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Sunday, September 19, 2021

10:20 AM

Section 1

MANE 6313

Subsection 1

Week 5, Module B

Student Learning Outcome

Analyze simple comparative experiments and experiments with a single factor.

Module Learning Outcome

Analyze a randomized complete block design using Minitab.

Problem 4.8

4.8. A chemist wishes to test the effect of four chemical agents on the strength of a particular type of cloth. Because there might be variability from one bolt to another, the chemist decides to use a randomized block design, with the bolts of cloth considered as blocks. She selects five bolts and applies all four chemicals in random order to each bolt. The resulting tensile strengths follow. Analyze the data from this experiment (use $\alpha = 0.05$) and draw appropriate conclusions.

Chemical	Bolt				
	1	2	3	4	5
1	73	68	74	71	67
2	73	67	75	72	70
3	75	68	78	73	68
4	73	71	75	75	69

Problem 4.8, continued

Problem 4.8 - 1

Treatment (Chemicals) - rows

$$y_{1.} = (73 + 68 + 74 + 71 + 67) = 353$$

$$y_{2.} = (73 + 67 + 75 + 72 + 70) = 357$$

$$y_{3.} = (75 + 68 + 78 + 73 + 68) = 362$$

$$y_{4.} = (73 + 71 + 75 + 75 + 69) = 363$$

$$y_{..} = (353 + 357 + 362 + 363) = 1435$$

$$SS_{\text{Treatment}} = \frac{1}{3} (353^2 + 357^2 + 362^2 + 363^2) - \frac{1435^2}{20} = 12.95$$

$$SS_{\text{Total}} = \sum \sum y_{ij}^2 - \frac{Y_{..}^2}{N}$$

$$= 103,153 - \frac{1435^2}{20} = 191.75$$

Blocks - column

$$y_{.1} = (73 + 73 + 75 + 73) = 294$$

$$y_{.2} = (68 + 67 + 68 + 71) = 274$$

$$y_{.3} = (74 + 75 + 78 + 75) = 302$$

$$y_{.4} = (71 + 72 + 73 + 75) = 291$$

$$y_{.5} = (67 + 70 + 68 + 69) = 274$$

$$SS_{\text{Blocks}} = \frac{1}{4} (294^2 + 274^2 + 302^2 + 291^2 + 274^2) - \frac{1435^2}{20}$$

Problem 4.8, continued

Problem 4.8 - 2

ANOVA					
Source	df	SS	MS	F ₀	Conclusion
Chemical	3	12.95	4.3167	2.376	N.S.
Blocks	4	157	39.25	21.606	Sig.
Error	12	21.8	1.8167		
Total	19				

$$F_{3,12,.05} = 3.49$$

$$F_{4,12,.05} = 3.26$$

Problem 4.8 , continued

- Minitab demonstration

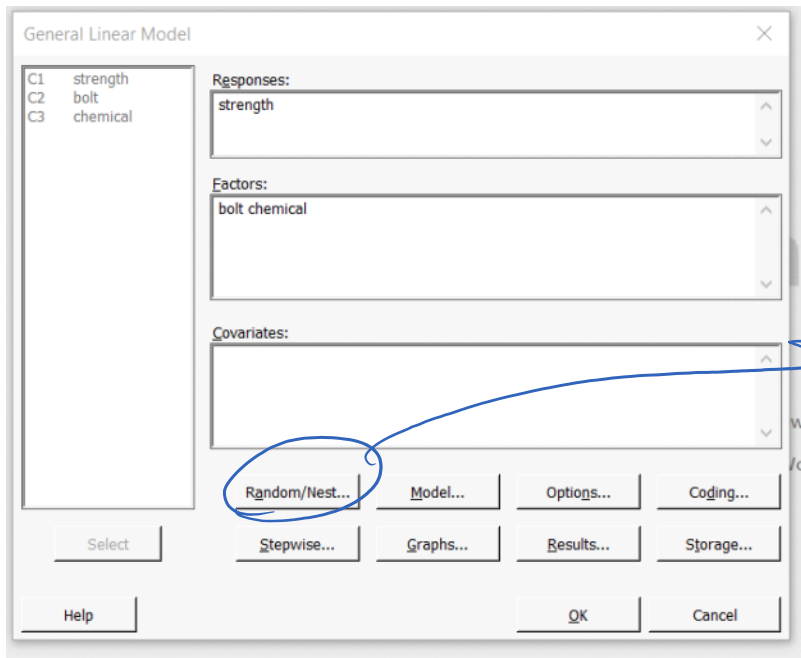
$\text{Minitab } F_0 > F_{0,3,12}$
 $\text{bbs } F_0 > F_{0,4,12}$

↓	C1 <i>strength</i>	C2 <i>bolt</i>	C3 <i>chemical</i>	C
1	73	1	1	
2	73	1	2	
3	75	1	3	
4	73	1	4	
5	68	2	1	

Worksheet 1

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Stat > ANOVA > General Linear Model > Fit general Linear model



treatments - fixed
blocks - random

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WORKSHEET 1

General Linear Model: strength versus bolt, chemical

Method

Factor coding (-1, 0, +1)

Factor Information

Factor	Type	Levels	Values
bolt	Random	5	1, 2, 3, 4, 5
chemical	Fixed	4	1, 2, 3, 4

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
bolt	4	157.00	39.250	21.61	0.000
chemical	3	12.95	4.317	2.38	0.121
Error	12	21.80	1.817		
Total	19	191.75			

✓ statistical significant
→ not statistically significant

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Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1.34784	88.63%	82.00%	68.42%



Coefficients

(Regression model)

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	71.750	0.301	238.07	0.000	
bolt					
1	1.750	0.603	2.90	0.013	*
2	-3.250	0.603	-5.39	0.000	*
3	3.750	0.603	6.22	0.000	*
4	1.000	0.603	1.66	0.123	*
chemical					
1	-1.150	0.522	-2.20	0.048	1.50
2	-0.350	0.522	-0.67	0.515	1.50
3	0.650	0.522	1.25	0.237	1.50

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Regression Equation

$$\text{strength} = 71.750 + 1.750 \text{ bolt}_1 - 3.250 \text{ bolt}_2 + 3.750 \text{ bolt}_3 + 1.000 \text{ bolt}_4 - 3.250 \text{ bolt}_5 - 1.150 \text{ chemical}_1 - 0.350 \text{ chemical}_2 + 0.650 \text{ chemical}_3 + 0.850 \text{ chemical}_4$$

Equation treats random terms as though they are fixed.

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Expected Mean Squares, using Adjusted SS

Source	Expected Mean Square for Each Term
1 bolt	(3) + 4.0000 (1)
2 chemical	(3) + Q[2]
3 Error	(3)

$$\sigma_e^2 + \frac{\sum (\tau_i)^2}{a-1}$$

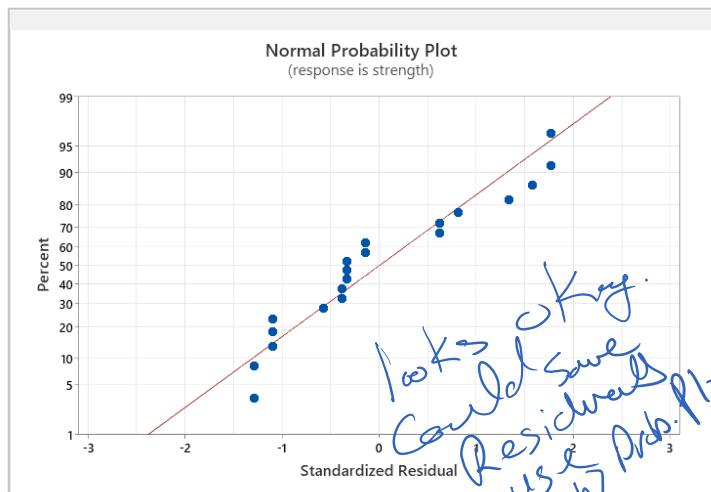
Error Terms for Tests, using Adjusted SS

Source	Error DF	Error MS	Synthesis of Error MS
1 bolt	12.00	1.8167	(3)
2 chemical	12.00	1.8167	(3)

Variance Components, using Adjusted SS

Source	Variance	% of Total	StDev	% of Total
bolt	9.35833	83.74%	3.05914	91.51%
Error	1.81667	16.26%	1.34784	40.32%
Total	11.175		3.34290	

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