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EST. 1927

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A (Very) Brief Intro to DOE

What *is* DOE?

- It's not

What *is* DOE?

- And it's not

What *is* DOE?

- **D**esign **o**f **E**xperiments
  - But wait! Aren't *all* experiments "designed"?!?
  - Well, not all…
    - …are designed with the end analysis in mind, and…
    - Not all meet the primary requirement of a DOE

What is that primary requirement?

- The ability to vary all the important input parameters to the desired levels
  - Many types of experiments do not allow you to set the inputs, rather, you can only observe the inputs

So, what *is* DOE?

- "…the process of planning the experiment so that the appropriate data that can be analyzed by statistical methods will be collected, resulting in valid and objective conclusions."
  - Douglas Montgomery, *Design and Analysis of Experiments*, 5th ed, pg 11

What *is* DOE?

- "…a planned approach for determining cause and effect relationships."
  - Mark Anderson & Patrick Whitcomb, *DOE Simplified*, pg ix

What *is* DOE?

- "…consists of purposeful changes of the inputs (factors) to a process in order to observe the corresponding changes in the outputs (responses)."
  - Stephen Schmidt and Robert Launsby, *Understanding Industrial Designed Experiments*, 3rd ed, pg 1-2

What *is* DOE?

- "The generation of response data from systematically selected combinations of input factors that are used to create mathematical models (equations) from which valid and objective conclusions about the inputs and outputs can be inferred."
  - Steve Figard, *Biostatistics with JMP-An Introductory Course*, in process

Goals of DOE

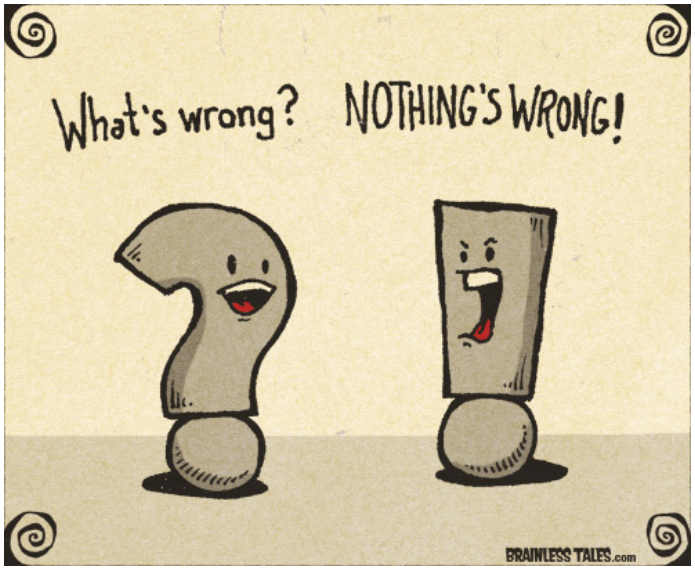
- To identify (screening)
- To predict (RSM)
  - “Prediction is very hard, especially when it is about the future.”
    - Yogi Berra
- To do so with minimum resources

Why DOE?

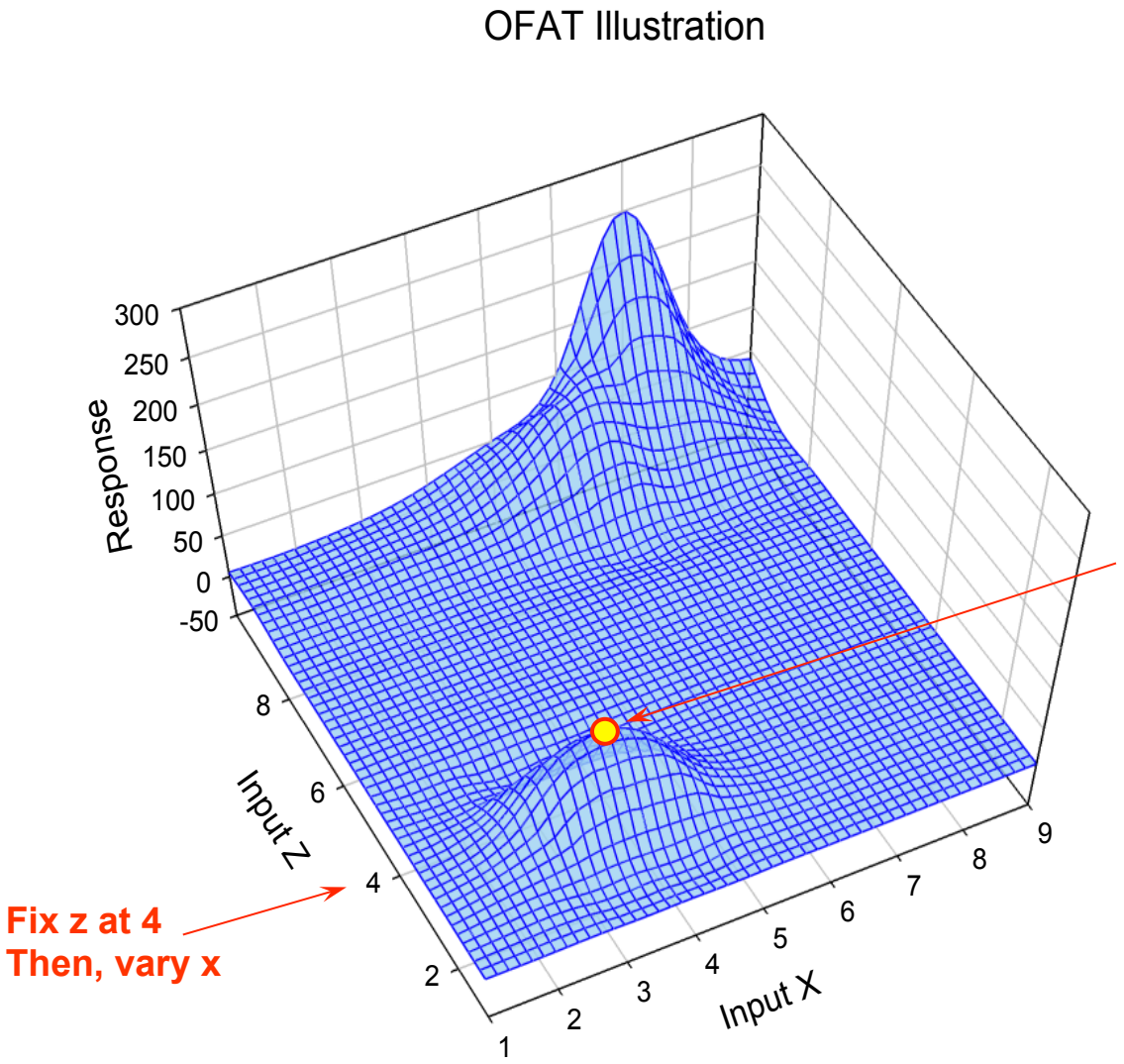
- Best to explain by way of contrast to OFAT
  - *Not* how you respond to your significant other's question about how her new dress makes her look!
- ***O***ne-***f***actor-***a***t-a-***t***ime: the time honored, traditional way of doing experiments via the scientific method

Why DOE?

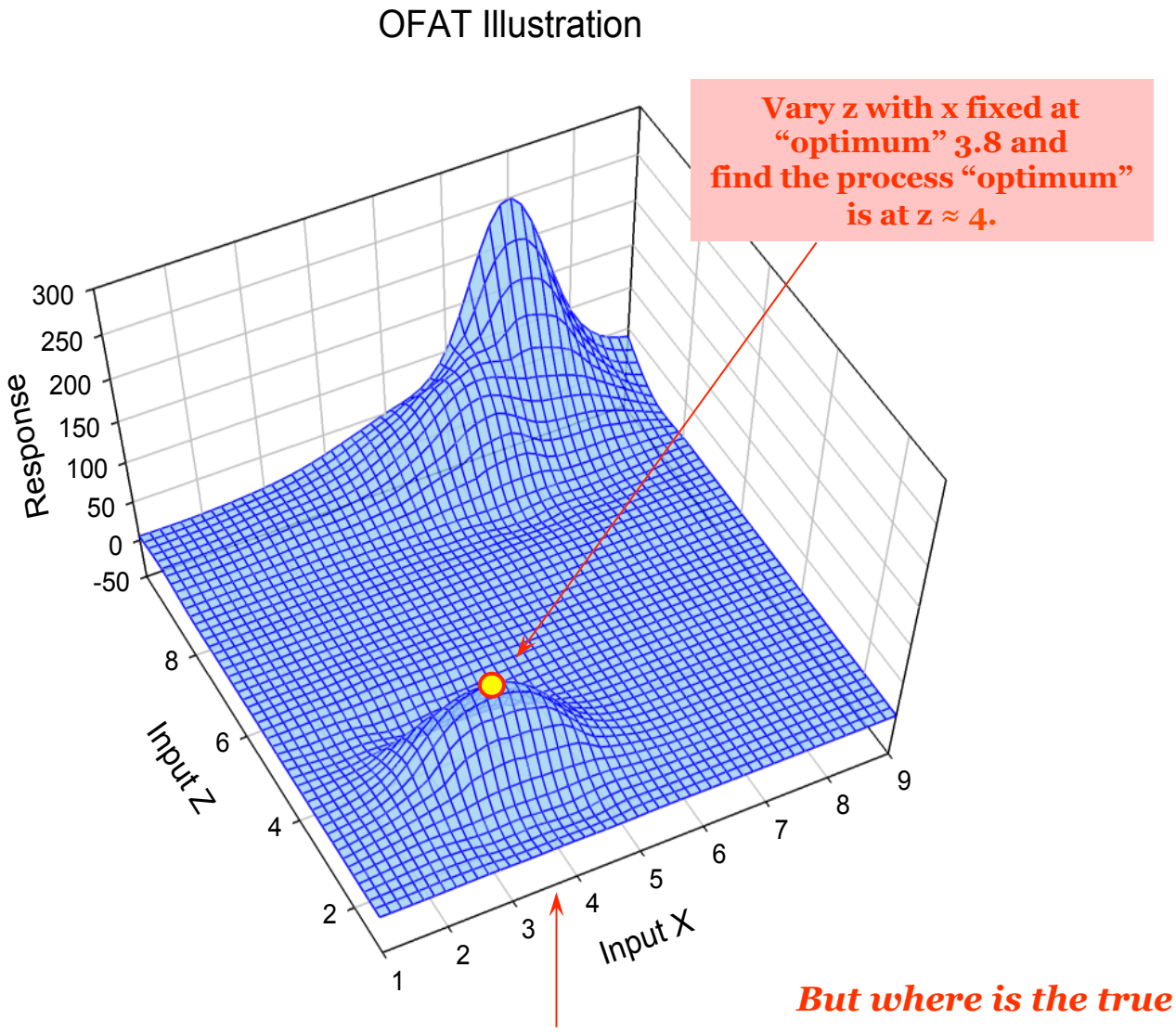
- What's wrong with OFAT…?
  - Can miss the true optimum
  - Does not account for interactions
  - Has lower statistical power of analysis



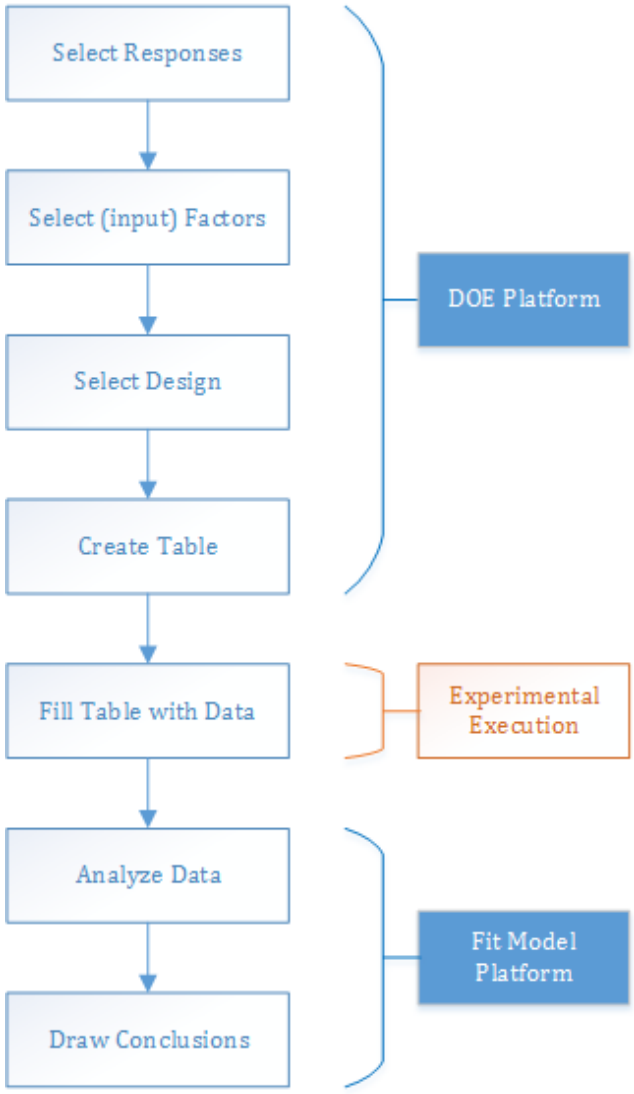
OFAT


OFAT Illustration
Response
300
250
200
150
100
50
0
-50
Input Z
8
6
4
2
Input X
1
2
3
4
5
6
7
8
9
Fix z at 4
Then, vary x
Find "optimum" at
x ≈ 3.8

OFAT

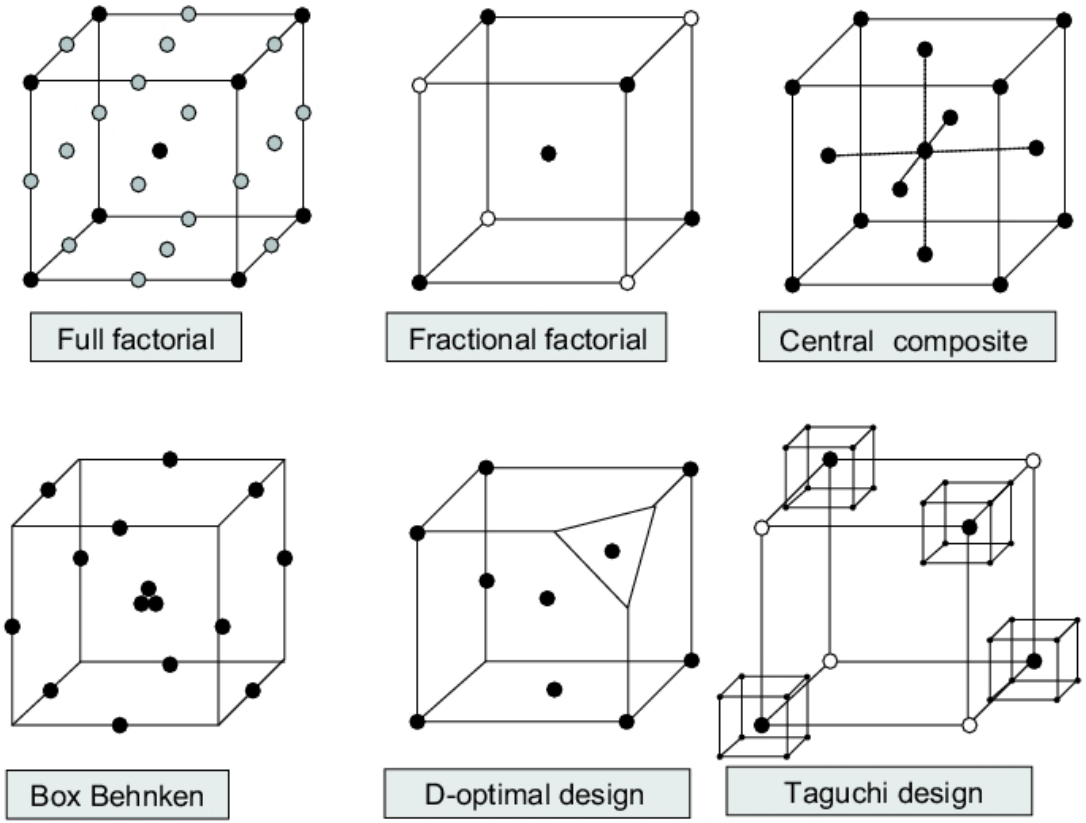

OFAT Illustration
Vary z with x fixed at "optimum" 3.8 and find the process "optimum" is at z ≈ 4.
Response
300
250
200
150
100
50
0
-50
Input Z
8
6
4
2
Input X
1
2
3
4
5
6
7
8
9
But where is the true optimum?

DOE in JMP


Select Responses
Select (input) Factors
Select Design
Create Table
Fill Table with Data
Analyze Data
Draw Conclusions
DOE Platform
Experimental Execution
Fit Model Platform

Design Selection?

- Determining what combinations of factors to run

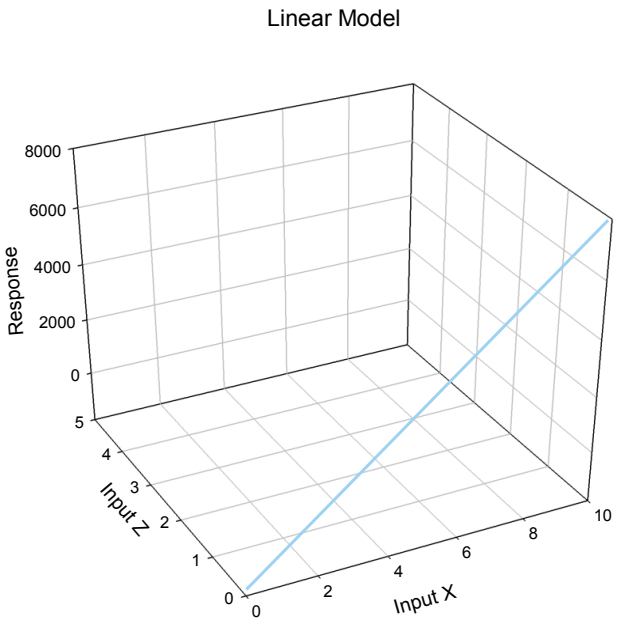


Modeling?

- Creating the equation that connects the input variable(s) to the response variable

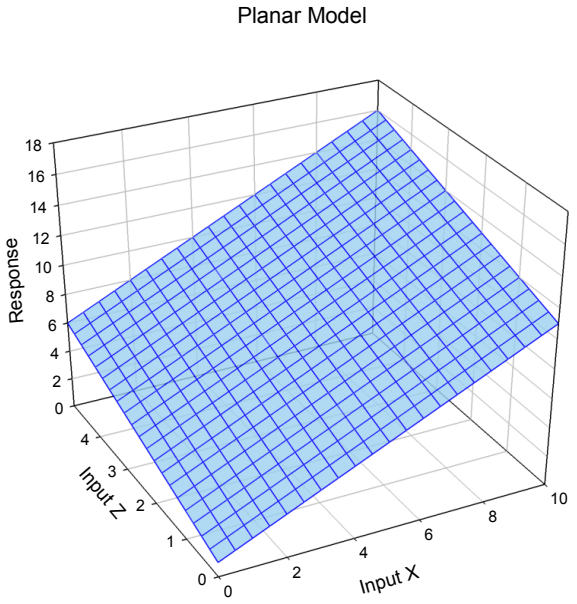
Modeling

- **Line:** Linear model in 1 variable
  - y = a + bx
  - slope in x direction
    - i.e., slope in X,Y plane
  - no slope in z direction
  - line for z = 0



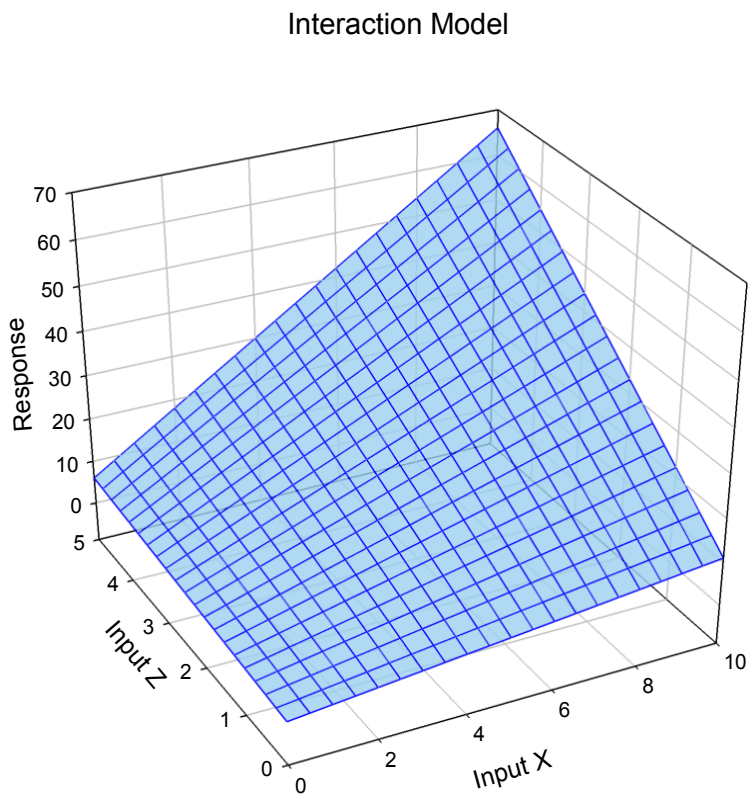
Modeling

- **Plane: Linear Model in 2 Variables**
  - y = a + bx + cz
  - Used to analyze screening designs
  - No curvature
  - No interactions
  - x and z are “Main Effects”



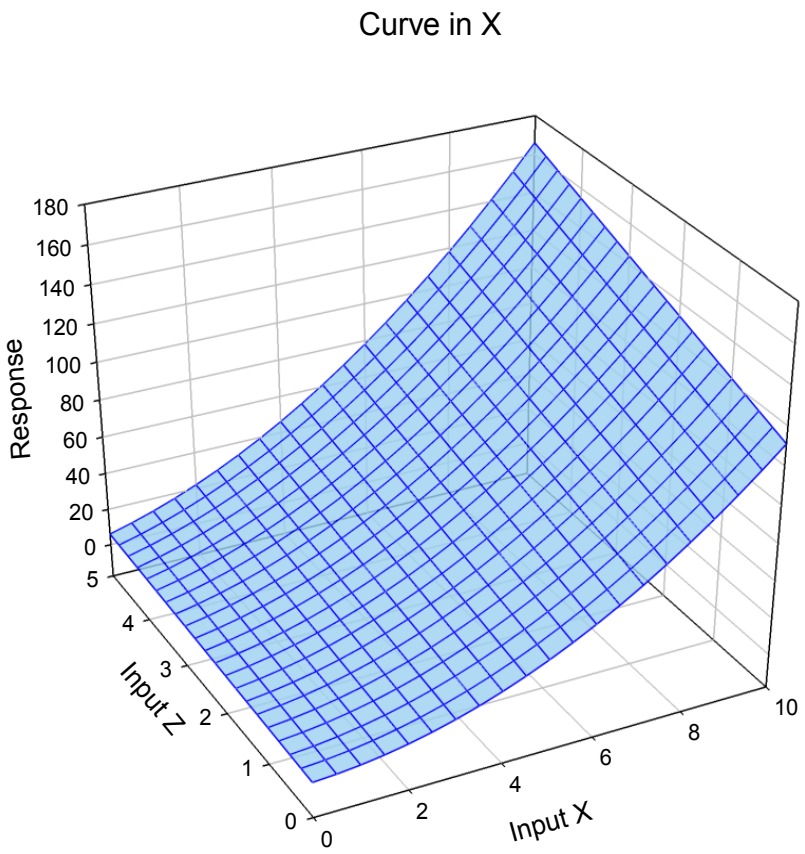
Modeling

- **Interaction Twists Plane**
  - $y = a + bx + cz + dxz$
  - Still no curvature
  - xz is an interaction between x and z



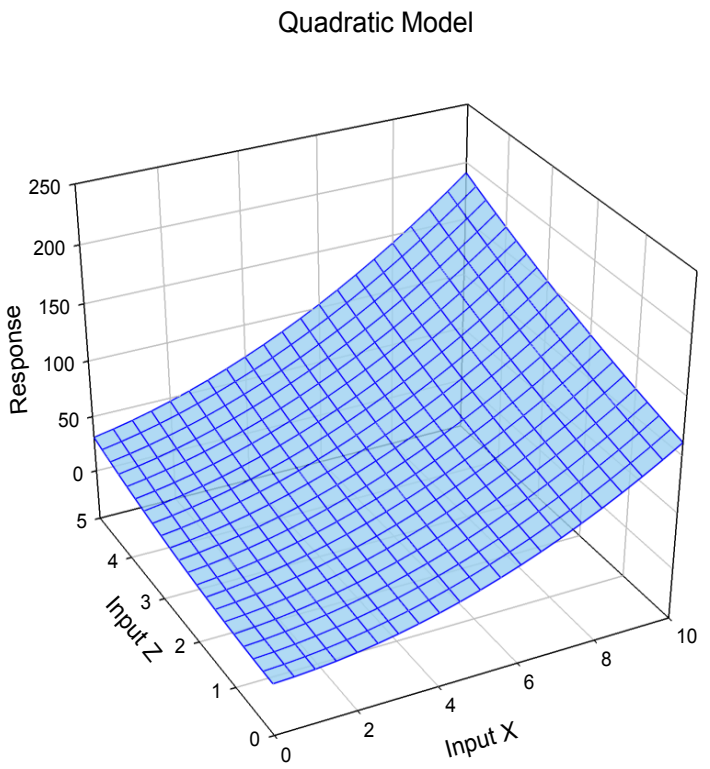
Modeling

- **Curvature in x Variable Only**
  - $y = a + bx + cz + dxz + ex^2$



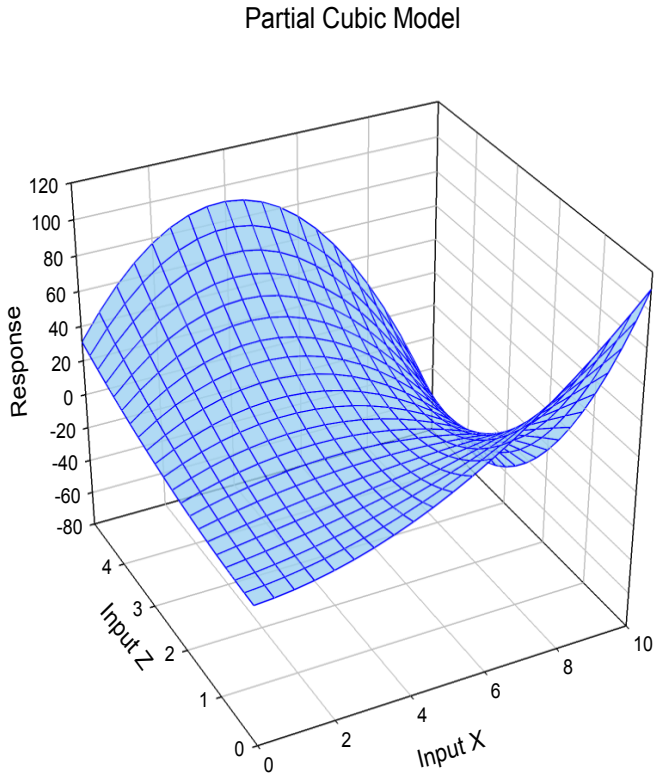
Modeling

- **Quadratic Allows Curves In All Variables**
  - $y = a + bx + cz + dxz + ex^2 + fz^2$
  - Used to analyze standard response surface designs
  - Constitutes the overwhelming majority of cases in “Nature”



Modeling

- **Partial Cubic Allows Curves Both Up and Down in All Variables**
  - $y = a + bx + cz + dxz + ex^2 + fz^2 + gx^2z + hxz^2$



Practice DOE

- Hand-Eye Coordination
  - Two factors
    - Hand: Dominant vs. Non-dominant
    - Target Diameter: small vs. large
  - Response
    - The number of dots the “operator” can mark
      - in two circles
      - alternating between circles
      - in 10 seconds
      - subtracting one from your count for each dot outside either circle

Practice DOE

- For *efficient* data collection, we need…
  - Three (3) volunteers
    - Operator to make the dots
    - Timer to time the 10 seconds
    - Someone to count the dots while data collection continues

- But let's go to JMP to set up the experiment while you cogitate on which you want to volunteer to do…