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Section 1

MANE 6313

Subsection 1

Week 10, Module E

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

Analyze a one-quarter fraction manually.

$\rightarrow 2^{k-2}$

The quarter-fraction of the 2^k Design

- You must select two generators, $I = P$ and $I = Q$
- Don't forget the generalized interaction. The *complete defining relation* is $I = P = Q = PQ$
- There are four possible fractions formed by the combinations of $(\pm P, \pm Q)$
- The principal fraction is defined by $I = P = Q$
- The complementary fractions are $I = -P = Q$, $I = P = -Q$, $I = -P = -Q$

Quarter Fraction Example – Problem 8.11 (Textbook 9th edition)

8.11 An article in *Industrial and Engineering Chemistry* ("More on Planning Experiments to Increase Research Efficiency," 1970, pp. 60–65) uses a 2^{5-2} design to investigate the effect of A = condensation temperature, B = amount of material 1, C = solvent volume, D = condensation time, and E = amount of material 2 on yield. The results obtained are as follows:

$$e = 23.2 \quad ad = 16.9 \quad cd = 23.8 \quad bde = 16.8$$
$$ab = 15.5 \quad bc = 16.2 \quad ace = 23.4 \quad abcde = 18.1$$

(a) Verify that the design generators used were $I = ACE$ and $I = BDE$.

(b) Write down the complete defining relation and the aliases for this design.

(c) Estimate the main effects.

(d) Prepare an analysis of variance table. Verify that the AB and AD interactions are available to use as error.

(e) Plot the residuals versus the fitted values. Also ...

$2^{5-2} = 2^3$

A B C

$D = f(A,B,C)$

$E = f(A,B,C)$

Design Verification

Design Generators

$I = ACE \rightarrow A = A^2CE \rightarrow A = CE$

$I = BDE \rightarrow B = B^2DE \rightarrow B = DE$

full factorial in C, D, E

Create full factorial in CDE and A & B using design generators

C	D	E	A = CE	B = DE	trt
−	−	−	+	+	ab
+	−	−	−	+	bc
−	+	−	+	−	ad
+	+	−	−	−	cd
−	−	+	−	−	e
+	−	+	+	−	ace
−	+	+	−	+	bde

makes Problem Statement

Defining Relation

Full Defining Relation

$I = ACE = BDE = ABCDE^2$

$= ACE = BDE = ABCD$ ✓

Aliasing for Main Effects

$\ell_A = A(I = ACE = BDE = ABCD) = AI = A^2CE = ABDE = A^2BCD$

$= A = CE = ABDE = BCD$

$\ell_B = B(I = ACE = BDE = ABCD) \Rightarrow B = ABCE = DE = ACD$

$\ell_C = C(I = ACE = BDE = ABCD) \rightarrow C = AE = BCDE = ABD$

$\ell_D = D(I = ACE = BDE = ABCD) \rightarrow D = ACDE = BE = ABC$

$\ell_E = E(I = ACE = BDE = ABCD) \rightarrow E = AC = BD = ABCDE$

Aliasing for Interaction Effects

2 - Factor Interactions

There are $\binom{4}{2} = 6$ two-factor interactions:

AB, AC, AD, BC, BD, CD

ℓ_{AB}: $AB(I = ACE = BDE = ABCD)$

: $AB = A^2BCE = AB^2DE = CD$

: $AB = BCE = ADE = CD$

ℓ_{AC}: $AC(I = ACE = BDE = ABCD)$

: $AC = E = ABCDE = BD$

ℓ_{AD}: $AD(I = ACE = BDE = ABCD)$

: $AD = CDE = ABE = BC$