STAT 514 Homework#10
(Due Thursday 12/03/15 BEFORE CLASS)

1. An experiment is designed to study pigment dispersion in paint. Four different mixes of a particular pigment are studied. The procedure consists of preparing a particular mix and then applying that mix to a panel by three application methods (brushing, spraying, and rolling). The response measured is the percentage reflectance of pigment. Three days are required to run the experiment, and the data obtained follow.

Day	Application Method	Mix 1	2	3	4
1	1	64.5	66.3	74.1	66.5
	2	68.3	69.5	73.8	70.0
	3	70.3	73.1	78.0	72.3
2	1	65.2	65.0	73.8	64.8
	2	69.2	70.3	74.5	68.3
	3	71.2	72.8	79.1	71.5
3	1	66.2	66.5	72.3	67.7
	2	69.0	69.0	75.4	68.6
	3	70.8	74.2	80.1	72.4

(a) Construct the ANOVA table for this split-plot design.

(b) Assuming that mixes and application methods are fixed, construct the EMS table. Analyze the data and draw conclusions.

(c) Assuming that the mixes are random and the application methods are fixed, construct the EMS table. Analyze the data and draw conclusions.

2. 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. Two levels of each factor are chosen, and three replicates of a 2^3 factorial design are run. The results follow:

factor A	B	C	replicate 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.

(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) 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?

3. 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 reactor 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 2^4 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

(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 is the regression model relating etch rate to the significant process variables?

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

(A Sample SAS file "design2level.sas" can be downloaded from the class website "SAS Files")