

1. An engineer is studying the mileage performance characteristics of five types of gasoline additives. In the road test he wishes to use cars as blocks; however, because of a time constraint, he must use an **incomplete block design**. He runs the balanced design with the five blocks that follow. Analyze the data from this experiment (use $\alpha = 0.05$) and draw conclusions.

Additives	Car				
	1	2	3	4	5
1	-	17	14	13	12
2	14	14	-	13	10
3	12	-	13	12	9
4	13	11	11	12	-
5	11	12	10	-	8

2. An industrial engineer is investigating the effect of four assembly methods (A, B, C, D) on the assembly time for a color television component. Four operators are selected for the study. Furthermore, the engineer knows that each assembly method produces such fatigue that the time required for the last assembly may be greater than the time required for the first, regardless of the method. That is, a trend develops in the required assembly time. To account for this source of variability, the engineer uses the **Latin square design** shown below. Analyze the data from this experiment ($\alpha = 0.05$) and draw appropriate conclusions.

Order of Assembly	Operator			
	1	2	3	4
1	C=10	D=14	A= 7	B= 8
2	B= 7	C=18	D=11	A= 8
3	A= 5	B=10	C=11	D= 9
4	D=10	A=10	B=12	C=14

3. Suppose that in Problem 2 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	$D\gamma = 9$	$A\beta = 8$	$C\alpha = 18$	$B\delta = 6$

4. An aluminum master alloy manufacturer produces grain refiners in ingot form. The company produces the product in four furnaces. Each furnace is known to have its own unique operating characteristics, so any experiment run in the foundry that involves more than one furnace will consider furnaces as a nuisance variable. The process engineers suspect that stirring rate impacts the grain size of the product. Each furnace can be run at four different stirring rates. A **randomized block design** is run for a particular refiner and the resulting grain size data is as follows

Stirring Rate	Furnace			
	1	2	3	4
5	8	4	5	6
10	14	5	6	9
15	14	6	9	2
20	17	9	3	6

- Is there any evidence that stirring rate impacts grain size?
- Graph the residuals from this experiment on a normal probability plot. Interpret this plot.
- Plot the residuals versus furnace and stirring rate. Does this plot convey any useful information?
- What should the process engineers recommend concerning the choice of stirring rate and furnace for this particular grain refiner if small grain size is desirable?