MA 60209 Design of Experiments
Assignment No. 3

1. A garden insecticide can be manufactured using one of the three base powders and one of two different ingredients. The response is the measure of strength after spreading. The following data are obtained based on two replications of the experiment. Analyze the data shown in the following table, assuming that both the factors are fixed. Find estimates of effects and sums of squares. Present results in ANOVA table and draw conclusions.

Ingredient	Powder		
	A1	A2	A3
B1	81 70	103 110	118 138
B2	123 131	142 143	180 189

2. The percentage of hardwood concentration in raw pulp, the freeness, and the cooking time of pulp are being investigated for their effects on the strength of paper. Analyze the data shown in the following table, assuming that all three factors are fixed. Find estimates of effects and sums of squares. Present results in ANOVA table and draw conclusions.

Percentage of Hardwood Concentration	Cooking Time 1.5 hours			Cooking time 2.0 hours		
	Freeness			Freeness		
	400	500	650	400	500	650
10	96.6 96.0	97.7 96.0	99.4 99.8	98.4 98.6	99.6 100.4	100.6 100.9
15	98.5 97.2	96.0 96.9	98.4 97.6	97.5 98.1	98.7 98.0	99.6 99.0
20	97.5 96.6	95.6 96.2	97.4 98.1	97.6 98.4	97.0 97.8	98.5 99.8

3. An experimenter is studying the effects of five different formulations of a rocket propellant used in aircrew escape systems on the observed burning rate. Each formulation is mixed from a batch of raw material that is only large enough for five formulations to be tested. Formulations are prepared by five different operators who may differ in skills and experience. The following Latin square design was used and the coded data is as follows:

		Operators				
		1	2	3	4	5
Batches of raw material	1	A -1	B -5	C -6	D -1	E -1
	2	B -8	C -1	D 5	E 2	A 11
	3	C -7	D 13	E 1	A 2	B -4
	4	D 1	E 6	A 1	B -2	C -3
	5	E -3	A 5	B -5	C 4	D 6

Carry out ANOVA and check if the significant differences exist due to different formulations, operators and batches?

4. In the Problem 3, an additional factor (five test assemblies, α, β, γ, δ and ε) is incorporated and a Graeco-Latin Square design is used. Based on the following experimental data, carry out ANOVA and check if the significant differences exist due to different assemblies?

		Operators				
		1	2	3	4	5
Batches of raw material	1	Aα -1	Bγ -5	Cε -6	Dβ -1	Eδ -1
	2	Bβ -8	Cδ -1	Dα 5	Eγ 2	Aε 11
	3	Cγ -7	Dε 13	Eβ 1	Aδ 2	Bα -4
	4	Dδ 1	Eα 6	Aγ 1	Bε -2	Cβ -3
	5	Eε -3	Aβ 5	Bδ -5	Cα 4	Dγ 6

5. To test the homogeneity of effects of five different treatments (manures - A, B, C, D, E) on wheat yield a 5×5 Latin square is used. The following yields (in metric tons per hectare) are recorded from the experiment. Here row factors are five different soil quality and column factors are five different seed variety.

	Columns				
Rows	1	2	3	4	5
1	A – 52.5	E – 46.3	D – 44.1	C – 48.1	B – 40.9
2	D – 44.2	B – 42.9	A – 51.3	E – 49.3	C – 32.6
3	B – 49.1	A – 47.3	C – 38.1	D – 41.0	E – 47.2
4	C – 43.2	D – 42.5	E – 67.2	B – 55.1	A – 45.3
5	E – 47.0	C – 43.2	B – 46.7	A – 46.0	D – 43.2

Prepare the ANOVA table for the above Latin square and test the hypotheses of homogeneity of treatment effects, row effects and column effects.

6. An experiment is conducted to investigate the effects of different materials of disk drive substrates on the amplitude (measured in microvolts×0.01) of the signal obtained during readback. Four treatments (types of substrate materials) are – A: aluminum, B: nickle-plated aluminum, C: glass type I, D: glass type II. Row factors are : Four machines, Column factors are: Four operators, Greek Letters are: Four different days. The outcomes of the experiment are presented below:

	Operator			
Machine	1	2	3	4
I	$A\alpha = 8$	$C\gamma = 11$	$D\delta = 2$	$B\beta = 8$
II	$C\delta = 7$	$A\beta = 5$	$B\alpha = 2$	$D\gamma = 4$
III	$D\beta = 3$	$B\delta = 9$	$A\gamma = 7$	$C\alpha = 9$
IV	$B\gamma = 4$	$D\alpha = 5$	$C\beta = 9$	$A\delta = 3$

Prepare the ANOVA table for the above Graeco-Latin square design and test the hypotheses of homogeneity of treatment effects, row effects, column effects and Greek Letter factor effects.