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## Section 1

## MANE 6313

Subsection 1

## Week 6, Module F

# 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

*General Factorial Design*

# General Factorial Design

- We will assume $n \geq 2$ so we can include all two-factor interactions and estimate SS-error
- For a fixed model with 3 factors we use the following model $\binom{3}{2}$ - 2 factor int. $\binom{3}{3}$ - 3-factor int

$$y_{ijkl} = \mu + \tau_i + \beta_j + \gamma_k + (\tau\beta)_{ij} + (\tau\gamma)_{ik} + (\beta\gamma)_{jk} + (\tau\beta\gamma)_{ijk} + \varepsilon_{ijkl} \begin{cases} i = 1, 2, \ldots, a \\ j = 1, 2, \ldots, b \\ k = 1, 2, \ldots, c \\ l = 1, 2, \ldots, n \end{cases}$$

- Sum of squares equations given on pages 201-202 (no surprises)

## Important Point

- The ANOVA and analysis is always the same for experiments with fixed effects factors
- The presence of random factors complicates the design
- The expected mean squares must be calculated and the divisor will not always be MS(error)!
- Discussed in chapter 12 (not covered in class).

# Blocking in a Factorial Design

- Consider the two-factor factorial design conducted as a randomized block design
- The statistical model is

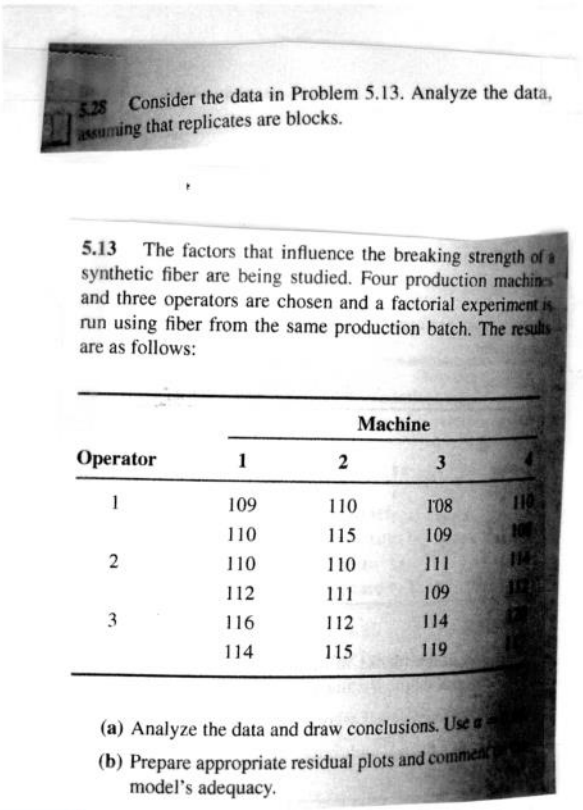
block effect

$$y_{ijk} = \mu + \tau_i + \beta_j + (\tau\beta)_{ij} + \delta_k + \varepsilon_{ijk} \begin{cases} i = 1, 2, \ldots, a \\ j = 1, 2, \ldots, b \\ k = 1, 2, \ldots, n \end{cases}$$

where $\delta_k$ is the block effect.

- The model assumes that interactions between blocks and treatments is negligible.
- If these interactions exist, they can not be separated from the error component.
- Sum of squares formulas and an example ANOVA are given in table

# Problem 5.28



5.28 Consider the data in Problem 5.13. Analyze the data, assuming that replicates are blocks.

**5.13** The factors that influence the breaking strength of a synthetic fiber are being studied. Four production machines and three operators are chosen and a factorial experiment is run using fiber from the same production batch. The results are as follows:

| | Machine | | | |
|---|---|---|---|---|
| **Operator** | **1** | **2** | **3** | **4** |
| 1 | 109 | 110 | 108 | 110 |
| | 110 | 115 | 109 | 108 |
| 2 | 110 | 110 | 111 | 114 |
| | 112 | 111 | 109 | 112 |
| 3 | 116 | 112 | 114 | 120 |
| | 114 | 115 | 119 | 117 |

**(a)** Analyze the data and draw conclusions. Use $\alpha$ =

**(b)** Prepare appropriate residual plots and comment on the model's adequacy.

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## Analysis of Variance

| Source | DF | Adj SS | Adj MS | F-Value | P-Value |
|---|---|---|---|---|---|
| Model | 12 | 219.500 | 18.292 | 4.63 | 0.008 |
| Blocks | 1 | 2.042 | 2.042 | 0.52 | 0.487 |
| Linear | 5 | 172.792 | 34.558 | 8.75 | 0.001 |
| Machine | 3 | 12.458 | 4.153 | 1.05 | 0.409 |
| Operator | 2 | 160.333 | 80.167 | 20.29 | 0.000 |
| 2-Way Interactions | 6 | 44.667 | 7.444 | 1.88 | 0.172 |
| Machine*Operator | 6 | 44.667 | 7.444 | 1.88 | 0.172 |
| Error | 11 | 43.458 | 3.951 | | |
| Total | 23 | 262.958 | | | |

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The block effect is not statistically significant and can be removed From the model

Only the operator term is statistically significant

Two-factor interaction is not statistically significant

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