STAT 514 Homework 10

Due: Nov 30

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

factor			replicate		
A	B	C	I	II	III
-	-	-	22	31	25
+	-	-	32	43	29
-	+	-	35	34	50
+	+	-	55	47	46
-	-	+	44	45	38
+	-	+	40	37	36
-	+	+	60	50	54
+	+	+	39	41	47

   (a) Estimate the factorial effects (calculate at least one main effect and one interaction by hand). Which effects appear to be large (significant)?

   (b) Use 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. (The model should only use significant main and interaction effects)

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

   (e) Generate main effect and interaction plots for significant effects. Based on them, what levels of A, B and C would you recommend?

   (f) (Optional) Generate the contour plot of the regression model. Does it provide information regarding the desirable operating conditions for the machine tool?

   (g) What is the standard error of the factorial effects?

2. An article in *Solid State Technology* describes the application of factorial designs in developing a nitride etch process on a single-wafer plasma etcher. The process uses C_2F_6 as the reactant gas. Four factors are of interests: anode-cathode gap (A), pressure in the reac- tor chamber (B), C_2F_6 gas flow (C), and power applied to the cathode (D). The response variable of interest is the etch rate for silicon nitride. A single replicate of a 24 design is run, and the data are shown below:

factor				
A	B	C	D	etch rate
-	-	-	-	550
+	-	-	-	669
-	+	-	-	604
+	+	-	-	650
-	-	+	-	633
+	-	+	-	642
-	+	+	-	601
+	+	+	-	635
-	-	-	+	1037
+	-	-	+	749
-	+	-	+	1052
+	+	-	+	868
-	-	+	+	1075
+	-	+	+	860
-	+	+	+	1063
+	+	+	+	729

Template SAS code used for the class example is in the file "design2level.sas".

(a) Estimate the factorial effects. Use QQ plot to identify potentially significant effects.

(b) Conduct an analysis of variance to confirm your findings in a).

(c) What should be the appropriate regression model relating etch rate to the significant process variables?

(d) Analyze the residuals from this experiment. Comment on the model adequacy.

(e) If not all factors are important,project the 2^4 design into a 2^k design with $k < 4$ and conduct the analysis of variance.

(f) (Optional)Draw graphs to interpret the significant interactions.

(g) (Optional) Construct contour plots of the etch rate using the model in c).

(h) (Optional) Suppose that it was necessary to operate this process at an etch rate of 800, what settings of the process variables would you recommend?