

Breaking Strength as a Function of Machine and Operator

```
1 options ls=120 ps=75 nocenter nodate;
2 data; title 'Breaking Strength as a Function of Machine and Operator';
3 * The factors that affect the breaking strength of synthetic fiber
4   are being studied. Four machines are chosen at random from a large
5   population of machines, and three operators are chosen at random from
6   a large population of operators. Two replications of a factorial
7   experiment are run using fiber from the same production batch. The
8   response is the breaking strength of the fiber.;
9
10 input operator machine y1 y2; drop y1 y2; y=y1; output;
11 y=y2; output; cards;
12 1 1 109 108
13 1 2 112 115
14 1 3 108 109
15 1 4 110 108
16 2 1 110 111
17 2 2 114 111
18 2 3 111 109
19 2 4 114 112
20 3 1 112 114
21 3 2 112 115
22 3 3 114 119
23 3 4 120 117
24 proc print;
25 proc anova; classes operator machine;
26 model y=machine operator machine*operator;
27 means machine operator machine*operator;
28
29 proc varcomp method=type1; classes operator machine;
30 model y=machine|operator;
31
```

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OBS	OPERATOR	MACHINE	Y
1	1	1	109
2	1	1	108
3	1	2	112
4	1	2	115
5	1	3	108
6	1	3	109
7	1	4	110
8	1	4	108
9	2	1	110
10	2	1	111
11	2	2	114
12	2	2	111
13	2	3	111
14	2	3	109
15	2	4	114
16	2	4	112
17	3	1	112
18	3	1	114
19	3	2	112
20	3	2	115
21	3	3	114
22	3	3	119
23	3	4	120
24	3	4	117

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Analysis of Variance Procedure
Class Level Information

Class	Levels	Values
OPERATOR	3	1 2 3
MACHINE	4	1 2 3 4

Number of observations in data set = 24

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Analysis of Variance Procedure

Dependent Variable: Y

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	216.5000000	19.68181818	5.90	0.0024
Error	12	40.0000000	3.33333333		
Corrected Total	23	256.5000000			
	R-Square	C.V.	Root MSE		Y Mean
	0.844055	1.626496	1.82574186		112.2500000

Source	DF	Anova SS	Mean Square	F Value	Pr > F
MACHINE	3	31.5000000	10.5000000	3.15	0.0647
OPERATOR	2	127.7500000	63.8750000	19.16	0.0002
OPERATOR*MACHINE	6	57.2500000	9.5416667	2.86	0.0572

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Analysis of Variance Procedure

Level of MACHINE	N	Mean	SD
1	6	110.666667	2.16024690
2	6	113.166667	1.72240142
3	6	111.666667	4.17931414
4	6	113.500000	4.46094160

Level of OPERATOR	N	Mean	SD
1	8	109.875000	2.47487373
2	8	111.500000	1.77281052
3	8	115.375000	3.02076149

Level of OPERATOR	Level of MACHINE	N	Mean	SD
1	1	2	108.500000	0.70710678
1	2	2	113.500000	2.12132034
1	3	2	108.500000	0.70710678
1	4	2	109.000000	1.41421356
2	1	2	110.500000	0.70710678
2	2	2	112.500000	2.12132034
2	3	2	110.000000	1.41421356
2	4	2	113.000000	1.41421356
3	1	2	113.000000	1.41421356
3	2	2	113.500000	2.12132034
3	3	2	116.500000	3.53553391
3	4	2	118.500000	2.12132034

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Variance Components Estimation Procedure
Class Level Information

Class	Levels	Values
OPERATOR	3	1 2 3
MACHINE	4	1 2 3 4

Number of observations in data set = 24

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Variance Components Estimation Procedure

Dependent Variable: Y

Source	DF	Type I SS	Type I MS	Expected Mean Square
MACHINE	3	31.50000000	10.50000000	Var(Error) + 2 Var(OPERATOR*MACHINE) + 6 Var(MACHINE)
OPERATOR	2	127.75000000	63.87500000	Var(Error) + 2 Var(OPERATOR*MACHINE) + 8 Var(OPERATOR)
OPERATOR*MACHINE	6	57.25000000	9.54166667	Var(Error) + 2 Var(OPERATOR*MACHINE)
Error	12	40.00000000	3.33333333	Var (Error)
Corrected Total	23	256.50000000		

Variance Component	Estimate
Var(MACHINE)	0.15972222
Var(OPERATOR)	6.79166667
Var(OPERATOR*MACHINE)	3.10416667
Var(Error)	3.33333333