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Section 1

MANE 6313

Subsection 1

Week 5, Module D

Student Learning Outcome

Analyze simple comparative experiments and experiments with a single factor.

Module Learning Outcome

Evaluate Graeco-Latin Square Design.

Graeco-Latin Square Design

- Is constructed by superimposing two Latin square designs.
- We can have one factor and three nuisance factors in this design.
- The model is given on page 161
- The ANOVA and SS formulas are given on page 146

Problem 4.41

4.41 Suppose that in Problem 4.28 the engineer suspects that the workplaces used by the four operators may represent an additional source of variation. A fourth factor, workplace ($\alpha, \beta, \gamma, \delta$) may be introduced and another experiment conducted, yielding the Graeco-Latin square that follows. Analyze the data from this experiment (use $\alpha = 0.05$) and draw conclusions.

Order of Assembly	Operator			
	1	2	3	4
1	$C\beta = 11$	$B\gamma = 10$	$D\delta = 14$	$A\alpha = 8$
2	$B\alpha = 8$	$C\delta = 12$	$A\gamma = 10$	$D\beta = 12$
3	$A\delta = 9$	$D\alpha = 11$	$B\beta = 7$	$C\gamma = 15$
4	$D\gamma = 9$	$A\beta = 8$	$C\alpha = 18$	

Notice that each Latin letter appears once in each row and each Greek letter appears once in each column.

2) the sum of the 182 for each Greek letter is 182 for each Latin letter.

	C1	C2	C3	C4	C5	C6
	time	operator	assembly	latin	greek	
1	11	1	1	1	beta	
2	8	2	2	2	alpha	
3	9	3	3	3	delta	
4	9	4	4	4	gamma	

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Problem 4.41, continued

Problem 4.41, page 2

Columns

$$\begin{aligned}
 y_{...1} &= (11 + 8 + 9 + 9) = 37 \\
 y_{...2} &= (10 + 12 + 11 + 8) = 41 \\
 y_{...3} &= (14 + 10 + 7 + 18) = 49 \\
 y_{...4} &= (8 + 12 + 15 + 6) = 41
 \end{aligned}$$

$$\begin{aligned}
 SS_{\text{columns}} &= \frac{1}{4}(37^2 + 41^2 + 49^2 + 41^2) - \frac{168^2}{16} \\
 &= 19
 \end{aligned}$$

Workplace (a, b, c, d)

$$\begin{aligned}
 y_{...a} &= (8 + 11 + 18 + 8) = 45 \\
 y_{...b} &= (11 + 8 + 7 + 12) = 38 \\
 y_{...c} &= (9 + 10 + 10 + 15) = 44 \\
 y_{...d} &= (9 + 12 + 14 + 6) = 41
 \end{aligned}$$

$$\begin{aligned}
 SS_{\text{workplace}} &= \frac{1}{4}(45^2 + 38^2 + 44^2 + 41^2) - \frac{168^2}{16} \\
 &= 7.5
 \end{aligned}$$

Problem 4.41, continued

Problem 4-28 -

Total Sum of Squares

$$\sum \sum y_{ijk}^2 = 1834 \quad y_{...} = 164$$

$$SS_{\text{Total}} = 1834 - \frac{164^2}{16} = 153$$

Treatments

$$y_{A.} = (5+10+7+8) = 30$$

$$y_{B.} = (7+10+12+8) = 37$$

$$y_{C.} = (10+18+11+14) = 53$$

$$y_{D.} = (10+14+11+9) = 44$$

$$SS_{\text{Treatments}} = \frac{1}{4}(30^2 + 37^2 + 53^2 + 44^2) - \frac{164^2}{16} = 72.5$$

Rows

$$y_{..1} = (10+14+7+8) = 39$$

$$y_{..2} = (7+18+11+8) = 44$$

$$y_{..3} = (5+10+11+9) = 35$$

$$y_{..4} = (10+10+12+14) = 46$$

$$SS_{\text{Rows}} = \frac{1}{4}(39^2 + 44^2 + 35^2 + 46^2) - \frac{164^2}{16} = 18.5$$

Problem 4.41, continued

Problem 4.41, page 3

ANOVA				
Source	df	SS	MS	F
Treatment	3	99.5	33.167	3.755
Rows	3	0.50	0.167	0.019
Columns	3	19	6.333	0.717
Workplace	3	7.5	2.5	0.283
Error	3	26.5	8.833	
Total	15	153		

$F_{3,3,10} = 9.28$

Problem 4.41, continued

- Minitab Demonstration

 y

Treatment

↓	C1	C2	C3	C4-T	C5-T	C6
	time	operator	assembly	latin	greek	
1	11	1	1 C		beta	
2	8	1	2 B		alpha	
3	9	1	3 A		delta	
4	9	1	4 D		gamma	
5	10	2	1 B		gamma	

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Factor Information

Factor	Type	Levels	Values
operator	Random	4	1, 2, 3, 4
assembly	Random	4	1, 2, 3, 4
latin	Fixed	4	A, B, C, D
greek	Random	4	alpha, beta, delta, gamma

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
operator	3	20.815	6.9385	0.83	0.560
assembly	3	2.315	0.7718	0.09	0.959
latin	3	101.315	33.7718	4.03	0.141
greek	3	9.857	3.2857	0.39	0.769
Error	3	25.143	8.3810		
Total	15	150.000			

$\alpha = .05$

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