Homework IV (2023)

1. An engineer is interested in the effects of cutting speed (A), tool geometry (B), and cutting angle on the life (in hours) of a machine tool. Two levels of each factor are chosen, and three replicates of a 2^3 factorial design are run. The results are as follows:

A	B	C	Treatment Combination	Replicate I	II	III
-	-	-	(1)	21	31	25
+	-	-	a	33	43	29
-	+	-	b	34	34	50
+	+	-	ab	56	47	46
-	-	+	c	43	45	38
+	-	+	ac	41	37	36
-	+	+	bc	61	50	54
+	+	+	abc	40	41	47

(a) Estimate the factor effects. Which effects appear to be large?

(b) Use the analysis of variance to confirm your conclusions for part (a).

(c) Write down a regression model for predicting tool life (in hours) based on the results of this experiment.

(d) Analyze the residuals. Are there any obvious problems?

(e) Based on the analysis of main effects and interaction plots, what levels of A, B, and C would you recommend using?

2. A manufacturer suspects that the batches of raw material furnished by her supplier differ significantly in calcium content. There are a large number of batches currently in the warehouse. Five of these are randomly selected for study. A chemist makes five determinations on each batch and obtains the following data:

Batch 1	Batch 2	Batch 3	Batch 4	Batch 5
23.46	23.59	23.51	23.28	23.29
23.48	23.46	23.64	23.40	23.46
23.56	23.42	23.46	23.37	23.37
23.39	23.49	23.52	23.46	23.32
23.40	23.50	23.49	23.39	23.38

(a) Is there significant variation in calcium content from batch to batch? Use $\alpha = 0.05$.

(b) Estimate the components of variance.

(c) Find a 95 percent confidence interval for $\sigma_\tau^2/(\sigma_\tau^2 + \sigma^2)$.

(d) Analyze the residuals from this experiment. Are the basic analysis of variance assumptions satisfied?

3. The factors that influence the breaking strength of a synthetic fiber are being studied. Four production machines and three operators are chosen at random, and a factorial experiment is run using fiber from the same production batch. The results are as follows:

	Machine			
Operator	1	2	3	4
1	110	111	108	109
	110	115	109	108
2	110	110	111	114
	112	111	109	112
3	116	112	114	120
	114	115	119	117

(a) Analyze the data from this experiment. Use $\alpha = 0.05$.

(b) Find point estimates of the variance components using the analysis of variance method.

4. A rocket propellant manufacturer is studying the burning rate of propellant from three production processes. Four batches of propellant are randomly selected from the output of each process and three determinations of burning rate are made on each batch. The results follow. Analyze the data and draw conclusions.

	Process 1				Process 2				Process 3			
Batch	1	2	3	4	1	2	3	4	1	2	3	4
	25	19	15	15	19	23	18	35	14	35	38	25
	30	28	17	16	17	24	21	27	15	21	54	29
	26	20	14	13	14	21	17	25	20	24	50	33