1. The yield of a chemical process is being studied. The two most important variables are thought to be the pressure and the temperature. Three levels of each factor are selected, and a factorial experiment with two replicates is performed. The yield data follow:

	Pressure		
Temperature	200	215	230
150	90.4	90.7	90.2
	90.2	90.6	90.4
160	90.1	90.5	89.9
	90.3	90.6	90.1
170	90.5	90.8	90.4
	90.7	90.9	90.1

   (a) Analyze the data and draw conclusions. Use $\alpha = 0.05$.

   (b) Prepare appropriate residual plots and comment on the models adequacy.

   (c) Under what conditions would you operate this process?

   (d) Use the regression method to predict yield in which both factors are considered as quantitative ones.

2. An experiment is conducted to study the influence of operating temperature and three types of face-plate glass in the light output of an oscilloscope tube. The following data are collected:

	Temperature		
Glass Type	100	125	150
1	580	1,090	1,392
	568	1,087	1,380
	570	1,085	1,386
2	550	1,070	1,328
	530	1,035	1,312
	579	1,000	1,299
3	546	1,045	867
	575	1,053	904
	599	1,066	889

   (a) Use $\alpha = 0.05$. Is there a significant interaction effect? Does glass type or temperature affect the response? What conclusions can you draw?

   (b) Fit an appropriate response surface model relating light output to glass type and temperature.

(c) Analyze the residuals from this experiment. Comment on the adequacy of the models you have considered.

3. The factors that influence the breaking strength of a synthetic fiber are being studied. Four production machines and three operators are chosen 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	109	110	108	110
	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 and draw conclusions. Use $\alpha = 0.05$.

(b) Prepare appropriate residual plots and comment on the models adequacy.

4. The yield of a chemical process is being studied. The two factors of interest are temperature and pressure. Three levels of each factor are selected; however, only 9 runs can be made in one day. The experimenter runs a complete replicate of the design on each day. The data are shown in the following table. Analyze the data assuming that the days are blocks.

	Day1			Day2		
	Pressure			Pressure		
Temperature	250	260	270	250	260	270
Low	86.3	84.0	85.8	86.1	85.2	87.3
Medium	88.5	87.3	89.0	89.4	89.9	90.3
High	89.1	90.2	91.3	91.7	93.2	93.7

5. 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 are as follows:

			Treatment	Replicate		
A	B	C	Combination	I	II	III
-	-	-	(1)	22	31	25
+	-	-	a	32	43	29
-	+	-	b	35	34	50
+	+	-	ab	55	47	46
-	-	+	c	44	45	38
+	-	+	ac	40	37	36
-	+	+	bc	60	50	54
+	+	+	abc	39	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) Use the regression model in (c) to generate response surface and contour plots of the tool life response. Interpret these plots. Do they provide insight regarding the desirable operating conditions for this process?

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

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