Homework

Suppose that you need to determine which of six factors affect the yield of an extraction process.

The factors and ranges are as follows:

Methanol, 0-10

Ethanol, 0-10

Propanol, 0-10

Butanol, 0-10

pH, 6-9

Time, 1-2

1. Use Easy DOE, Definitive Screening Design, or Custom Design to create a design. Consider the benefits of any of these methods. Why might you choose one over another?
2. Using the **Extraction Data** table linked from the course journal, resulting from a DSD, analyze the results in order to determine the active factors. Because this is a DSD, you can determine the active main effects AND possibly identify curvature and 2-way interactions.

Solution

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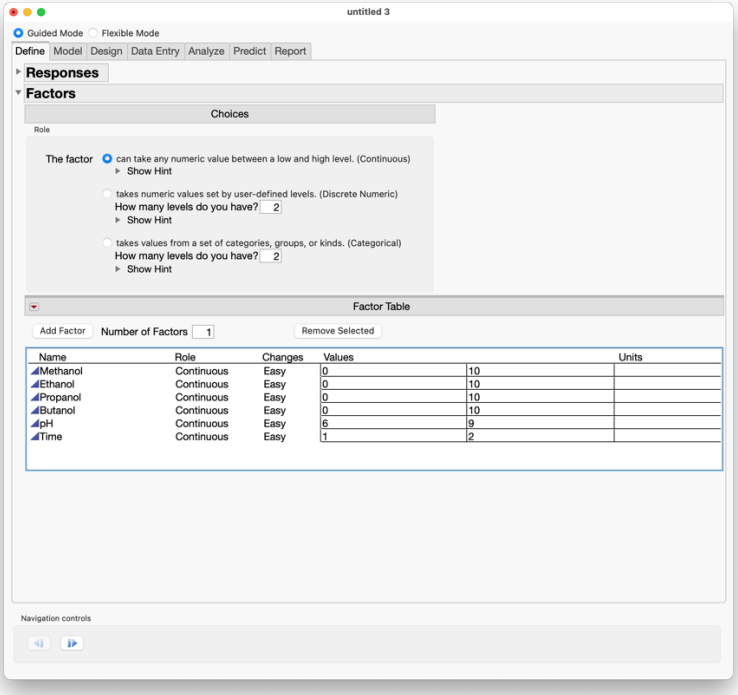
1. Use Easy DOE, Definitive Screening Design, or Custom Design to create a design. Consider the benefits of any of these methods. Why might you choose one over another?

a. Using Easy DOE:

1) Select **DOE** > **Easy DOE**.

2) In the **Number of Factors** box, enter 6, then click **Add Factor**.

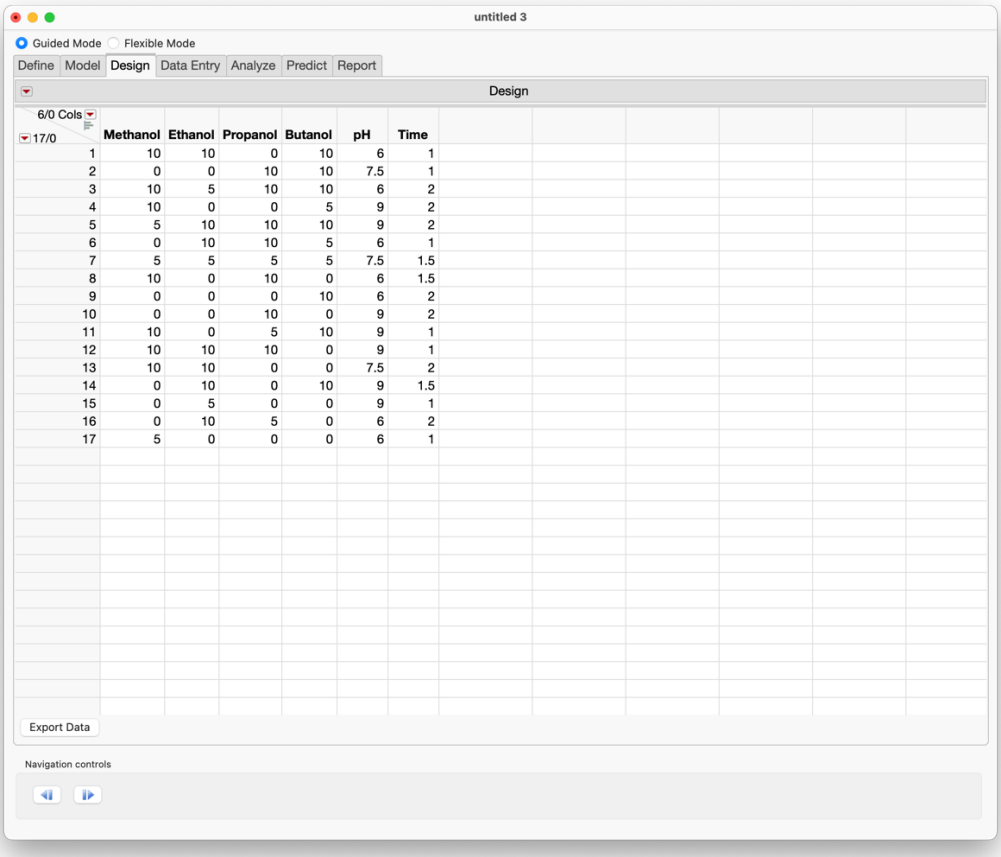
3) Enter the names and ranges of the factors as specified above.



4) Click the forward navigation control button.

5) Choose the model of interest. Choose only Main Effects if your primary concern is a low budget for runs. Choose Main Effects with some Two-Factor Interactions to add just a few more runs but gain the possibility of testing for interactions and curvature from the screening experiment. Choose All Main Effects and Two-Factor Interactions if you want to estimate all main effects and all 2-way interactions from the initial screening experiment. Choose All Main Effects, Two-Factor Interactions, and Quadratics to create a response surface design that also allows curvature for any factor.

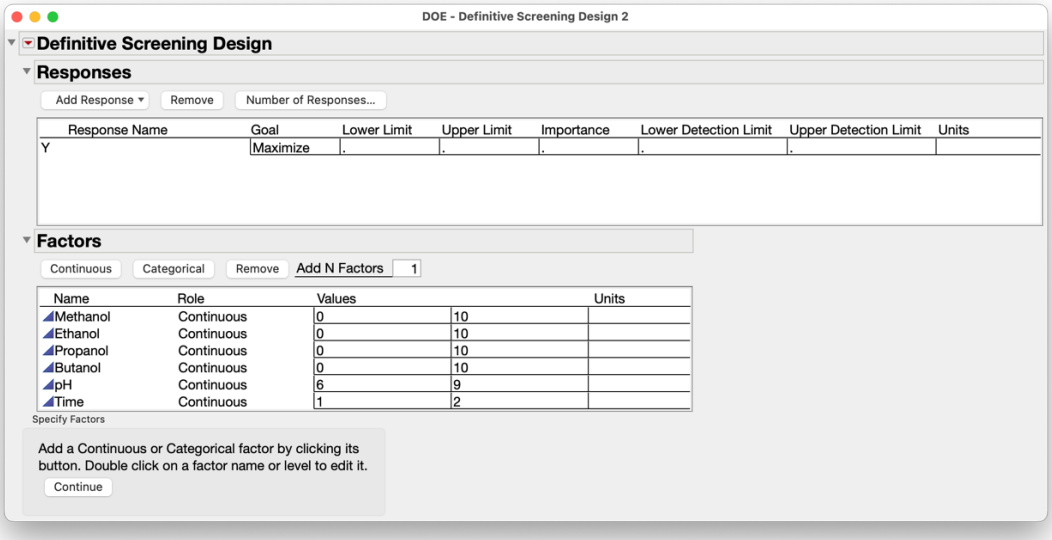
   Here we show the choice of Main Effects with some Two-Factor Interactions for comparison with the DSD created through the Definitive Screening Design platform.



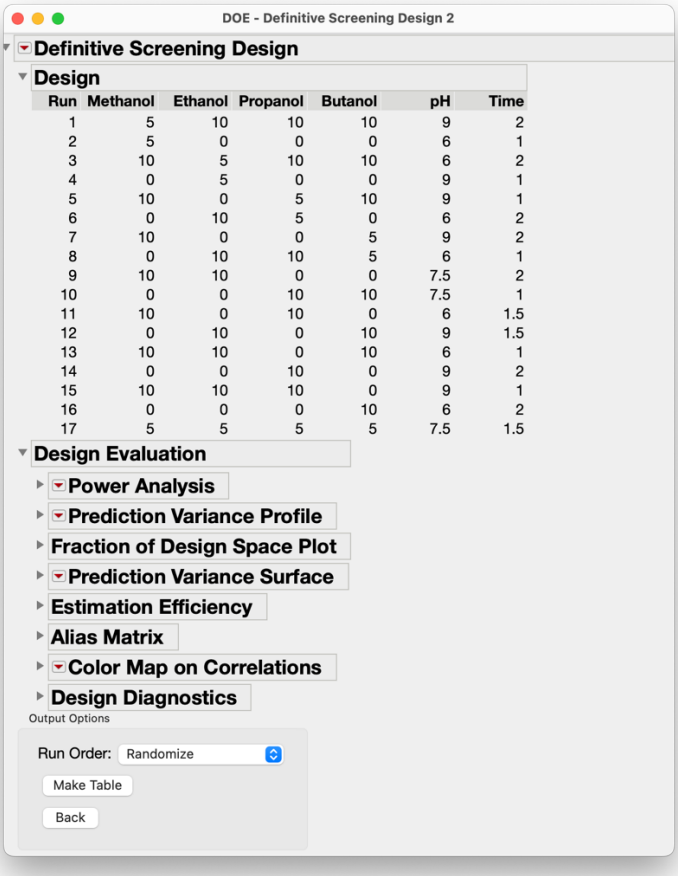
	Methanol	Ethanol	Propanol	Butanol	pH	Time
1	10	10	0	10	6	1
2	0	0	10	10	7.5	1
3	10	5	10	10	6	2
4	10	0	0	5	9	2
5	5	10	10	10	9	2
6	0	10	10	5	6	1
7	5	5	5	5	7.5	1.5
8	10	0	10	0	6	1.5
9	0	0	0	10	6	2
10	0	0	10	0	9	2
11	10	0	5	10	9	1
12	10	10	10	0	9	1
13	10	10	0	0	7.5	2
14	0	10	0	10	9	1.5
15	0	5	0	0	9	1
16	0	10	5	0	6	2
17	5	0	0	0	6	1

b. Using Definitive Screening Design:

1) Select **DOE** > **Definitive Screening > Definitive Screening Design**.
2) In the **Add N Factors** box, enter 6, then click **Continuous**.
3) Enter the names and ranges of the factors as specified above.
4) Click **Continue**.



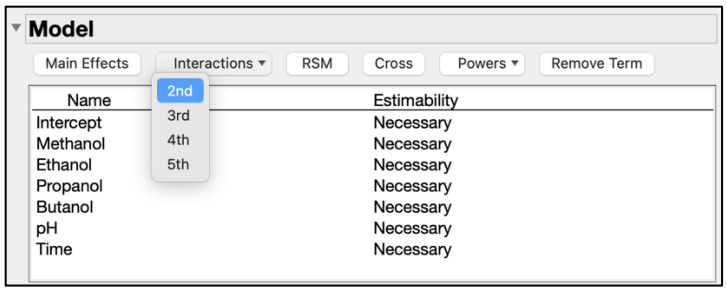
5) Click **Make Design**.



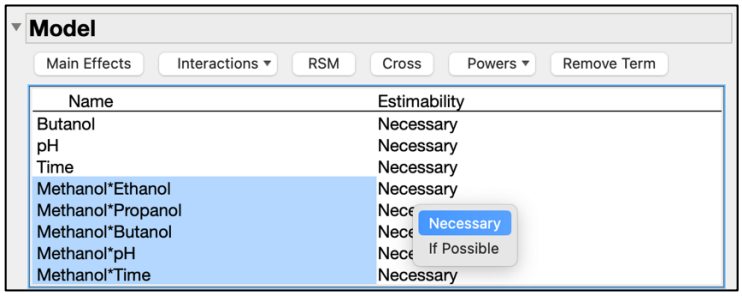
6) Click **Make Table**.

c. Using Custom Design:

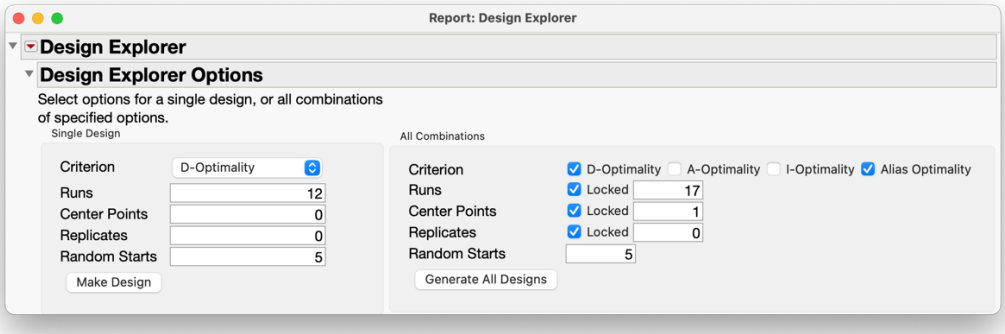
1) Select **DOE** > **Custom Design**.
2) In the **Add N Factors** box, enter 6, then click **Add Factor** > **Continuous**.
3) Enter the names and ranges of the factors as specified above.
4) Click **Continue**.



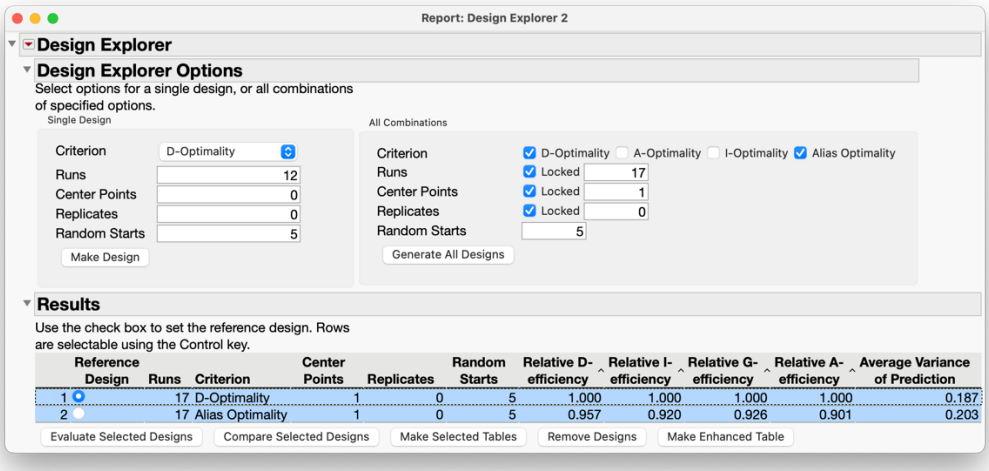
5) In the **Model**, select the **Interactions** drop-down and choose **2nd**. This model is equivalent to the *All Main Effects and Two-Factor Interactions* option from **Easy DOE**.
6) Select all of the 2-way interaction terms and click on **Necessary** next to one of these terms. Change **Necessary** to **If Possible** for all 2-way interactions. The Default **Number of Runs** changes from 28 to 12. Now it matches the Easy DOE option to estimate only *Main Effects*.



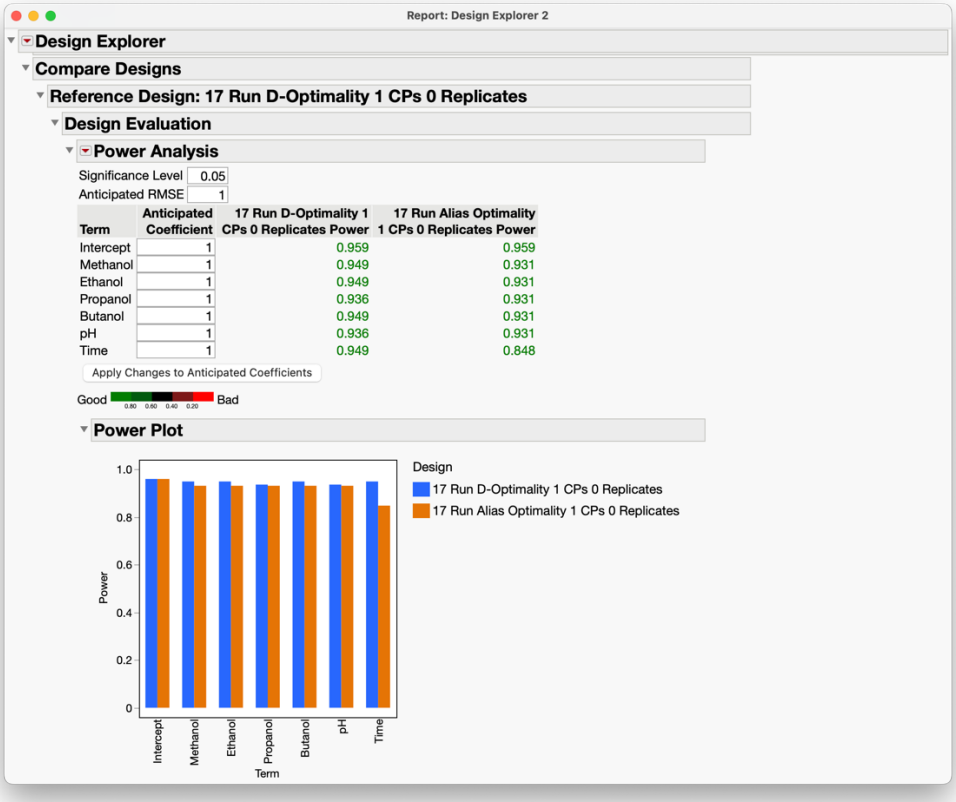
7) Click the **Design Explorer** button.
8) In the **All Combinations** box, enter 17 for **Runs** and 1 for **Center Points**.
9) Select the **Alias Optimality** options in addition to the **D-Optimality** option which is selected by default.



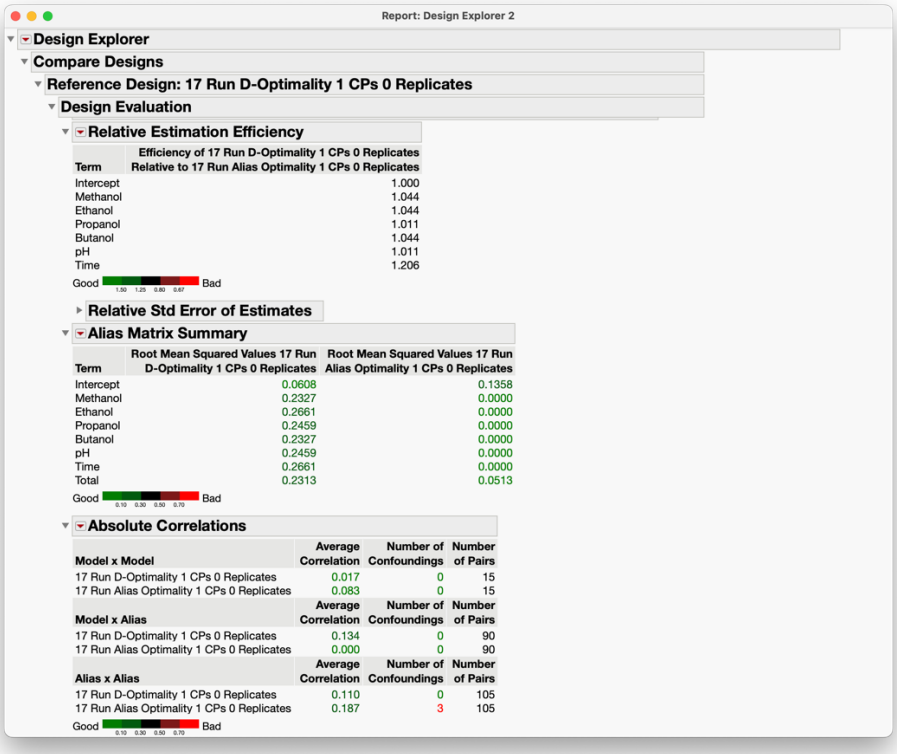
10) Click **Generate All Designs**.



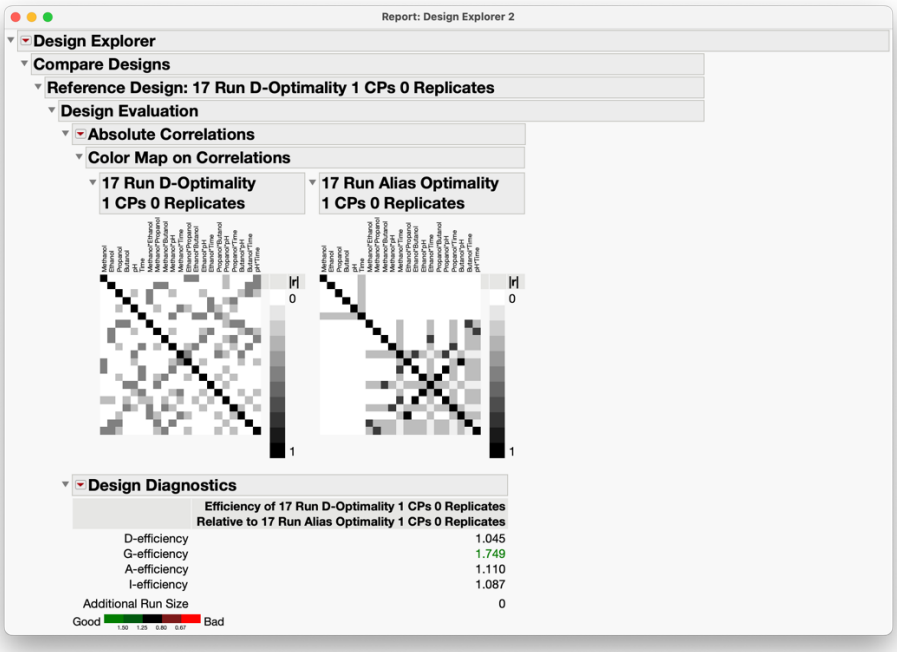
11) Select both resulting designs. Click **Compare Selected Designs**. Explore the comparison report to identify benefits and drawbacks of each design. For example, in the randomly generated designs compared below, the Alias-Optimal design has lower power to detect an effect for Time than the D-Optimal design has.



The D-Optimal design is slightly more efficient (with tighter confidence intervals on estimates) than the Alias-Optimal design.



The Alias-Optimal design has 3 completely confounded pairs of effects, but all interactions are uncorrelated with the main effects. The D-Optimal design has some correlation between interactions and main effects, so their estimation cannot be completely independent.



12) Select your preferred design in the **Results** report list and click **Make Selected Tables**.

d. Consider the benefits of any of these methods. Why might you choose one over another?

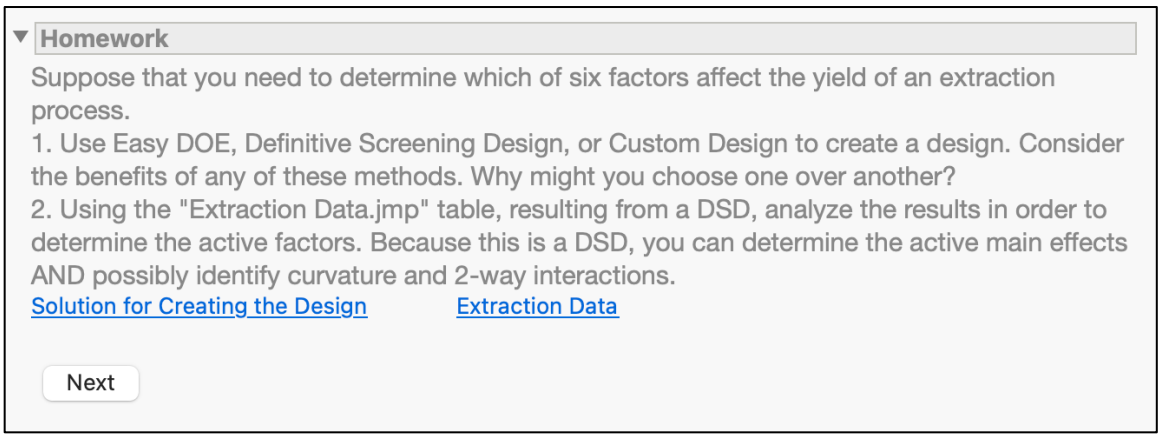
For this simple example of a single continuous response and six continuous factors, with no constraints or complications, the Definitive Screening Design is an excellent choice. It has the benefits of extracting maximum information, especially about 2-way interactions and curvature, from a minimum number of runs. The DSD allows estimation of the main effects independent of any model form that might include higher-order effects, which allows the two-stage ability to first find active effects and then build the response surface model to those effects.

The DSD will be fit, in this case, from Easy DOE, so either platform can produce this design.

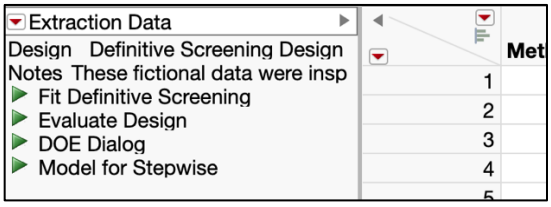
The Custom platform is the most flexible (and often the only choice) for more complex situations, but in this case the designs it produces will not be as efficient as the straightforward DSD.

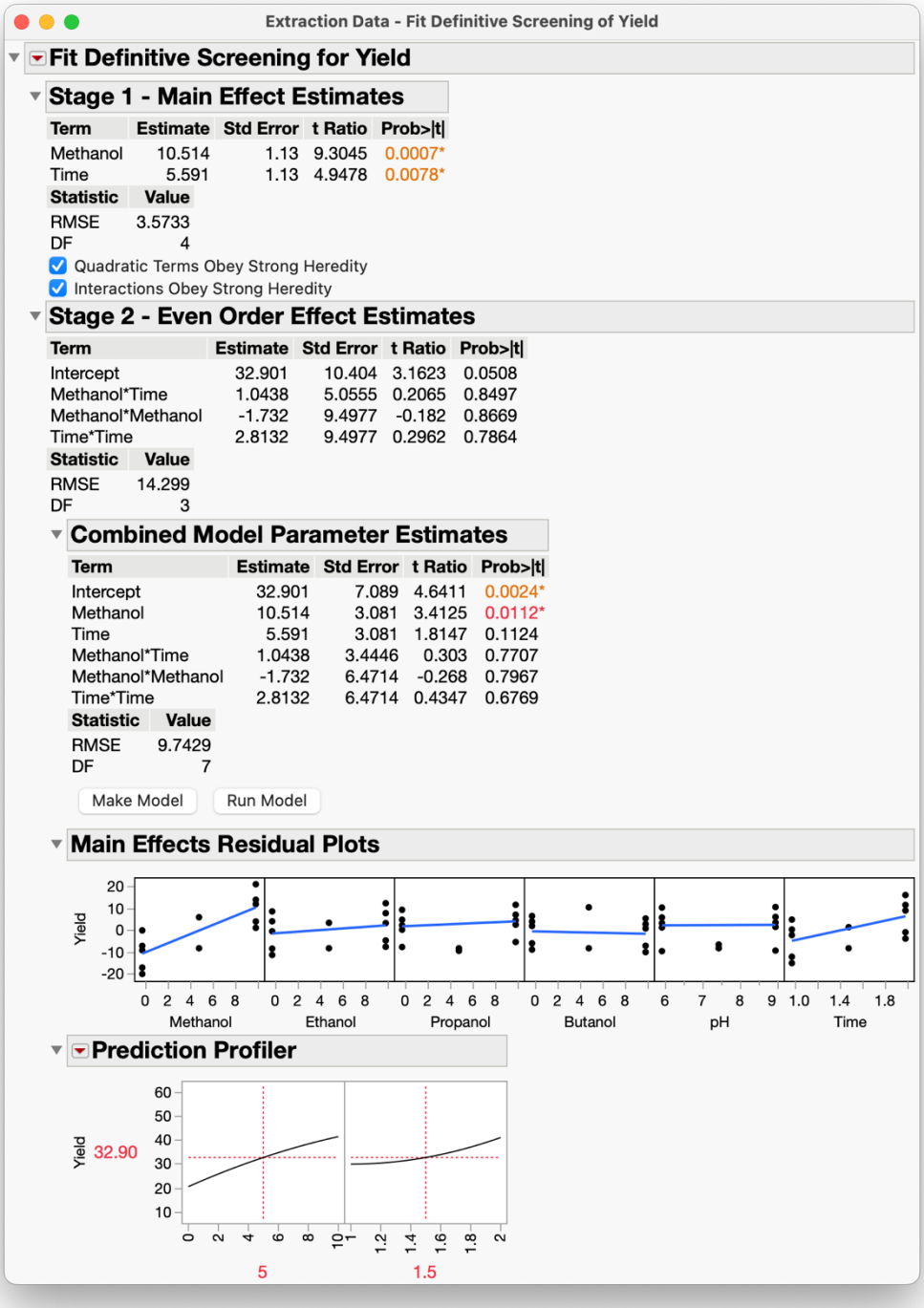
2. Using the **Extraction Data** table linked from the course journal, resulting from a DSD, analyze the results in order to determine the active factors. Because this is a DSD, you can determine the active main effects AND possibly identify curvature and 2-way interactions.

a. Select **Extraction Data** from the **Homework** section of the journal.



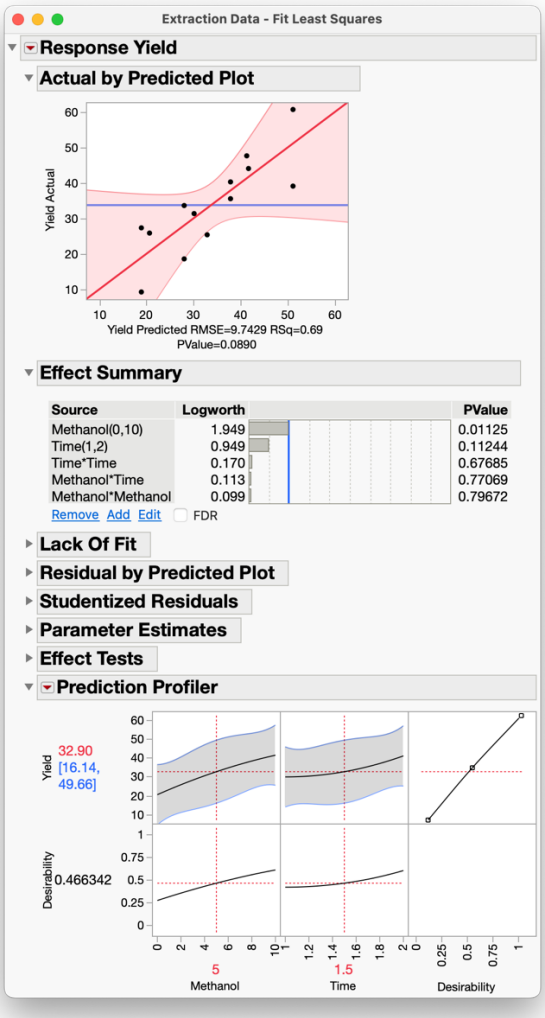
b. Click the green play button next to the **Fit Definitive Screening** script in the table panel.





In Stage 1, Methanol and Time are identified as the only active factors. In Stage 2, these factors are added, along with their interaction and their quadratic effects. Stage 2 shows a statistically significant effect for Methanol, but non-significant effects for all others. A follow-up experiment, or augmentation to this experiment, may add power to further investigate the non-significant effects.

c. Click the **Run Model** button to produce additional output for this Stage 2 model.



d. From the red triangle by **Response Yield**, select **Factor Profiling** > **Surface Profiler**. Click in the plot to rotate and explore.