```
/* Montgomery 14.19 */
proc import datafile="/home/u63048916/STAT571B/Homework/Homework 7/Q14-19.xlsx"
    dbms=xlsx
    out=split
    replace;
    getnames=yes;
run;

/* proc mixed =>  Stat model 1: all terms included */
proc mixed data=split method=type1 CL;
class Temperature Shift Time;
model Strength=Temperature Time Temperature*Time;
random Shift Shift*Temperature Shift*Time Shift*Temperature*Time;
run;

/* proc mixed =>  Stat model 2: only 5 terms included (rest terms are pooled as the random error term) */
proc mixed data=split method=type1 CL;
class Temperature Shift Time;
model Strength=Temperature Time Temperature*Time;
random Shift Shift*Temperature;
run;
```

14.19. Steel is normalized by heating above the critical temperature, soaking, and then air cooling. This process increases the strength of the steel, refines the grain, and homogenizes the structure. An experiment is performed to determine the effect of temperature and heat treatment time on the strength of normalized steel. Two temperatures and three times are selected. The experiment is performed by heating the oven to a randomly selected temperature and inserting three specimens. After 10 minutes one specimen is removed, after 20 minutes the second is removed, and after 30 minutes the final specimen is removed. Then the temperature is changed to the other level and the process is repeated. Four shifts are required to collect the data, which are shown below. Analyze the data and draw conclusions, assuming both factors are fixed.

		Temperature (°F)	
Shift	**Time (min)**	**1500**	**1600**
	10	63	89
1	20	54	91
	30	61	62
	10	50	80
2	20	52	72
	30	59	69
	10	48	73
3	20	74	81
	30	71	69
	10	54	88
4	20	48	92
	30	59	64

ANOVA

Type 1 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square	Error Term	Error DF	F Value	Pr > F
Temperature	1	2340.375000	2340.375000	Var(Residual) + Var(Temperatu*Shift*Time) + 3 Var(Temperature*Shift) + Q(Temperature,Temperature*Time)	MS(Temperature*Shift)	3	29.20	0.0124
Time	2	159.250000	79.625000	Var(Residual) + Var(Temperatu*Shift*Time) + 2 Var(Shift*Time) + Q(Time,Temperature*Time)	MS(Shift*Time)	6	1.00	0.4223
Temperature*Time	2	795.250000	397.625000	Var(Residual) + Var(Temperatu*Shift*Time) + Q(Temperature*Time)	MS(Temperatu*Shift*Time)	6	9.76	0.0130
Shift	3	145.458333	48.486111	Var(Residual) + Var(Temperatu*Shift*Time) + 2 Var(Shift*Time) + 3 Var(Temperature*Shift) + 6 Var(Shift)	MS(Temperature*Shift) + MS(Shift*Time) - MS(Temperatu*Shift*Time)	4.0824	0.41	0.7568
Temperature*Shift	3	240.458333	80.152778	Var(Residual) + Var(Temperatu*Shift*Time) + 3 Var(Temperature*Shift)	MS(Temperatu*Shift*Time)	6	1.97	0.2203
Shift*Time	6	478.416667	79.736111	Var(Residual) + Var(Temperatu*Shift*Time) + 2 Var(Shift*Time)	MS(Temperatu*Shift*Time)	6	1.96	0.2170
Temperatu*Shift*Time	6	244.416667	40.736111	Var(Residual) + Var(Temperatu*Shift*Time)	MS(Residual)	0	3.67E13	.
Residual	0	2.318146E-13	1.110223E-12	0	.	.	.	.

Covariance Parameter Estimates

Cov Parm	Estimate	Alpha	Lower	Upper
Shift	-11.7778	0.05	-18.4416	-5.1140
Temperature*Shift	13.1389	0.05	5.7050	20.5728
Shift*Time	19.5000	0.05	8.4670	30.5330
Temperatu*Shift*Time	40.7361	0.05	17.6879	63.7843
Residual	1.11E-12	.	.	.

Figure 14.19.1

The whole plot treatment Temperature is significant at an $\alpha = 0.05$ level with P value of 0.0124. The whole plot / sub plot interaction term is also significant at $\alpha = 0.05$ level with P value of 0.0130. No other factors (including block factor Shift) or interactions are individually significant.

What does significance mean?

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Need to check assumptions