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College of Engineering
Department of Electrical Engineering
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C. SPANOS Special Issues in Semiconductor Manufacturing EECS 290H
K. POOLLA Spring 1999

PROBLEM SET No. 4

1. A process engineer is about to begin a comprehensive study to determine the effects of five variables on the etch rate of polysilicon.
 - a) If a 2^5 factorial design were used, how many runs would be made?
 - b) If σ^2 is the experimental error variance of an individual observation, what is the variance of the main effect?
 - c) What is the usual formula for a 99% confidence interval for the main effect of variable 1?
 - d) On the basis of some previous work it is believed that $\sigma=200$ A/min. If the experimenter wants 95% confidence intervals for the main effect and interactions whose lengths are equal to 50 A/min, (i.e. the upper limit minus the lower limit is equal to 50 A/min), how many replications of the 2^5 factorial design will be required?
(This problem is derived from problem 4 in Box, pp. 435.)
 2. Tests were carried out on a newly designed carburetor. Four variables were studied as follows:

variable	-	+	
<i>A</i>	tension on spring	low	high
<i>B</i>	air gap	narrow	open
<i>C</i>	size of aperture	small	large
<i>D</i>	rate of flow of gas	slow	rapid

The immediate object was to find the effects of these changes on the amount of unburned hydrocarbons in the engine exhaust gas. The following results were obtained:

<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>	unburned hydrocarbons
—	+	+	+	8.2
—	—	+	—	1.7
—	—	—	+	6.2
+	—	—	—	3.0
+	—	+	+	6.8
+	+	+	—	5.0
—	+	—	—	3.8
+	+	—	+	9.3

- a) Stating any assumptions, analyze the data, using one Multivariate Analysis of Variance (MANOVA) table.
 - b) Can you test any or all the hypotheses of model additivity?
 - c) A MANOVA table uses the F distribution. Can you think of equivalent tests that make use of the student-t distribution? (just formulate the problem - do not do calculations).
 - d) Comment on the differences and similarities of this analysis compared to the simpler, factorial analysis method. (This problem is derived from problem 9 in Box, pp. 438.)

3. Estimate the effects of the following 2^{5-1} fractional factorial design, stating your assumptions.

A	B	C	D	E	observation y
-	-	-	-	+	14.8
+	-	-	-	-	14.5
-	+	-	-	-	18.1
+	+	-	-	+	19.4
-	-	+	-	-	18.4
+	-	+	-	+	15.7
-	+	+	-	+	27.3
+	+	+	-	-	28.2
-	-	-	+	-	16.0
+	-	-	+	+	15.1
-	+	-	+	+	18.9
+	+	-	+	-	22.0
-	-	+	+	+	19.8
+	-	+	+	-	18.9
-	+	+	+	-	29.9
+	+	+	+	+	27.4

Plot the effects on probability paper, draw tentative conclusions, and verify by plotting residuals. (This is problem 22 from Box, pp. 445.)