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. 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?

2. An experiment was run in a semiconductor fabrication plant in an effort to increase yield. Five factors, each at two levels, were studied. The factors (and levels) were A = aperture setting (small, large), B = exposure time (20% below nominal, 20% above nominal), C = development time (30s, 45s), D = mask dimension (small, large), and E = etch time (14.5min, 15.5min). The unreplicated 2^5 design shown below was run.

(1) = 7	d = 8	e = 8	de = 6	a = 9	ad =10	ae = 12	ade = 10
b = 34	bd = 32	be = 35	bde = 30	ab = 55	abd = 50	abe = 52	abde = 53
c = 16	cd = 18	ce = 15	cde = 15	ac = 20	acd = 21	ace = 22	acde = 20
bc = 40	bcd = 44	bce = 45	bcde = 41	abc = 60	abcd = 61	abce = 65	abcde =63

(a) Construct a normal probability plot of the effect estimates. Which effects appear to be large?

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

(c) Write down the regression model relating yield to the significant process variables.

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

(e) Interpret any significant interactions.

(f) What are your recommendations regarding process operating conditions?

3. Using the data from the 2^5 design in Problem 2, construct and analyze a design in two blocks with $ABCDE$ confounded with blocks.

4. An experiment was performed to improve the yield of a chemical process. Four factors, A, B, C and D were selected. Suppose that in the chemical process development experiment, it was only possible to run a one-half fraction of the 2^4 design. Construct the design and perform the statistical analysis, using the data from replicate 1.

Treatment Combination	Replicate I	Treatment Combination	Replicate I
(1)	90	d	98
a	74	ad	72
b	81	bd	87
ab	83	abd	85
c	77	cd	99
ac	81	acd	79
bc	88	bcd	87
abc	73	abcd	80