SIE 330R Homework, Spring 2023

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HW 9 (Chapter 8)

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Homework must be readable! Do not just send in numbers or charts. You must explain the homework answers Preferred to receive homework in Word doc format with any excel or Minitab results pasted into word document. You may choose to use pdf which is also OK.

Put answers to all questions in one document NOT in separate documents

- Homework 9 Chapter 8, Prob 8.1, 8.2, 8.A, 8.B

8.1. Suppose that in the chemical process development experiment in Problem 6.11, it was only possible to run a one-half fraction of the 2^4 design. Construct the design and perform the statistical analysis, using the data from replicate 1.

6.11. An experiment was performed to improve the yield of a chemical process. Four factors were selected, and two replicates of a completely randomized experiment were run. The results are shown in the following table:

Treatment Combination	Replicate I	Replicate II	Treatment Combination	Replicate I	Replicate II
(1)	90	93	*d*	98	95
a	74	78	*ad*	72	76
b	81	85	*bd*	87	83
ab	83	80	*abd*	85	86
c	77	78	*cd*	99	90
ac	81	80	*acd*	79	75
bc	88	82	*bcd*	87	84
abc	73	70	*abcd*	80	80

Design Summary

Factors:	4	Base Design:	4, 8	Resolution:	IV
Runs:	8	Replicates:	1	Fraction:	1/2
Blocks:	1	Center pts (total):		0	

Design Generators: D = ABC

Alias Structure

I + ABCD
A + BCD
B + ACD
C + ABD
D + ABC
AB + CD
AC + BD
AD + BC

StdOrder	RunOrder	CenterPt	Blocks	A	B	C	D
1	1	1	1	-1	-1	-1	-1
6	2	1	1	1	-1	1	-1
8	3	1	1	1	1	1	1
3	4	1	1	-1	1	-1	1
5	5	1	1	-1	-1	1	1
7	6	1	1	-1	1	1	-1
2	7	1	1	1	-1	-1	1

We see from the ANOVA provided below that factors A, AB, and AD are the most significant.
These factors are chosen because A is aliased with a three-factor interaction, which is assumed to be more negligible. Furthermore, AB and AD are significant over their aliases since they include factor A, the most significant.

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	7	448.000	64.000	*	*
Linear	4	324.000	81.000	*	*
A	1	288.000	288.000	*	*
B	1	2.000	2.000	*	*
C	1	32.000	32.000	*	*
D	1	2.000	2.000	*	*
2-Way Interactions	3	124.000	41.333	*	*
A*B	1	72.000	72.000	*	*
A*C	1	2.000	2.000	*	*
A*D	1	50.000	50.000	*	*
Error	0	*	*		
Total	7	448.000			

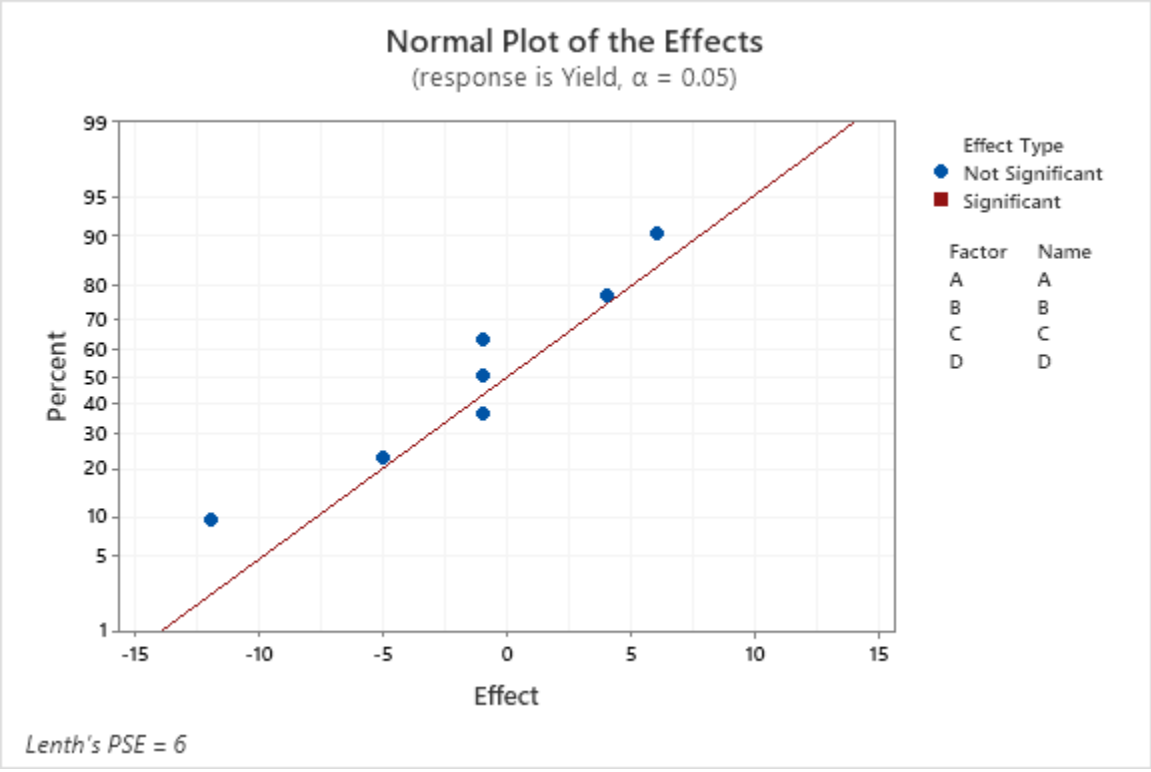
Model Summary

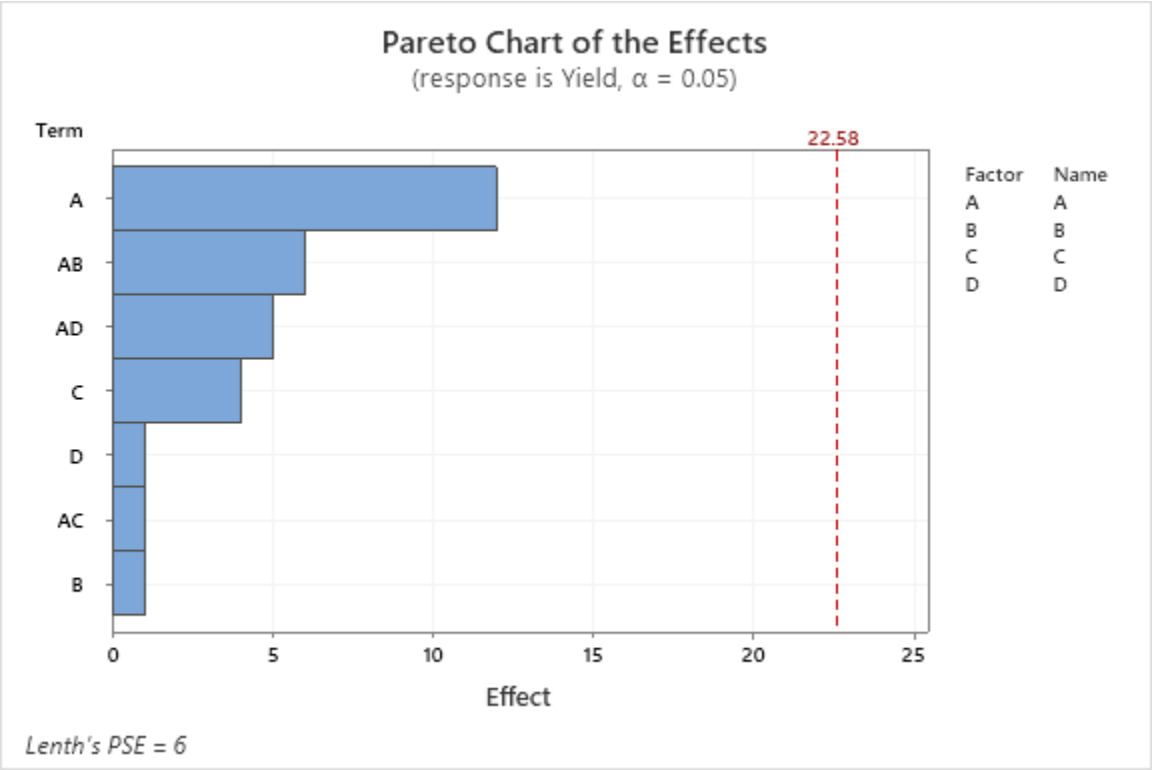
S	R-sq	R-sq(adj)	PRESS	R-sq(pred)
4.12311	92.41%	73.44%	544	0.00%

Regression Equation in Uncoded Units

Yield = 85.00 - 6.000 A - 0.5000 B + 2.000 C - 0.5000 D + 3.000 A*B - 0.5000 A*C - 2.500 A*D

The ANOVA performed above outputs an R^2 of 92.41%, meaning that there is still room for improvement. Because none of the factors are significant at the 5% significance level, this further evidences that the model is not perfect. This can be seen in the normal probability plot below.





8.2S. Consider the plasma etch experiment described in Example 6.1. Suppose that only a one-half fraction of the design could be run. See below for fractional experiment setup. Analyze the data.

A	B	C	Etch Rate
-1	-1	-1	550
-1	-1	-1	604
-1	-1	1	1037
-1	-1	1	1052
-1	1	-1	633
-1	1	-1	601
-1	1	1	1075
-1	1	1	1063
1	-1	-1	669
1	-1	-1	650
1	-1	1	749
1	-1	1	868
1	1	-1	642
1	1	-1	635
1	1	1	729
1	1	1	860

Design Summary

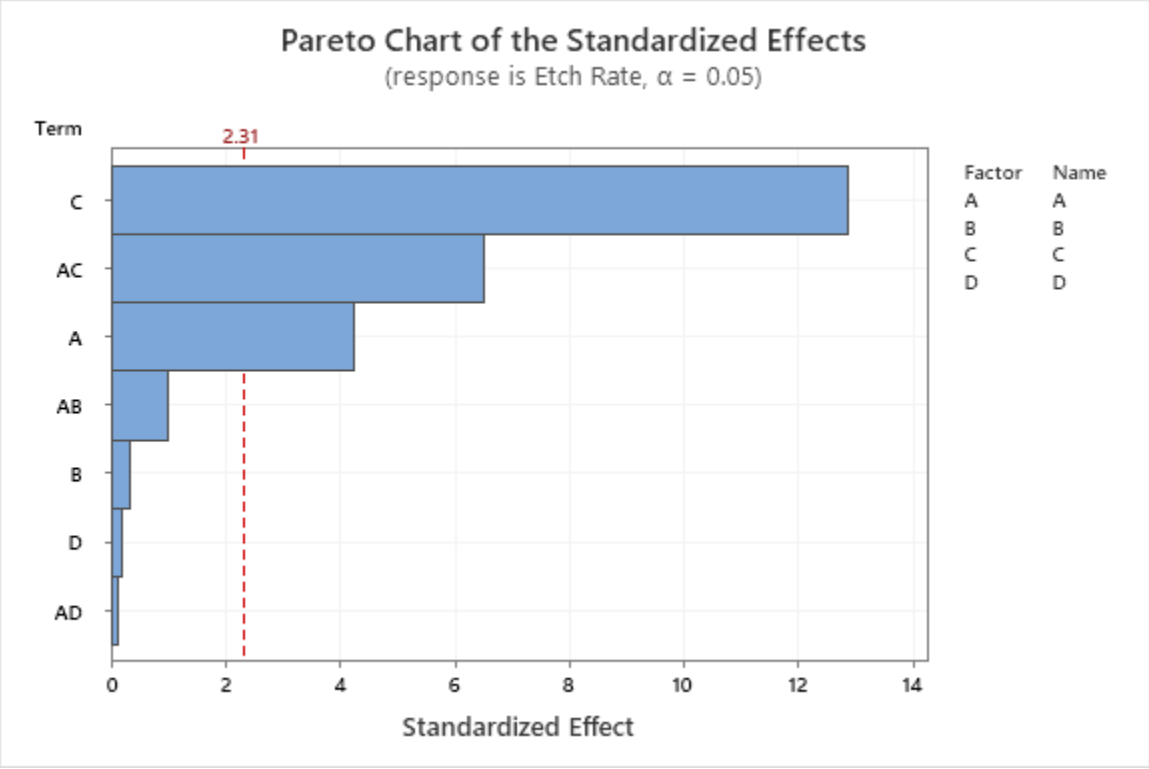
Factors:	4	Base Design:	4, 8	Resolution:	IV
Runs:	16	Replicates:	2	Fraction:	1/2
Blocks:	1	Center pts (total):	0		

Design Generators: D = ABC

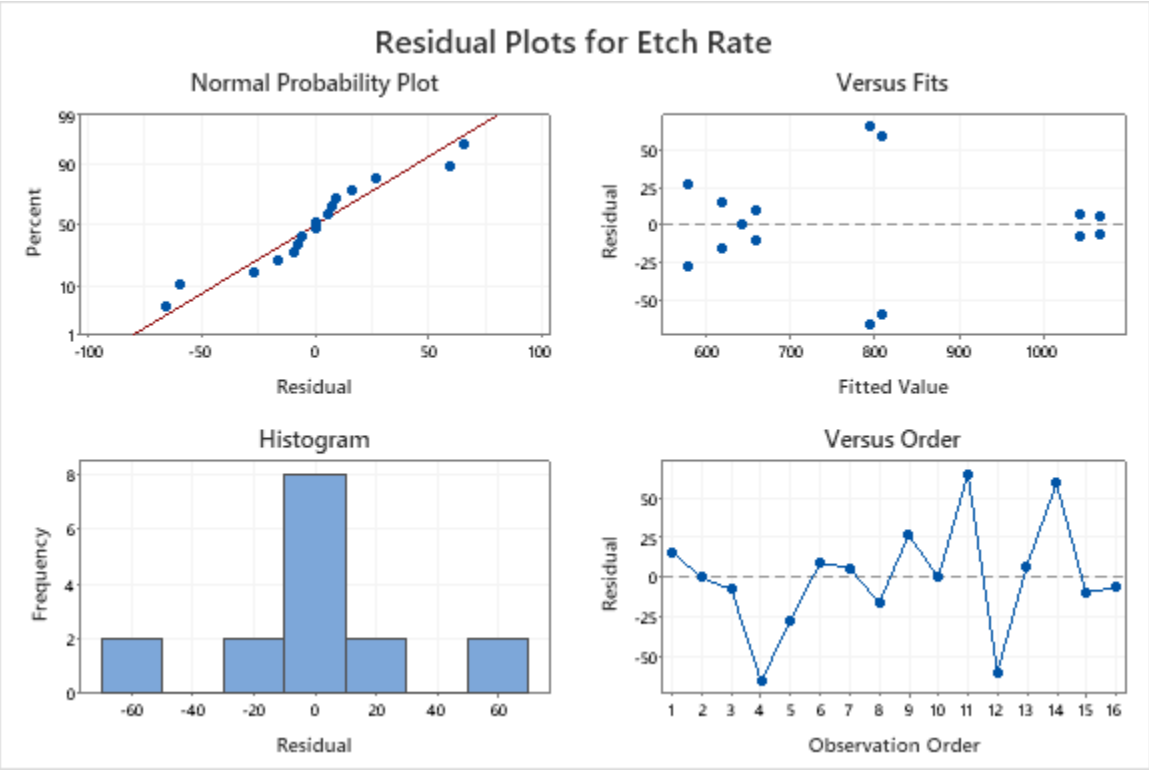
Alias Structure

I + ABCD
A + BCD
B + ACD
C + ABD
D + ABC
AB + CD
AC + BD
AD + BC

The normal probability plot below graphically proves that A, C, and AC are the significant factors.



The Residual Plots for Etch Rate below cause concern with the points of the Versus Fits plot hinting at a possible inequality of variance.



8A: A experiment is to be run on 8 Factors. Only 64 experimental units are available for the experiment.

What Fraction will this experiment be?

Assuming a 2-level design, one possible fractional factorial design that tests half of the possible combinations is the 2^7 design, also known as the half-fraction design. In this design, each factor is tested at two levels (e.g., high and low), and only 7 of the 8 factors are tested in all possible combinations. This design requires 64 experimental units, which is the exact number available. Therefore, in this case, the fraction of the full factorial design that will be tested is 1/2 or 0.5, using the 2^7 design.

What is the highest Resolution for this experiment?

The highest resolution that can be achieved is 3. Therefore, the design can estimate main effects, two-factor interactions, and three-factor interactions.

Will any Main Effects be confounded with 2-way or 3-way interactions? Will any 2-way interactions be confounded with 3-way interactions?

In fractional factorial design, some main effects may be confounded with other effects due to the design's specific structure. Each main effect will be confounded with a 3-way interaction involving two other factors. Each 2-way interaction will be confounded with a 3-way interaction involving the two interacting factors and another factor. However, it is not possible to estimate the main effects or 2-way interactions independently of some 3-way interactions.

8B: A experiment is to be run on 7 Factors. Only 16 experimental units are available for the experiment. What Fraction will this experiment be?

To determine the fraction of this experiment, the appropriate design must be selected. The 2^4-1 design, also known as the Plackett-Burman design, which tests 7 factors in 8 experimental runs. This design can estimate main effects but cannot estimate interactions among the factors. However, since we have only 16 experimental units available, we can use the folded version of the 2^4-1 design, which requires 16 experimental runs. Therefore, using the folded 2^4-1 design, the fraction for this experiment will be ½.

What is the highest Resolution for this experiment?

The folded version of the Plackett-Burman design, used in this design, can estimate main effects, but cannot estimate interactions among the factors. Therefore, the highest resolution that can be achieved for this experiment is 1.

Will any Main Effects be confounded with 2-way or 3-way interactions?

None of the main effects will be confounded with any 2-way or 3-way interactions.

Will any 2-way interactions be confounded with 3-way interactions?

Since the highest resolution for this experiment is 1, none of the 2-way interactions will be confounded with any 3-way interactions.