Randomized Blocks Homework Chapter 4

- Problem 4-6 Montgomery 5th edition
- ***Randomized Block Design***
- An engineer working on an aluminum smelter wants to investigate the effect of 4 different "ratio control algorithms" has on the cell voltage. This is the effect of the way the alumina is added to the cell (Vessel holding aluminum melt) to maintain the proper ratio to the other ingredients has on cell voltage (which controls the cell or melt temperature). He knows that the time the measurement is made may have an influence on the results. Set up and run analysis and draw conclusions.

Randomized Blocks Homework Chapter 4

- Problem 4-6 Montgomery 5th edition
- Randomized Block Design Design Expert
- Setup data as>>>>>
- Block on observation time
- Questions
- A. Does ratio control algorithm effect average cell voltage?
- B. Does ratio control algorithm effect the std dev ("pot noise") cell voltage?
- C. Conduct residual analysis.
- D. Which ratio control algorithm reduces both average cell voltage and pot noise?

Std	Run	Block	Factor 1 A:Algorithm	Response 1 Average	Response 2 StDev
7	1	Block 1	2	4.85	0.04
13	2	Block 1	3	4.83	0.09
1	3	Block 1	1	4.93	0.05
19	4	Block 1	4	4.89	0.03
20	5	Block 2	4	4.77	0.04
2	6	Block 2	1	4.86	0.04
14	7	Block 2	3	4.88	0.13
8	8	Block 2	2	4.91	0.02
9	9	Block 3	2	4.79	0.03
3	10	Block 3	1	4.75	0.05
21	11	Block 3	4	4.94	0.05
15	12	Block 3	3	4.9	0.11
22	13	Block 4	4	4.86	0.05
16	14	Block 4	3	4.75	0.15
10	15	Block 4	2	4.85	0.05
4	16	Block 4	1	4.95	0.06
23	17	Block 5	4	4.79	0.03
5	18	Block 5	1	4.79	0.03
11	19	Block 5	2	4.75	0.03
17	20	Block 5	3	4.82	0.08
12	21	Block 6	2	4.85	0.02
18	22	Block 6	3	4.9	0.12
6	23	Block 6	1	4.88	0.05
24	24	Block 6	4	4.76	0.02

Randomized Blocks Homework Chapter 4

- Problem 4-6 Montgomery 5th edition Solution
- Randomized Block Design Design Expert
- **Average Cell voltage ANOVA Table CONCLUSIONS??**

Response: Average

ANOVA for Selected Factorial Model

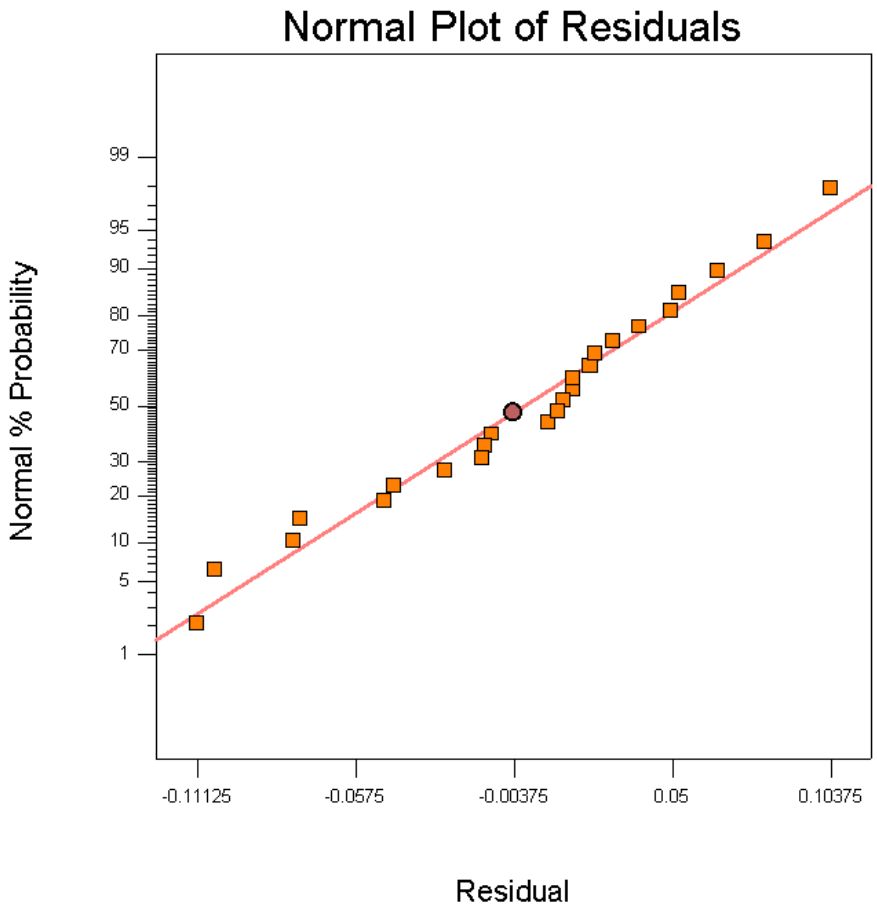
Analysis of variance table [Partial sum of squares]

Source		Sum of Squares	DF	Mean Square	F Value	Prob > F
Block		0.017	5	3.487E-003		
Model		2.746E-003	3	9.153E-004	0.19	0.9014
	A	*2.746E-003*	3	*9.153E-004*	*0.19*	*0.9014*
Residual		0.072	15	4.812E-003		
Cor Total		0.092	23			

Std. Dev.	0.069	R-Squared	0.0366
Mean	4.84	Adj R-Squared	-0.1560
C.V.	1.43	Pred R-Squared	-1.4662
PRESS	0.18	Adeq Precision	2.688

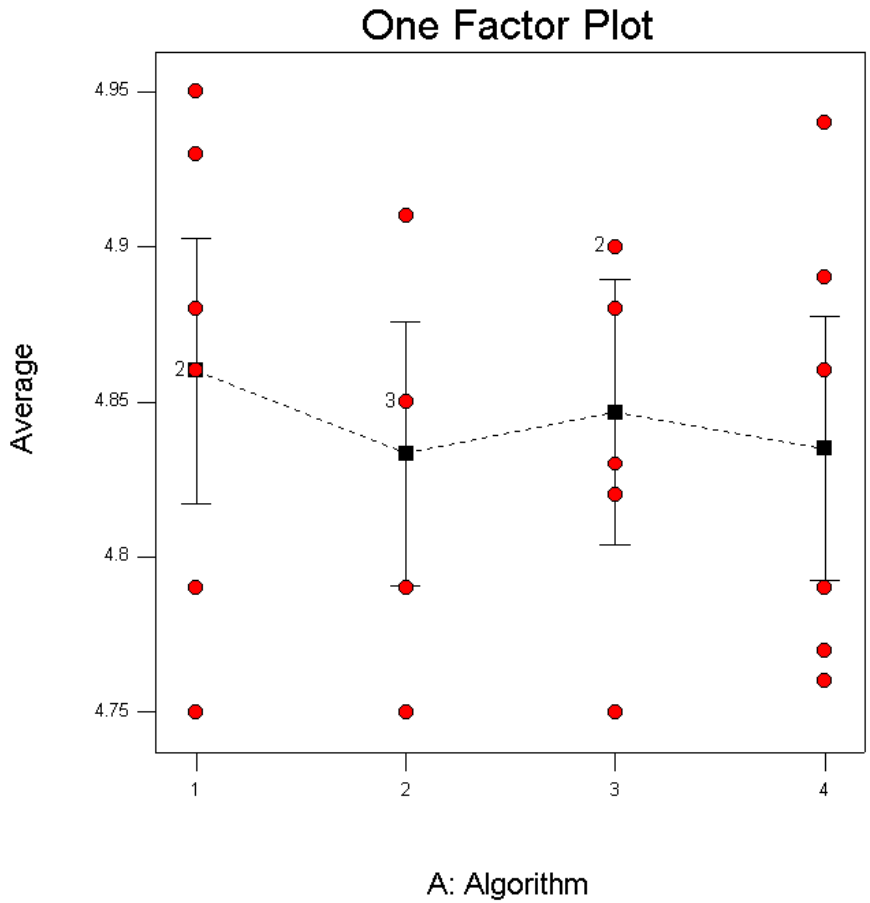
Randomized Blocks Homework Chapter 4

- Problem 4-6 Montgomery 5th edition Solution
- Randomized Block Design Design Expert
- **Average Cell voltage residuals**



Randomized Blocks Homework Chapter 4

- Problem 4-6 Montgomery 5th edition Solution
- Randomized Block Design Design Expert
- **Plot of Average Cell voltage Vs Alumina Ratio control algorithm**



Randomized Blocks Homework Chapter 4

- Problem 4-6 Montgomery 5th edition Solution
- Randomized Block Design Design Expert Note transform to natural log as per page 111 (stabilizes distribution of standard deviations)
- **Standard Deviation Cell voltage ANOVA Table CONCLUSIONS??**

Response: StDev **Transform:** Natural log **Constant:** 0.000

ANOVA for Selected Factorial Model

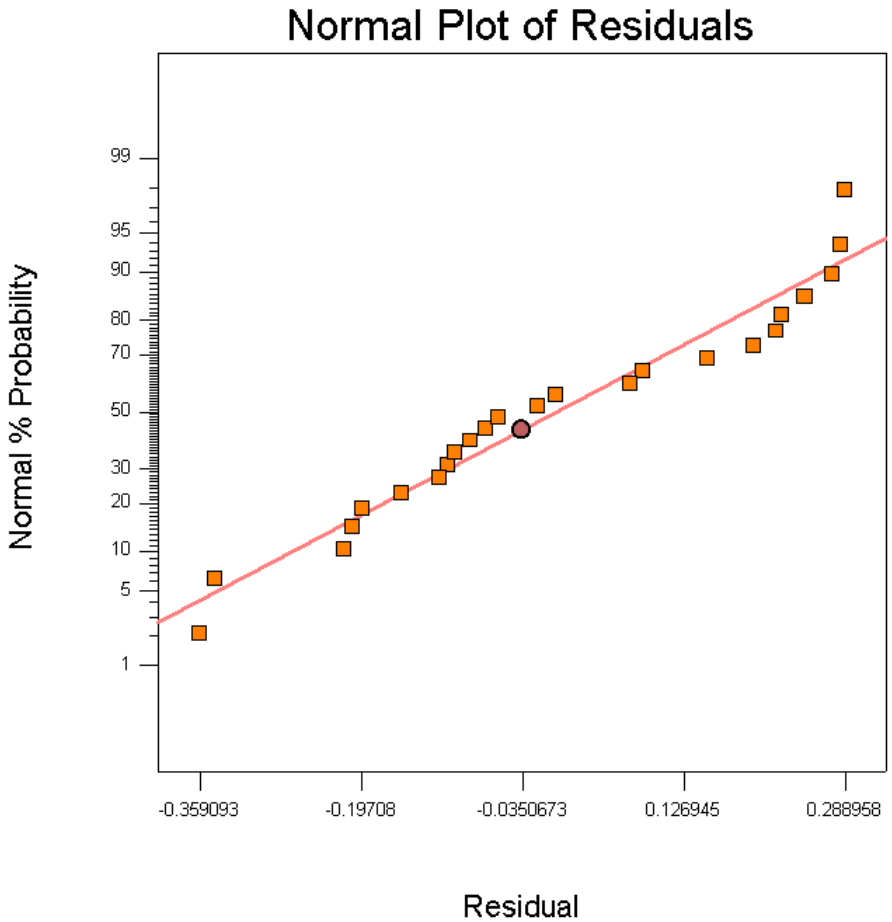
Analysis of variance table [Partial sum of squares]

Source	Sum of Squares	DF	Mean Square	F Value	Prob > F
Block	0.94	5	0.19		
Model	6.17	3	2.06	33.26	< 0.0001
A	*6.17*	*3*	*2.06*	*33.26*	*< 0.0001*
Residual	0.93	15	0.062		
Cor Total	8.04	23			

Std. Dev.	0.25	R-Squared	0.8693
Mean	-3.04	Adj R-Squared	0.8432
C.V.	-8.18	Pred R-Squared	0.6654
PRESS	2.37	Adeq Precision	12.446

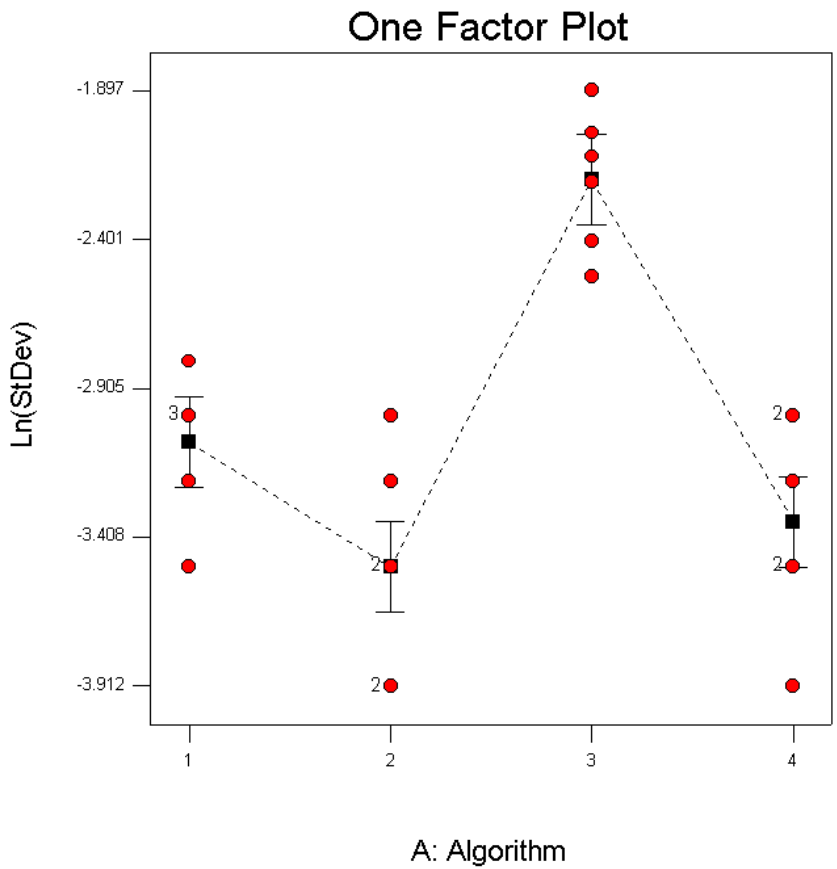
Randomized Blocks Homework Chapter 4

- Problem 4-6 Montgomery 5th edition Solution
- Randomized Block Design Design Expert
- **Standard Deviation Cell voltage residuals**



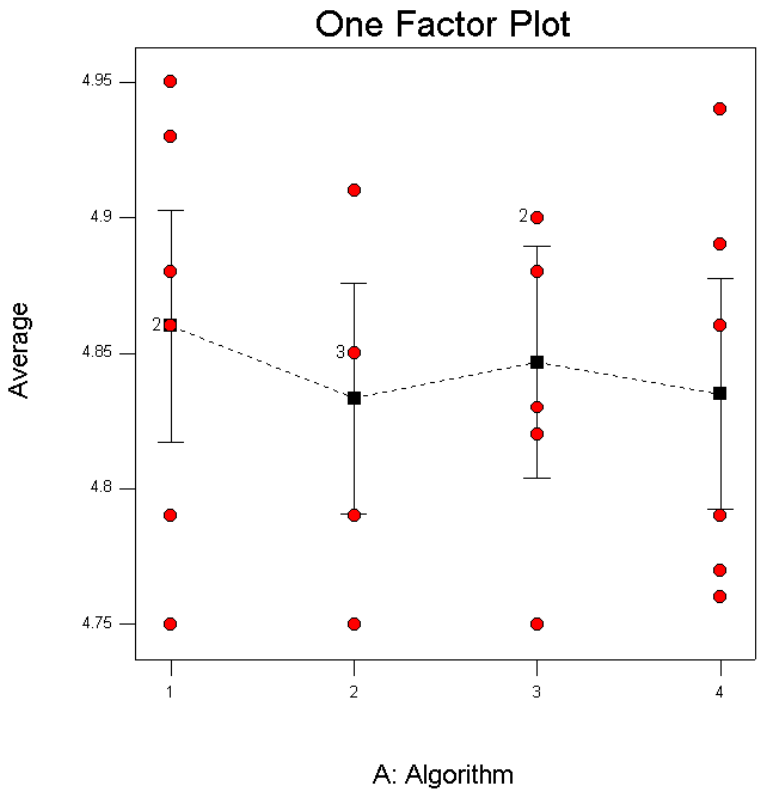
Randomized Blocks Homework Chapter 4

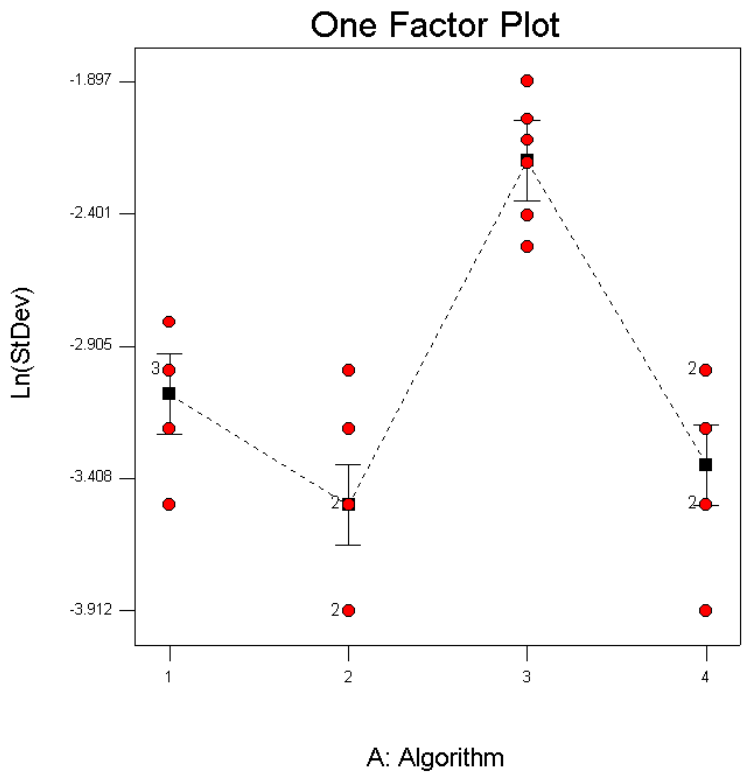
- Problem 4-6 Montgomery 5th edition Solution
- Randomized Block Design Design Expert
- **Plot of Standard Deviation Cell voltage Vs Alumina Ratio control algorithm**



Randomized Blocks Homework Chapter 4

- Problem 4-6 Montgomery 5th edition Solution Randomized Block Design Design Expert
- The objective of this evaluation was to minimize both Average Cell voltage and the Standard Deviation of Cell voltage, Which Alumina Ratio control algorithm achieves this?





Randomized Blocks Homework Chapter 4

- Problem 4-15 Montgomery 5th edition
- Blocking using Latin square method
- Engineer wants to investigate the effect of 4 assembly methods have on the assembly time for a color television subsystem. He knows operators and assembly order (fatigue) are nuisance factors. Set up and run analysis and draw conclusions

Order of Assembly	Operator				Row Totals $y_{.j.}$	Latin Letter Totals $y_{i..}$
	1	2	3	4		
1	$C = 10$	$D = 14$	$A = 7$	$B = 8$	39	A 30
2	$B = 7$	$C = 18$	$D = 11$	$A = 8$	44	B 37
3	$A = 5$	$B = 10$	$C = 11$	$D = 9$	35	C 53
4	$D = 10$	$A = 10$	$B = 12$	$C = 14$	46	D 44
Col. Totals $y_{..k}$	32	52	41	39	164	

Randomized Blocks Homework Chapter 4

- Problem 4-15 Montgomery 5th edition Solution
- Blocking using Latin square method

$$\sum_{i=1}^{4}\sum_{j=1}^{4}\sum_{k=1}^{4} y_{ijk}^2 = (10)^2 + (14)^2 + \cdots + (12)^2 + (14)^2 = 1834$$

$$y_{..} = \sum_{i=1}^{4}\sum_{j=1}^{4} y_{ijk} = (10) + (14) + \cdots + (12) + (14) = 164$$

$$SST = \sum_{i=1}^{4}\sum_{j=1}^{4}\sum_{k=1}^{4} y_{ijk}^2 - \frac{(y_{...})^2}{N} = 1843 - \frac{(164)^2}{16} = 153$$

$$SS_{Method} = \sum_{i=1}^{4}\frac{y_{i..}^2}{4} - \frac{(y_{..})^2}{N} = \frac{(30)^2}{4} + \frac{(37)^2}{4} + \frac{(53)^2}{4} + \frac{(44)^2}{4} - \frac{(164)^2}{16} = 72.5$$

$$SS_{Order} = \sum_{j=1}^{4}\frac{y_{.j.}^2}{4} - \frac{(y_{..})^2}{N} = \frac{(39)^2}{4} + \frac{(44)^2}{4} + \frac{(35)^2}{4} + \frac{(46)^2}{4} - \frac{(164)^2}{16} = 18.5$$

$$SS_{Operator} = \sum_{j=1}^{4}\frac{y_{..k}^2}{4} - \frac{(y_{..})^2}{N} = \frac{(32)^2}{4} + \frac{(52)^2}{4} + \frac{(41)^2}{4} + \frac{(39)^2}{4} - \frac{(164)^2}{16} = 51.5$$

$$SSE = SST - SS_{Method} - SS_{Order} - SS_{Operator} = 153 - 72.5 - 18.5 - 51.5 = 10.5$$

Randomized Blocks Homework Chapter 4

- Problem 4-15 Montgomery 5th edition solution
- Blocking using Latin square method

- ANOVA TABLE problem 4-15 Solution

Source	df	SS	MS	F
Method	3	72.5	24.17	13.81
Order	3	18.5	6.17	3.53
Operator	3	51.5	17.17	9.81
Error	6	10.5	1.75	
Total	15	153.0		

Using the 5% significance level the critical F-value is $F_{0.05,3,6} = 4.76$. Therefore, the null hypothesis of equal treatment (Method) means is rejected.

Also it was worth blocking on Operator but probably not for Order since the F-value for Order is below 4.76.

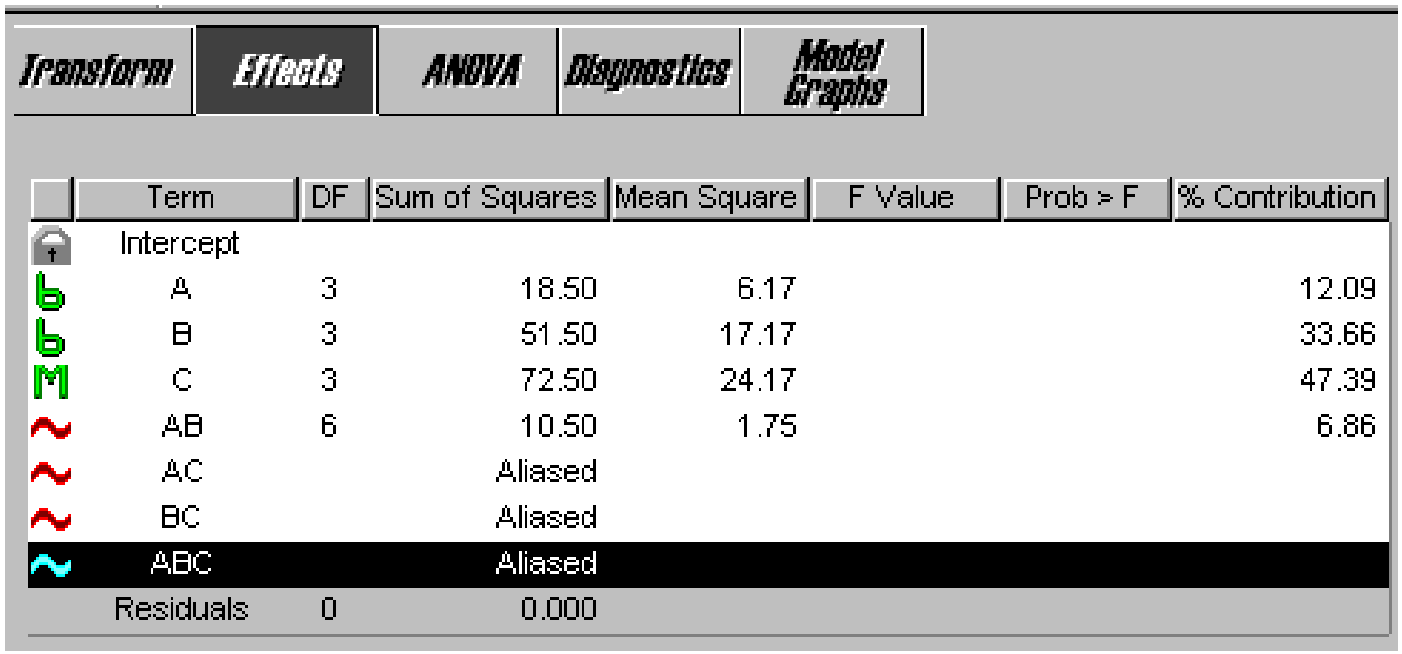
Randomized Blocks Homework Chapter 4

- Problem 4-15 Montgomery 5th edition solution
- Blocking using Latin square method in Design Expert Set up:

Std	Run	Block	Factor 1 A:row Block	Factor 2 B:Column block	Factor 3 C:ASSEMBLY METHOD	Response 1 Assembly Time Hours
1	1	Block 1	Order 1	Operator 1	C	10
2	2	Block 1	Order 2	Operator 1	B	7
3	3	Block 1	Order 3	Operator 1	A	5
4	4	Block 1	Order 4	Operator 1	D	10
5	5	Block 1	Order 1	Operator 2	D	14
6	6	Block 1	Order 2	Operator 2	C	18
7	7	Block 1	Order 3	Operator 2	B	10
8	8	Block 1	Order 4	Operator 2	A	10
9	9	Block 1	Order 1	Operator 3	A	7
10	10	Block 1	Order 2	Operator 3	D	11
11	11	Block 1	Order 3	Operator 3	C	11
12	12	Block 1	Order 4	Operator 3	B	12
13	13	Block 1	Order 1	Operator 4	B	8
14	14	Block 1	Order 2	Operator 4	A	8
15	15	Block 1	Order 3	Operator 4	D	9
16	16	Block 1	Order 4	Operator 4	C	14

Randomized Blocks Homework Chapter 4

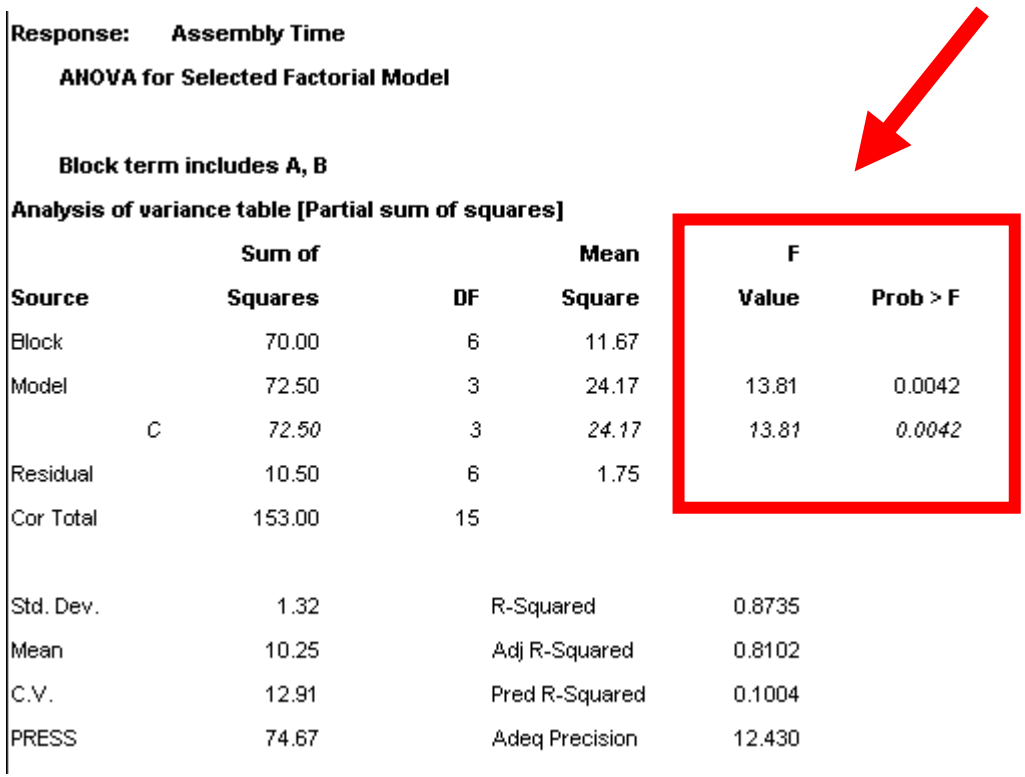
- Problem 4-15 Montgomery 5th edition solution
- Blocking using Latin square method in Design Expert:
- Click on Effects and Change A and B to blocks



Term	DF	Sum of Squares	Mean Square	F Value	Prob > F	% Contribution
Intercept						
A	3	18.50	6.17			12.09
B	3	51.50	17.17			33.66
C	3	72.50	24.17			47.39
AB	6	10.50	1.75			6.86
AC		Aliased				
BC		Aliased				
ABC		Aliased				
Residuals	0	0.000				

Randomized Blocks Homework Chapter 4

- Problem 4-15 Montgomery 5th edition solution
- Blocking using Latin square method in Design Expert:
- Click on ANOVA Method of assembly has a significant effect on time of assembly!



Response: Assembly Time

ANOVA for Selected Factorial Model

Block term includes A, B

Analysis of variance table [Partial sum of squares]

Source	Sum of Squares	DF	Mean Square	F Value	Prob > F
Block	70.00	6	11.67		
Model	72.50	3	24.17	13.81	0.0042
C	*72.50*	*3*	*24.17*	*13.81*	*0.0042*
Residual	10.50	6	1.75		
Cor Total	153.00	15			

Std. Dev.	1.32	R-Squared	0.8735
Mean	10.25	Adj R-Squared	0.8102
C.V.	12.91	Pred R-Squared	0.1004
PRESS	74.67	Adeq Precision	12.430

Randomized Blocks Homework Chapter 4

- Problem 4-15 Montgomery 5th edition solution
- Blocking using Latin square method in Design Expert: Graphic have many options. Can look at operators and Assembly Orders separately!