Day 3 Homework Exercises

Smart Experimentation for Scientists and Engineers

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Day 3 Homework Exercise 1

Designing a Fractional Factorial Experiment

You have five continuous factors, X1 through X5. You'd like to conduct a screening experiment to identify important effects. You have enough time and resources to run a total of 20 trials, and you don't need to run the experiment in blocks.

In JMP use the Screening Design platform from the DOE, Classical, Two Level Screening menu to explore potential screening designs. (Hint: Enter the five continuous factors, click Continue and then use Choose from a list of fractional factorial designs to see available designs.)

Questions:

1. Based on the information provided, what are the potential screening designs?
2. Select the 2^{5-1} (16-run) design and click Continue. Look at the Aliasing of Effects outline. Which effects are aliased?
3. Add four center points to this design and click Make Table. How many runs are in this design?
4. Look at the pattern for the center points. Describe these design points.
5. Run the Model script, which was saved to the data table. Which effects can you estimate?

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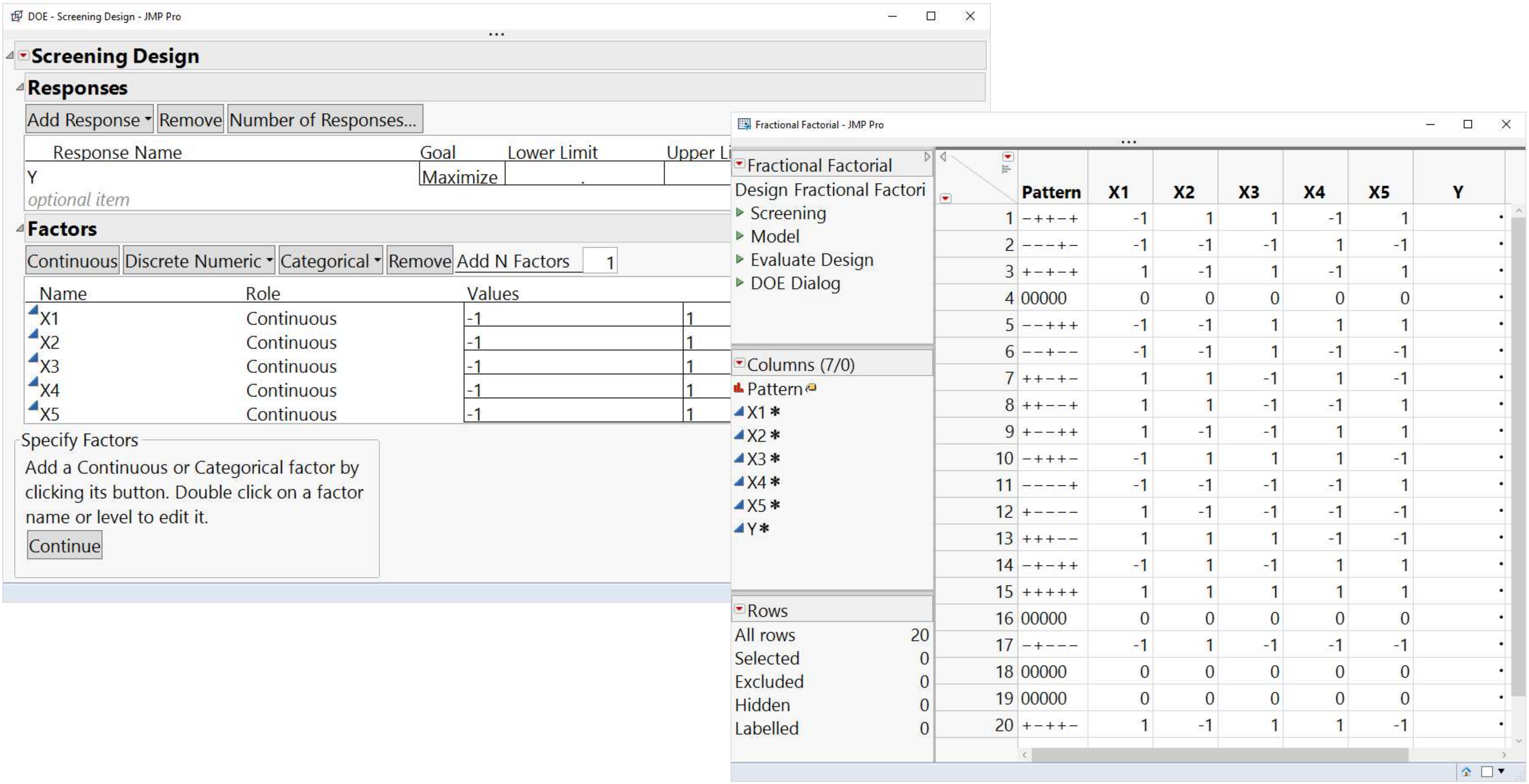
Day 3 Homework Exercise 1



	Pattern	X1	X2	X3	X4	X5	Y
1	−++−+	-1	1	1	-1	1	•
2	−−−+−	-1	-1	-1	1	-1	•
3	+−+−+	1	-1	1	-1	1	•
4	00000	0	0	0	0	0	•
5	−−+++	-1	-1	1	1	1	•
6	−−+−−	-1	-1	1	-1	-1	•
7	++−+−	1	1	-1	1	-1	•
8	++−−+	1	1	-1	-1	1	•
9	+−−++	1	-1	-1	1	1	•
10	−+++−	-1	1	1	1	-1	•
11	−−−−+	-1	-1	-1	-1	1	•
12	+−−−−	1	-1	-1	-1	-1	•
13	+++−−	1	1	1	-1	-1	•
14	−+−++	-1	1	-1	1	1	•
15	+++++	1	1	1	1	1	•
16	00000	0	0	0	0	0	•
17	−+−−−	-1	1	-1	-1	-1	•
18	00000	0	0	0	0	0	•
19	00000	0	0	0	0	0	•
20	+−++−	1	-1	1	1	-1	•

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Day 3 Homework Exercise 1

Designing a Fractional Factorial Experiment

Solutions:

1. Based on the information provided, what are the potential screening designs?

   The potential screening designs are an 8-run 2^{5-2} design, a 16-run 2^{5-1} fractional design, or a 12-run Plackett-Burman design.

2. Select the 2^{5-1} (16-run) design and click **Continue**. Look at the Aliasing of Effects outline. Which effects are aliased?

   No effects up to 2-way interactions are aliased with other effects up to 2-way interactions. So you can estimate main effects and 2-way interactions.

3. Add four center points to this design and click **Make Table**. How many runs are in this design?

   There are 20 runs: 16 factorial points and 4 center points.

4. Look at the pattern for the center points. Describe these design points.

   The center points are all run at the midpoints of the factor levels (0).

5. Run the Model script, which was saved to the data table. Which effects can you estimate?

   You can estimate all main effects and 2-way interactions. (Note that you haven't conducted this experiment, so you don't have values for the response and can't run the analysis.)

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Day 3 Homework Exercise 2

Analyzing a 20-Run Custom Design

The results of many designed experiments can be found in JMP in the Sample Data Library, under the Help menu. There are several topic-specific folders in the Sample Data Library. For this practice, we use the file Reactor 20 Custom.jmp, which is in the Design Experiment folder.

This experiment is discussed in Box, Hunter, and Hunter (2005), and in the "Design of Experiments" chapter in the JMP Start Statistics book.

In this experiment, a chemical reactor has five 2-level continuous factors: Feed Rate, Catalyst, Stir Rate, Temperature, and Concentration. These factors are all believed to be important, along with many 2-way interactions.

The experimental goal is to find the combination of factor settings to optimize reactor output, measured as a percent. A 20-run optimal design was generated, and Percent Reacted was recorded for each experimental trial.

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Day 3 Homework Exercise 2

Analyzing a 20-Run Custom Design

Questions:

1. Open the file, and use the Model script to fit the model. Which terms are significant? (Use a significance level of 0.05 and remove interactions first.)

2. Slowly reduce this model by removing non-significant terms (PValue > 0.05). Remove interactions first. How many terms are in the reduced model?

3. Use the Prediction Profiler to find settings of the factors that maximize Percent Reacted. What are the settings, and what is the predicted response at these settings?

4. Interpret the bracketed values for the predicted Percent Reacted. What do these values represent?

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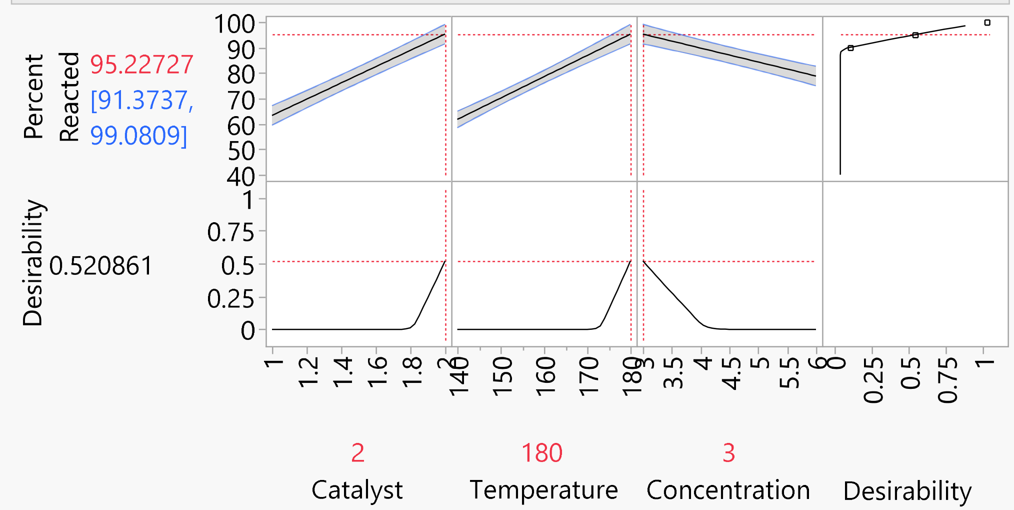
Day 3 Homework Exercise 2

Effect Summary

Source	LogWorth	PValue	
Catalyst(1,2)	3.246	0.00057	
Catalyst*Temperature	2.429	0.00372	
Temperature(140,180)	2.292	0.00511	^
Temperature*Concentration	2.134	0.00734	
Concentration(3,6)	1.483	0.03291	^
Feed Rate*Concentration	0.362	0.43489	
Stir Rate*Concentration	0.316	0.48301	
Feed Rate*Temperature	0.286	0.51729	
Catalyst*Concentration	0.286	0.51729	
Catalyst*Stir Rate	0.286	0.51729	
Feed Rate(10,15)	0.147	0.71365	^
Stir Rate*Temperature	0.121	0.75725	
Feed Rate*Catalyst	0.037	0.91746	
Stir Rate(100,120)	0.026	0.94097	^
Feed Rate*Stir Rate	0.016	0.96455	

Prediction Profiler



Effect Summary

Source	LogWorth	PValue	
Catalyst(1,2)	9.176	0.00000	
Catalyst*Temperature	6.423	0.00000	
Temperature(140,180)	5.998	0.00000	^
Temperature*Concentration	5.615	0.00000	
Concentration(3,6)	3.341	0.00046	^

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Day 3 Homework Exercise 2

Analyzing a 20-Run Custom Design

Solutions:

1. Open the file, and use the Model script to fit the model. Which terms are significant? (Use a significance level of 0.05 and remove interactions first)

   The terms Catalyst, Catalyst*Temperature, Temperature, Temperature*Concentration, and Concentration are significant.

2. Slowly reduce this model by removing non-significant terms (PValue > 0.05). Remove interactions first. How many terms are in the reduced model?

   The same five terms are in the reduced model: three main effects and two 2-way interactions.

3. Use the Prediction Profiler to find settings of the factors that maximize Percent Reacted. What are the settings, and what is the predicted response at these settings?

   (Hint: Click the red triangle for the Prediction Profiler, select Optimization and Desirability, and then select Maximize Desirability.) The settings are Catalyst (2), Temperature (180), and Concentration (3). At these settings, the predicted Percent Reacted is 95.227.

4. Interpret the bracketed values for the predicted Percent Reacted. What do these values represent?

   The bracketed values (91.37 to 99.08) are a 95% confidence interval for the mean Percent Reacted at the optimal settings. Assuming that the process is stable and that other factors can be controlled, you can be confident that the mean Percent Reacted will be in this range.

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