

Response Surface Method

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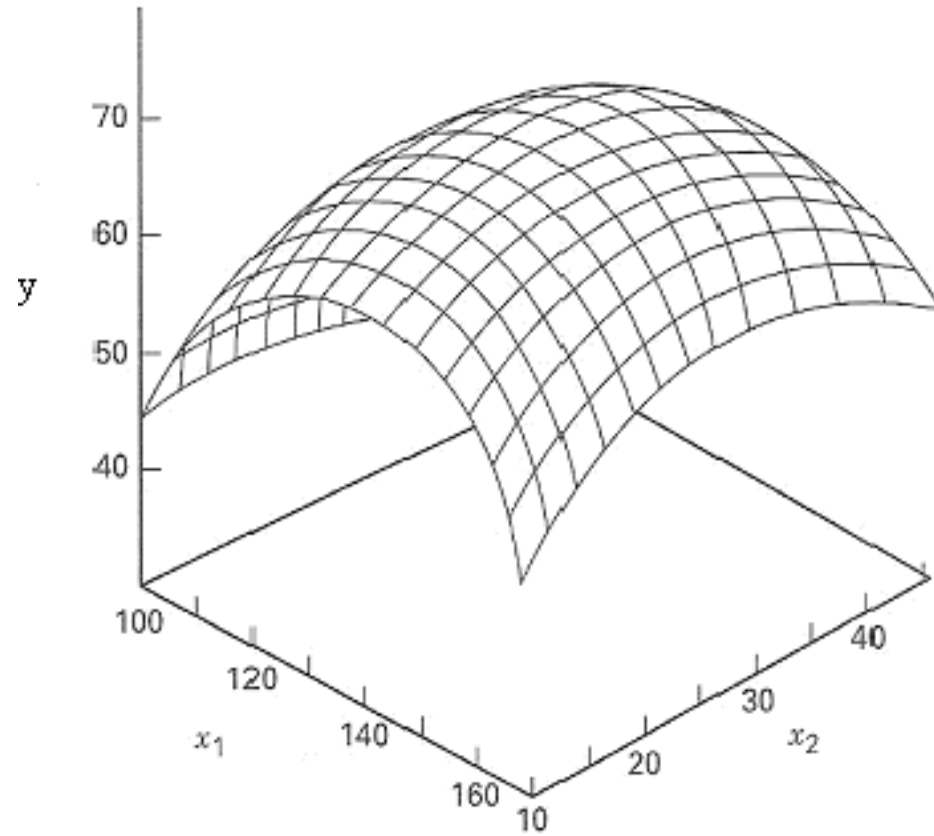
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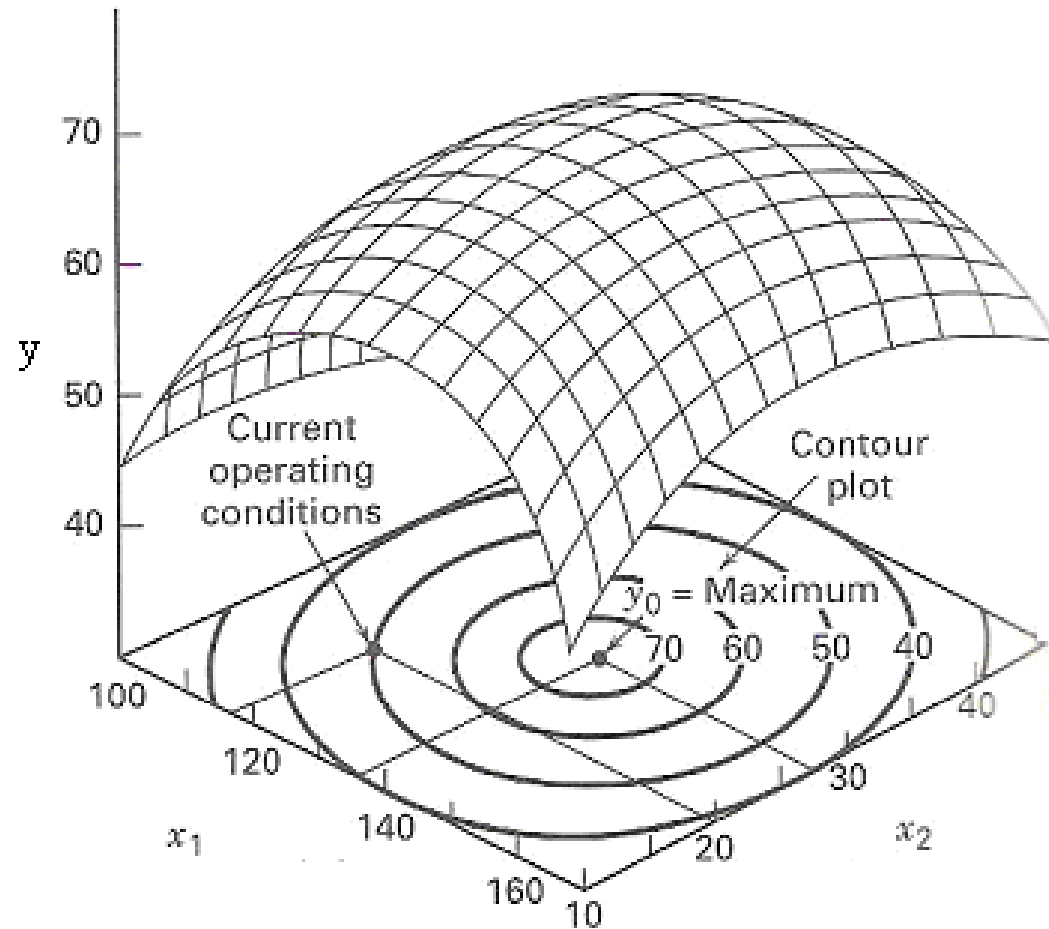
- The experimentation plays an important role in Science & Engineering
- The experimentation carried out to experimental units result in measurement of one or more responses.
- results and conclusions can be drawn by experiment
- The approximation of the response function $y = f(x_1, x_2, \dots, x_q) + \varepsilon$ is called Response Surface Methodology.

Response Surface Method

- The response surface methodology (RSM) is a widely used mathematical and statistical method for modeling and analyzing a process in which the response of interest is affected by various variables
- The **first goal** for Response Surface Method is to find the optimum response.
- The **second goal** is to understand how the response changes in a given direction by adjusting the design variables.
- In general, the response surface can be visualized graphically.
- The graph is helpful to see the shape of a response surface; **hills, valleys, and ridge lines.**



The function $f(x_1, x_2)$ can be plotted versus the levels of x_1 and x_2 as shown as Figure. This three-dimensional graph shows the response surface from the side and it is called a **response surface plot**.



- The contour plots can show contour lines of x_1 and x_2 pairs that have the same response value y .
- To understand the surface of a response, graphs are helpful tools.
- But, when there are **more than two independent variables**, graphs are difficult or almost impossible to use to illustrate the response surface, since it is beyond 3-dimension.
- For this reason, response surface models are essential for analyzing the unknown function f .



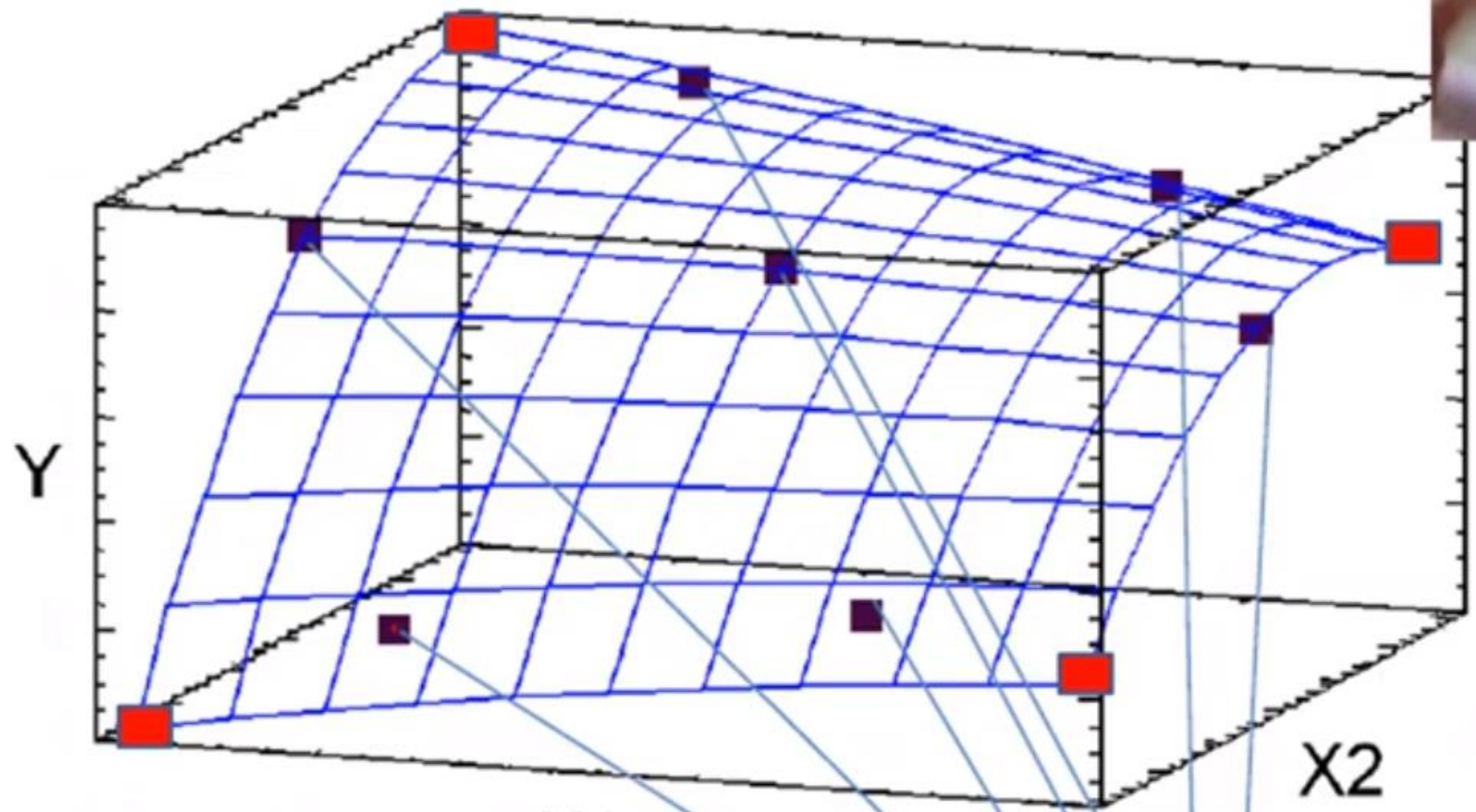
RSM = Response Surface Methodology; Introduction

- It is a collection of statistical & mathematical techniques
- It is useful for developing optimizing process of new formulations
- It is used to improving the existing formulations for still betterment
- Consider there is 3 Factors & 5 Levels in experiment
- Total possible runs are $3 \times 3 \times 3 \times 3 \times 3 = 243$ trials
- Actually researcher to conduct 243 trials which takes long time & investment



RSM = Response Surface Methodology; Introduction

- ☛ But, If they use RSM, with the help of just 20 trials, he can get results of 243 trials
- ☛ Hence, RSM saves lot of time & investment
- ☛ It gives maximum information from minimum number of experiments
- ☛ It screen out all factors at all possible levels, so it tests all possible runs
- ☛ RSM can be used with the help of specialized following soft wares
- ☛ Example: Micro soft Excel, Minitab, Matrex, Omega, Design Expert etc.,



 **Points Estimated Manually
& feed into software**

 **Points Estimated
by RSM**

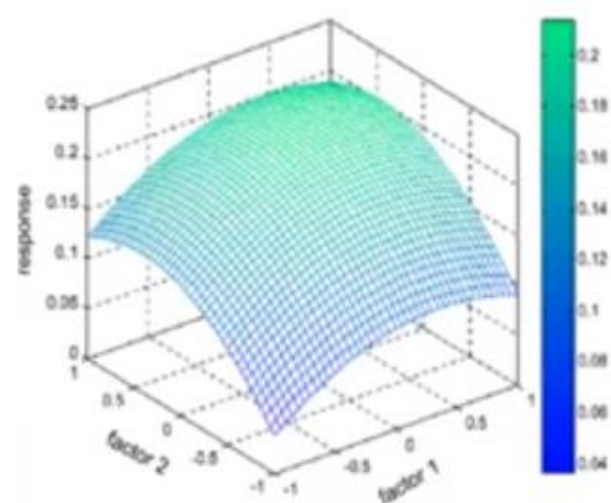
Surface Response Plots (SRP); Types of Presentation

◀ Graphical presentation of all 243 trials can be done in three types

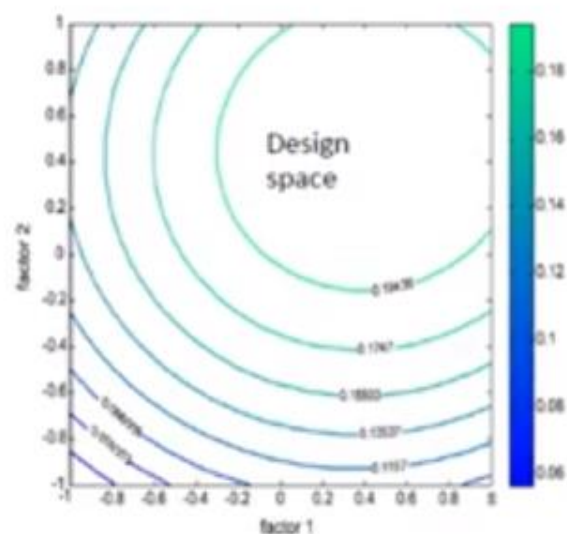
◀ Type 1: SRP 3-D type

◀ Type 2: SRP 2-D type (Contour Plot) (Circular Plots)

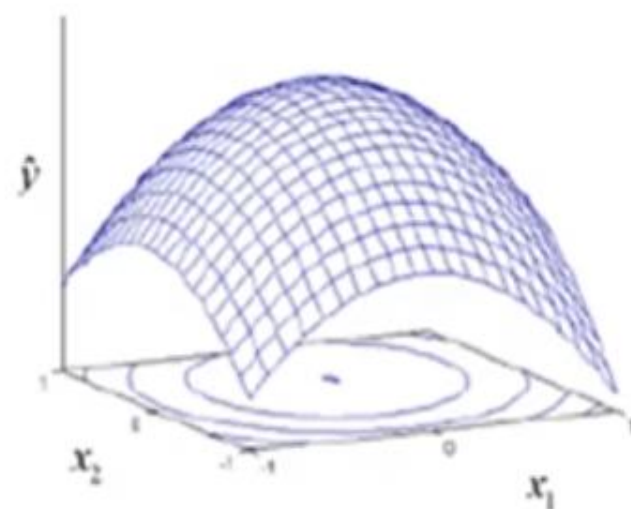
◀ Type 3: SRP Combination of 3-D & 2-D plots



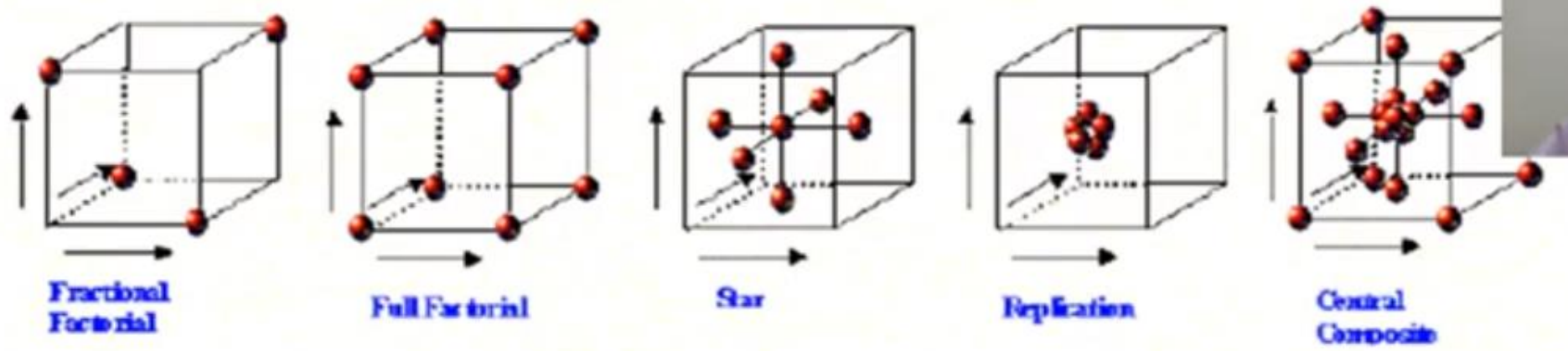
Type 1: 3-D Type



Type 2: 2-D Type



Type 3:
Combination of
3-D Type & 2-D Type

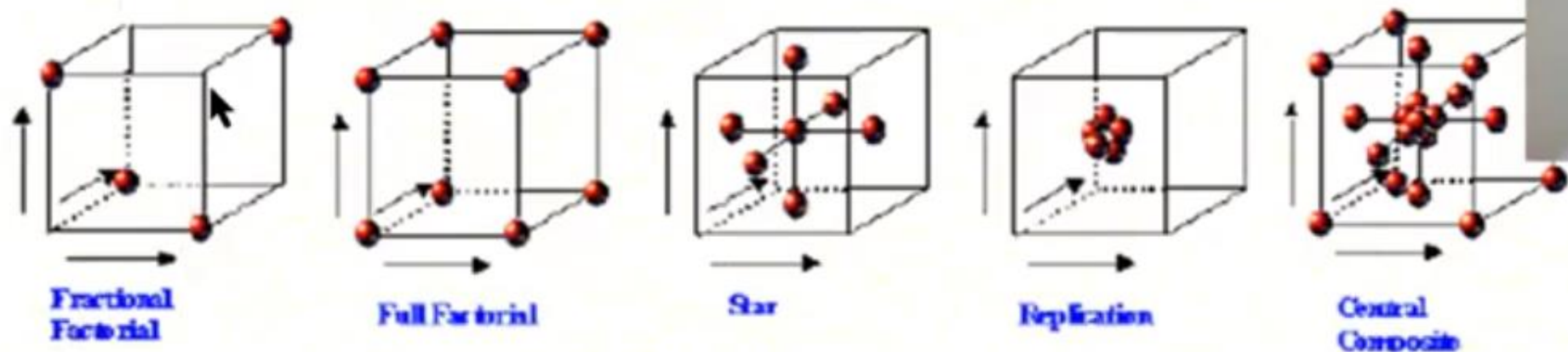


Surface Response Design (SRD); Types of Designs

- ◀ Fractional Factorial Design
- ◀ Full Factorial Design
- ◀ Star Factorial Design
- ◀ Replication Design
- ◀ Central Composite Design

Central Composite Design (CCD)

- ◀ It is also called as “Box-Wilson Central Composite”
- ◀ It is an important design as it suits to 2nd order reactions, empirical model
- ◀ CCD = A combination of Fractional Points + Set of Centre Points + Set of Star Points



Surface Response Design (SRD); Types of Designs

◀ Fractional Factorial Design

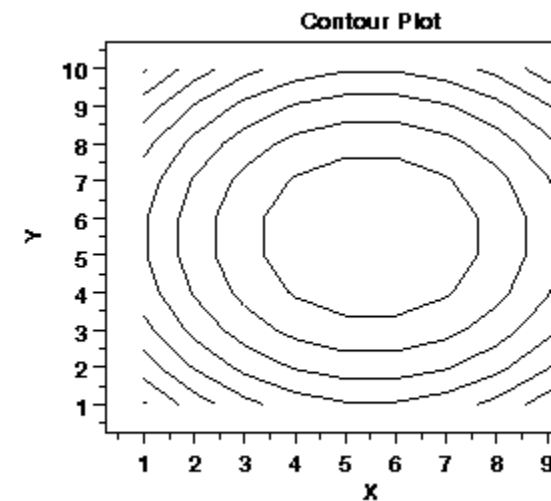
◀ Full Factorial Design

◀ Star Factorial Design

◀ Replication Design

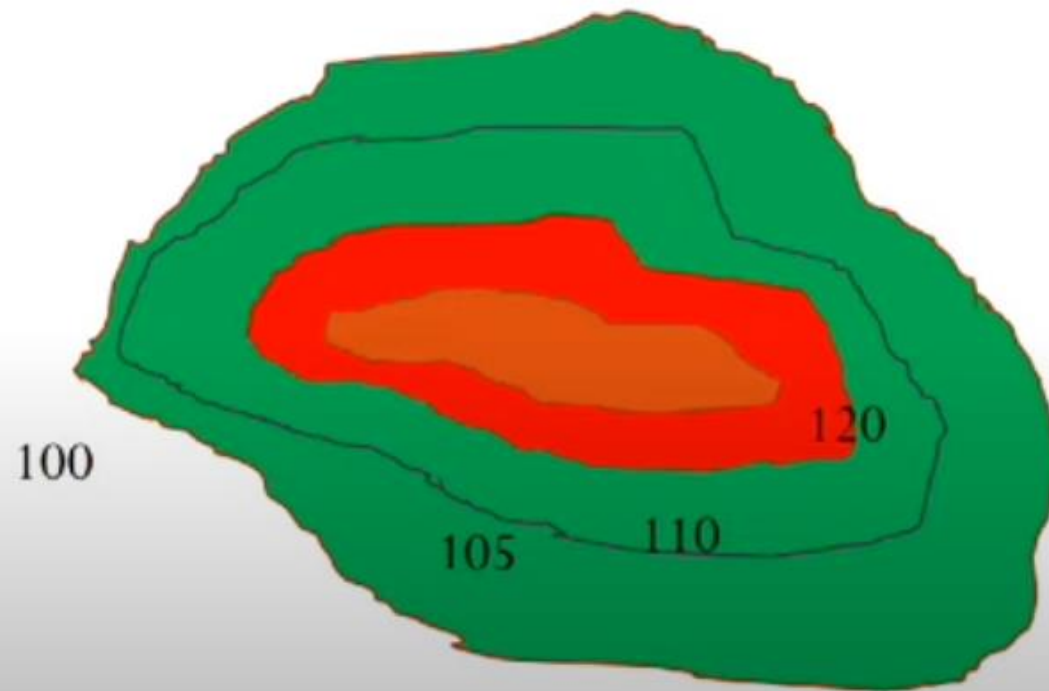
◀ Central Composite Design

- Contour plots (sometimes called Level Plots) are a way to show a three-dimensional surface on a [two-dimensional plane](#).
- A contour plot allows you to visualize three-dimensional data in a two-dimensional plot.
- A contour plot is a graphical technique for representing a 3-dimensional surface by plotting constant z slices, called contours, on a 2-dimensional format.
- That is, given a value for z , lines are drawn for connecting coordinates where that z value occurs.



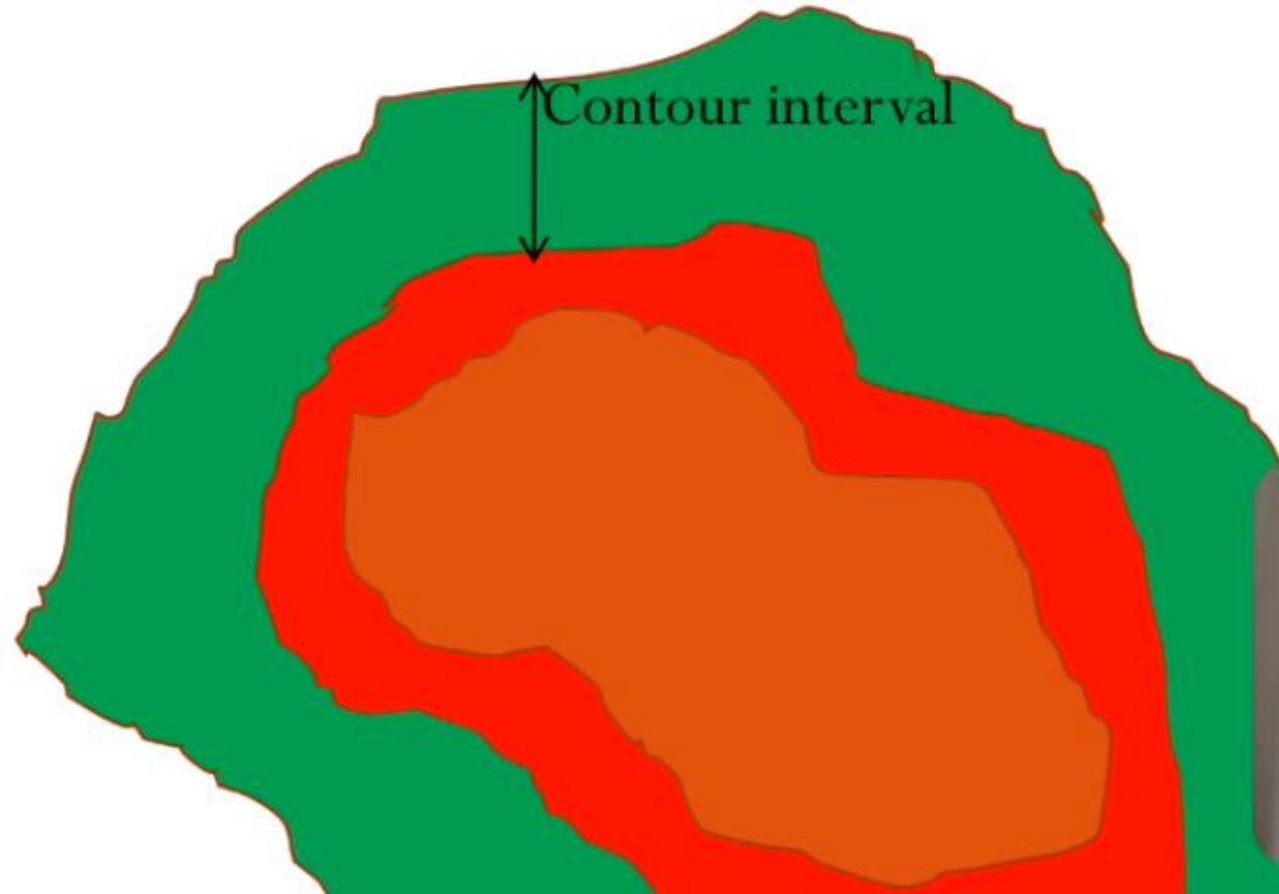
Contour

A contour is an imaginary line joining points of equal elevation



Contour Interval

- *The vertical distance between any two consecutive contours is known as contour interval*



Characteristics of contour lines

- *A series of contour lines with higher value inside indicate a hill*
- *A series of contour lines with lower value inside the loop always indicate depression*
- *Close contour lines indicate steep slope*
- *Wide contour lines indicate flatter slope*
- *Contour lines never cross each other except in case of overhanging cliff.*



contour line joins points of equal and constant values.

