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Saturday, September 25, 2021 11:11 AM

Section 1

MANE 6313

Subsection 1

Week 6, Module A

Student Learning Outcome

- Select an appropriate experimental design with one or more factors,
- Select an appropriate model with one or more factors,
- Evaluate statistical analyses of experimental designs,
- Assess the model adequacy of any experimental design, and
- Interpret model results.

Module Learning Outcome

Describe factorial designs.

Introduction

- We want to extend the analysis of variance to consider two or more treatment factors
- In general, the most efficient type of experiment is a factorial design.
- Suppose factor A has a levels and factor B has b levels. Each replicate of the factorial design contains all ab treatment combinations.
- This arrangement of treatments is said to be a *crossed* design

Nested

- Examine two-factor example in figure 5-1 & 5-2 on page 180

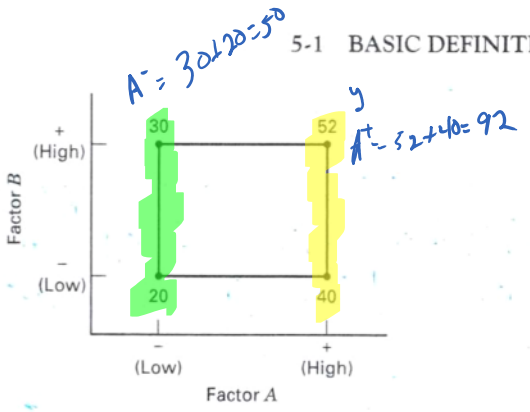


Figure 5-1 A two-factor factorial experiment, with the response (y) shown at the corners.

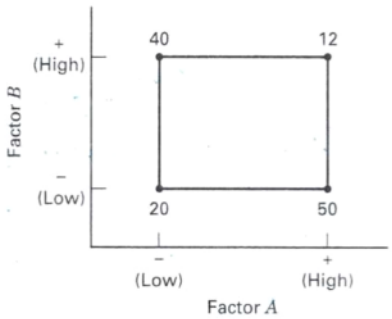
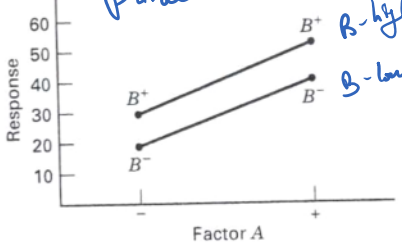


Figure 5-2 A two-factor factorial experiment with interaction.

Interaction plot

Parallel lines → no interaction



Not Parallel → interaction

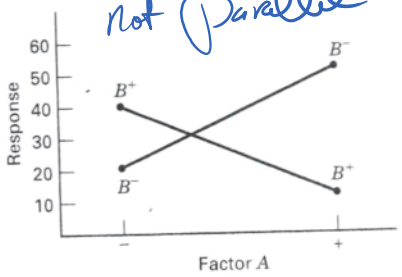


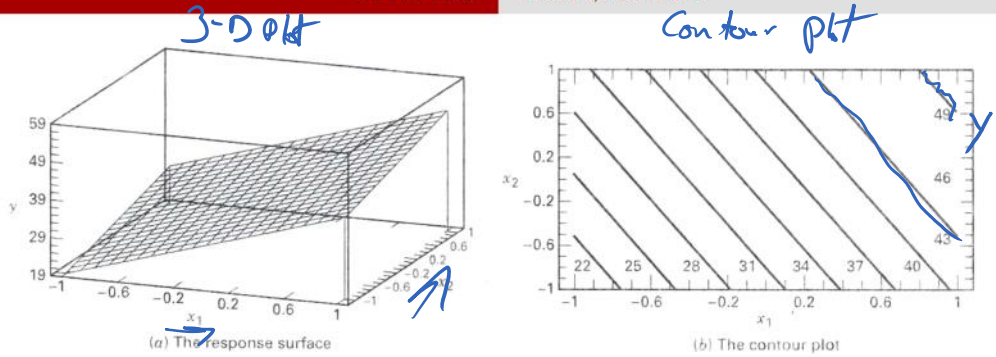
Figure 5-4 A factorial experiment with

Notation and other details

- If each factor has two levels, we can label the observations at a high level as (+) and observations at a low level as (-)
- Thus A^+, represent those experiments in which factor A is at its high level.
- The effect of switching from the high level to level of a factor can be found by $A^+ - A^-$ where A^+ is the average of all observations at the high level of A and A^- is the average of all observations at the low level of A
- When referring to one of the primary factors of an experiment, such as A, the difference due to changing levels is often called a *main effect*

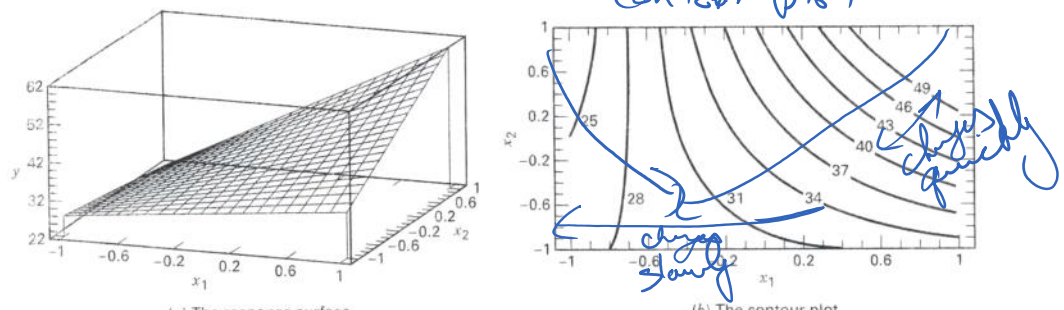
Interactions

- We may observe differences in response between the levels of one factor are not the same at all levels of the other factor.
- When these differences occur, an *interaction* is said to have occurred
- Study Figures 5-3 and 5-4 on page 181 to understand interactions
- We will be investigating this phenomenon with new models and analysis



(a) The response surface (b) The contour plot

Figure 5-5 Response surface and contour plot for the model $\hat{y} = 35.5 + 10.5x_1 + 5.5x_2$. No interaction



(a) The response surface (b) The contour plot

Figure 5-6 Response surface and contour plot for the model $\hat{y} = 35.5 + 10.5x_1 + 5.5x_2 + 8x_1x_2$. ← interaction term

Advantages of Factorial Designs

- More efficient (less experiments with same precision) than one-at-a-time experiments
- Inherent replication
- When interactions are present, one-at-a-time experiments may produce wrong results
- We are making estimates at several levels of each of the factors yielding results that are valid over a range of experimental conditions.

One-Factor At a Time Experiments

- Read Supplemental article "One-Factor-at-a-Time versus Designed Experiments"

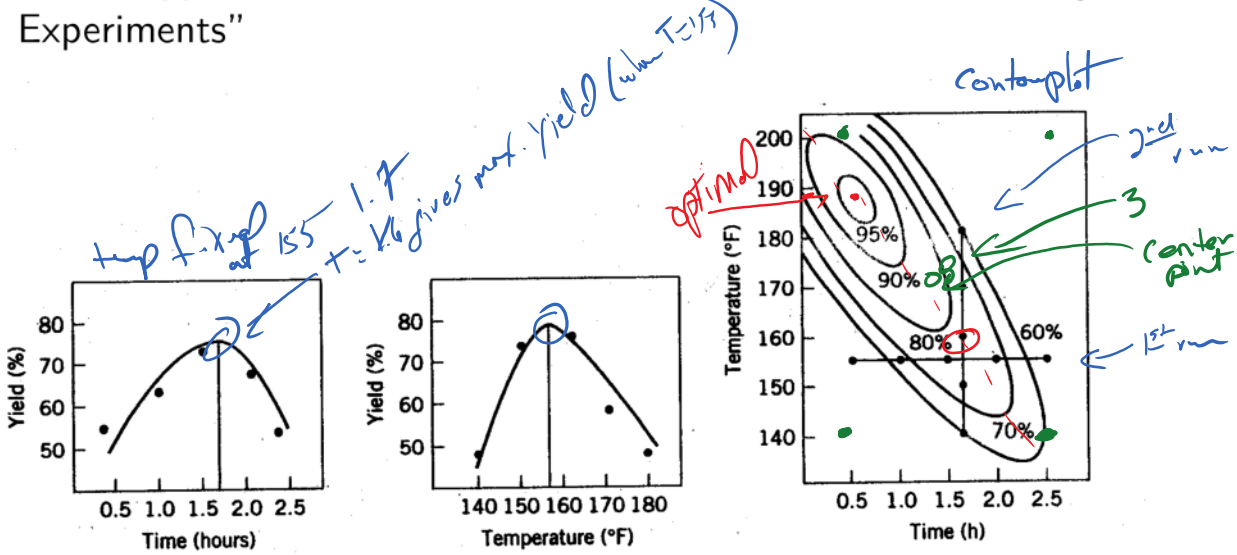


Figure 12-9 Yield versus reaction time with temperature constant at 155°F.

Figure 12-10 Yield versus temperature with reaction time constant at 1.7 h.

Figure 12-11 Optimization experiment using the one-factor-at-a-time method.

Figure 3: image

OFAT - bad
Factorial - Good