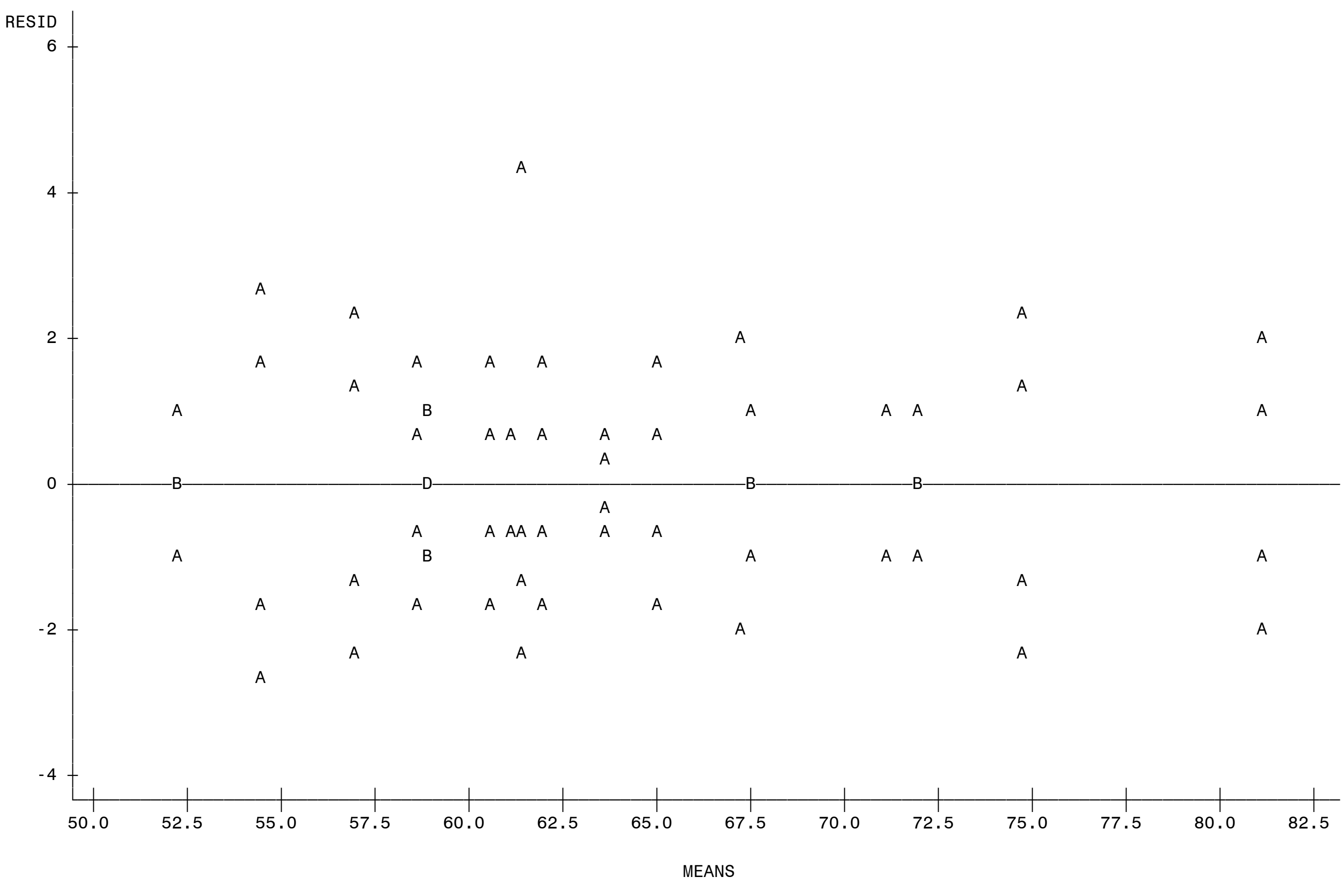


SAS OUTPUT FOR Problem I - EXAM II - 2020

The GLM Procedure

Brown and Forsythe's Test for Homogeneity of G Variance ANOVA of Absolute Deviations from Group Medians					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
TRT	14	19.9093	1.4221	2.16	0.0259
Error	45	29.6400	0.6587		

Plot of RESID*MEANS. Legend: A = 1 obs, B = 2 obs, etc.



NOTE: 6 obs had missing values.

Tests for Normality				
Test	**Statistic**		**p Value**	
Shapiro-Wilk	**W**	0.978642	**Pr < W**	0.3122
Kolmogorov-Smirnov	**D**	0.097563	**Pr > D**	0.1195
Cramer-von Mises	**W-Sq**	0.074841	**Pr > W-Sq**	0.2417
Anderson-Darling	**A-Sq**	0.423236	**Pr > A-Sq**	>0.2500

SAS OUTPUT FOR Problem I - EXAM II - 2020

The UNIVARIATE Procedure