## Day 2 Homework Exercises

Double your impact by getting started with Design of Experiments (DoE)



### Day 2 Homework Exercise 1 Double your impact by getting started with Design of Experiments (DoE) Designing a Full Factorial

You are studying a process for cleaning metal components. Your response is Particles, measured as particles per cm<sup>2</sup>. You want to design an experiment to study three continuous factors, at the following settings:

- Bath Time (hours): 10 and 20
- % Solution: 5 and 15
- Rinse Time: 1 and 5 hours

In JMP use the Full Factorial Design platform (from DOE, Classical) to design a randomized 2<sup>3</sup> full factorial experiment. Replicate the entire design once. Before you make the design table, click the top red triangle, select **Set Random Seed**, and enter the value 1234. (This ensures that you generate the design in the same randomized order as the one used in the solutions.)

Questions:

- 1. How many treatments are in this design?
- 2. How many runs are in this design?
- 3. Interpret the pattern for the first trial. What are the factor settings for this trial?
- 4. Which row is a replicate of row 1?



## Day 2 Homework Exercise 1 Double your impact by getting started with Design of Experiments (DoE)

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## Day 2 Homework Exercise 1

#### Double your impact by getting started with Design of Experiments (DoE) Designing a Full Factorial

#### Solutions:

#### 1. How many treatments are in this design?

In a 2<sup>3</sup> full factorial experiment, there are 8 treatments. Remember that a treatment is a unique combination of factor levels.

#### 2. How many runs are in this design?

There are 16 runs. Each treatment is replicated once.

#### 3. Interpret the pattern for the first trial. What are the factor settings for this trial?

The pattern is ++-. The trial should be run with the high level of Bath Time (20), the high level of % Solution (15), and the low level of Rinse Time (1).

#### 4. Which row is a replicate of row 1?

Row 16 is a replicate of row 1.



### Day 2 Homework Exercise 2 Double your impact by getting started with Design of Experiments (DoE) Analyzing a Replicated Full Factorial Experiment

Open the file **Particles 2.jmp**. This is based on the 2<sup>3</sup> full factorial experiment that you designed in the previous exercise, but it includes a fourth factor: the two-level categorical variable **Type**.

The response is **Particles** (measured in Particles/cm2).

The experiment has been conducted, and the measured particle values have been added to the design table.

Analyze these experimental results. (Hint: Run the **Model** script to launch the Model Specification window. Run the analysis with the default model.)

Questions:

- 1. How many main effects are in the model?
- 2. How many two-way interactions are in the model?
- 3. Which three effects are the most significant?
- 4. Slowly remove nonsignificant terms one at a time, starting with the least significant two-way interactions. Keep all terms with a p-value of 0.05 or less. Which terms are in your reduced model?
- 5. Your response goal is to minimize Particles. Use the Prediction Profiler to find the best (most desirable) factor settings. What are these settings, and what is the predicted **Particles** value at these settings?



## Day 2 Homework Exercise 2

# Double your impact by getting started with Design of Experiments (DoE)

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Day 2 Homework Exercise 2 Double your impact by getting started with Design of Experiments

## (DoE)

Effect Summary								
Source	LogWorth		PValue					
Bath Time(10,20)	11.117		0.00000					
% Solution*Rinse Time	9.632		0.00000					
Rinse Time(1,5)	6.500		0.00000 ^					
Bath Time*% Solution	1.968		0.01077					
% Solution(5,15)	1.362		0.04347 ^					



## Day 2 Homework Exercise 2

Double your impact by getting started with Design of Experiments (DoE)

#### Analyzing a Replicated Full Factorial Experiment

Solutions:

1. How many main effects are in the model?

There are four main effects

2. How many two-way interactions are in the model?

There are six 2-way interactions

3. Which three effects are the most significant?

Bath Time, the %Solution\*Rinse Time interaction, and Rinse Time

4. Slowly remove nonsignificant terms one at a time, starting with the least significant twoway interactions. Keep all terms with a p-value of 0.05 or less. Which terms are in your reduced model?

Bath Time, the %Solution\*Rinse Time interaction, Rinse Time, Bath time\*%Solution, and % Solution

5. Your response goal is to minimize Particles. Use the Prediction Profiler to find the best (most desirable) factor settings. What are these settings, and what is the predicted **Particles** value at these settings?

The best settings are the high level of **Bath Time** (20), the low level of **% Solution** (5), and the high level of **Rinse Time** (5). At these settings, the predicted response is 0.998. (Hint: To find the optimal settings, click the red triangle for the Prediction Profiler and select **Optimization and Desirability**, and then **Maximize Desirability**.)

