MTH 325, Homework #3, Spring 2023 Name _____

Instructions: Show work or attach R code used to perform calculations (or any other technology used). Be sure to answer all parts of each problem as completely as possible, and attach work to this cover sheet with a staple.

1. The accompanying data resulted from an experiment to investigate whether yield from a certain chemical process depended either on the formulation of the particular input or on mixer speed.

		Speed		
		60	**70**	**80**
Formulation	**1**	189.7	185.1	189.0
		188.6	179.4	193.0
		190.1	177.3	191.1
	2	165.1	161.7	163.3
		165.9	159.8	166.6
		167.6	161.6	170.3

   a. Does there appear to be an interaction between factors?
   b. Does yield appear to depend on either formulation or speed?
   c. Calculate estimates of the main effects.
   d. Explain how the ANOVA model is similar to a linear model? How is it similar to using dummy variables for the categories?
   e. Construct normal probability plots from the residuals. Do they appear to be normally distributed?

2. In a study of processes used to remove impurities from cellulose goods. The following data resulted from a 2^4 Factorial experiment involving the desizing process. The four factors were enzyme concentration (A), pH (B), temperature (C) and time (D).

A	B	C	D	Enzyme (g/L)	pH	Temp (C)	Time (hr)	Starch % by Weight
0	0	0	0	.50	6.0	60.0	6	9.72
0	0	0	0	.50	6.0	60.0	6	13.50
1	0	0	0	.75	6.0	60.0	6	9.80
1	0	0	0	.75	6.0	60.0	6	14.04
0	1	0	0	.50	7.0	60.0	6	10.13
0	1	0	0	.50	7.0	60.0	6	11.27
1	1	0	0	.75	7.0	60.0	6	11.80
1	1	0	0	.75	7.0	60.0	6	11.30
0	0	1	0	.50	6.0	70.0	6	12.70
0	0	1	0	.50	6.0	70.0	6	11.37
1	0	1	0	.75	6.0	70.0	6	11.96
1	0	1	0	.75	6.0	70.0	6	12.05
0	1	1	0	.50	7.0	70.0	6	11.38
0	1	1	0	.50	7.0	70.0	6	9.92
1	1	1	0	.75	7.0	70.0	6	11.80
1	1	1	0	.75	7.0	70.0	6	11.10

0	0	0	1	.50	6.0	60.0	8	13.15
0	0	0	1	.50	6.0	60.0	8	13.00
1	0	0	1	.75	6.0	60.0	8	10.60
1	0	0	1	.75	6.0	60.0	8	12.37
0	1	0	1	.50	7.0	60.0	8	10.37
0	1	0	1	.50	7.0	60.0	8	12.00
1	1	0	1	.75	7.0	60.0	8	11.30
1	1	0	1	.75	7.0	60.0	8	11.64
0	0	1	1	.50	6.0	70.0	8	13.05
0	0	1	1	.50	6.0	70.0	8	14.55
1	0	1	1	.75	6.0	70.0	8	11.15
1	0	1	1	.75	6.0	70.0	8	15.00
0	1	1	1	.50	7.0	70.0	8	12.70
0	1	1	1	.50	7.0	70.0	8	14.10
1	1	1	1	.75	7.0	70.0	8	13.20
1	1	1	1	.75	7.0	70.0	8	16.12

a. Obtain an ANOVA table.
b. Do there appear to be any second-, third- or fourth-order interaction effects present? Explain your reasoning.
c. Which main effects appear to be significant?

3. An article presents data from an experiment to assess the effects of vibration (A), temperature (B), altitude cycling (C) and temperature for altitude cycling and firing (D) on thrust duration. Obtain an ANOVA table. Assume that three- and four-factor interactions are absent. Obtain an estimate of σ^2 (pooled), and test all appropriate hypotheses at the 0.05 level.

A	**B**	**C**	**D**	**Effect**
1	1	1	1	21.60
1	1	2	1	21.60
1	1	1	2	11.54
1	1	2	2	11.50
1	2	1	1	21.09
1	2	2	1	22.17
1	2	1	2	11.14
1	2	2	2	11.32
2	1	1	1	21.60
2	1	2	1	21.86
2	1	1	2	11.75
2	1	2	2	9.82
2	2	1	1	19.57
2	2	2	1	21.85
2	2	1	2	11.69
2	2	2	2	11.18

4. The bond strength when mounting an integrated circuit on a metalized glass substrate was studied as a function of factor A is adhesive type, factor B is cure time, and factor C is conductor material. What conclusions can you draw from the data?

Adhesive Type	Cure Time	Conductor	Bond Strength
1	1	Copper	72.7
1	1	Copper	80.0
2	1	Copper	77.8
2	1	Copper	75.3
3	1	Copper	77.3
3	1	Copper	76.5
1	2	Copper	74.6
1	2	Copper	77.5
2	2	Copper	78.5
2	2	Copper	81.1
3	2	Copper	80.9
3	2	Copper	82.6
1	3	Copper	80.0
1	3	Copper	82.7
2	3	Copper	84.6
2	3	Copper	78.3
3	3	Copper	83.9
3	3	Copper	85.0
1	1	Nickel	74.7
1	1	Nickel	77.4
2	1	Nickel	79.3
2	1	Nickel	77.8
3	1	Nickel	77.2
3	1	Nickel	78.4
1	2	Nickel	75.7
1	2	Nickel	78.2
2	2	Nickel	78.8
2	2	Nickel	75.4
3	2	Nickel	84.5
3	2	Nickel	77.5
1	3	Nickel	77.2
1	3	Nickel	74.6
2	3	Nickel	83.0
2	3	Nickel	83.9
3	3	Nickel	89.4
3	3	Nickel	81.2