Exercises for Chapter 7

7.1 The following data[1] was recorded for an 8-run Plackett-Burman screening design.

Run	X_1	X_2	X_3	X_4	X_5	X_6	X_7	Yield
1	+	+	+	-	+	-	-	1.1
2	-	+	+	+	-	+	-	6.3
3	-	-	+	+	+	-	+	1.2
4	+	-	-	+	+	+	-	0.8
5	-	+	-	-	+	+	+	6.0
6	+	-	+	-	-	+	+	0.9
7	+	+	-	+	-	-	+	1.1
8	-	-	-	-	-	-	-	1.4

a) Calculate the effects for factors $X_1 – X_7$.

b) Make a Normal Probability plot of the effects and a Pareto diagram of the absolute effects

c) Which main effect is the X_1 X_2 interaction confounded with? X_1X_6? X_2X_6?

d) What would you recommend after the analysis of this data?

[1]Nelson, L. S., "Extreme Screening Designs," *Journal of Quality Technology*, (1982) pp. 99-100.

7.2 Using Table B.1-7 and the method of pseudo factors:

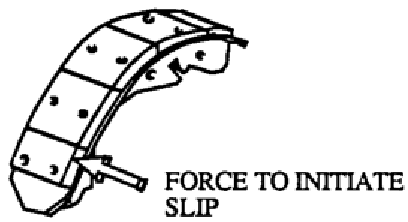
a) Create a 16 run fraction of a $4\times4\times2^2$ design.

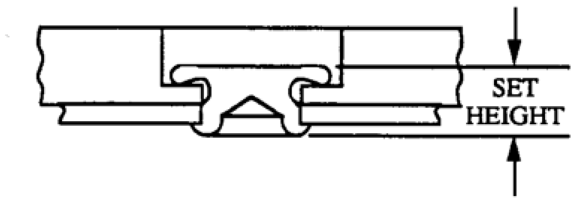
b) Create a 16 run fraction of a 8×2^3 design.

c) Using the dummy levels method with the design you created in Part (a), create a 16 run $4\times3\times2^2$ design.

d) Using the dummy levels method with the design you created in Part (b), create a 16 run 6×2^3 design.

7.3 In the fall of 1986, durability tests of GM trucks at the desert proving grounds[2] revealed that the shoe friction material was loosening from the shoe assembly on the rear brakes. An immediate but costly solution was implemented by adding a preconditioning process to the assembly. Next a screening design was undertaken to discover the cause of the problem. Eight factors (four process factors and four product design factors) were selected for the screening experiment. The experiments were conducted and the response, force to initiate lateral slip, was recorded on 16 experimental brake shoes. The experimental design was given by Table B.1-8 and the resulting data is listed on the next page.





	Levels	
Process Factors:	-	+
X_1 - Spring Force	Min	Max
X_2 - Anvil and Hammer Design	Delco	GMC
X_3 - Anvil and Hammer Condition	New	Worn
X_4 - Method	End Start	Center Start
Design Factors:		
X_5 - Shoe Surface Finish	Varnish	Sandblast
X_6 - Rivet Venders	Acme	Townsend
X_7 - Rivet Length	Short	Long
X_8 - Counter Bore Depth	0.05"	0.06"

[2]Gibbons, N. M., "Applications of Experimental Designs to a Brake Riveting Process," Presented at the ASA Annual Meeting, (1988).

Data in Standard order of Table B.1-8

Run	Y = Force to initiate lateral slip
1	0.0
2	162.5
3	90.0
4	90.0
5	40.0
6	92.5
7	60.0
8	70.0
9	50.0
10	90.0
11	90.0
12	112.5
13	80.0
14	100.0
15	40.0
16	137.5

a) Calculate the 15 effects as shown in Table B.1-8 and make a Normal plot to judge which effects are significant.

b) Are there any relatively lare unassigned effects? If so interpret. (i.e., what interactions might they represent)

7.4 In an experimental program to investigate the properties of a thin film plastic coating on ceramic based resistors, six factors were identified.

X_1 - Supplier of a basic component of the plastic (there were 2)
X_2 - Viscosity of the coating at time of application
X_3 - Thickness of coating
X_4 - Temperature of the first bake (dry) cycle
X_5 - Temperature of the second bake (cure) cycle
X_6 - Speed of the conveyer

a) List the experiments and a random list of run orders for a half faction design with these six factors using symbolic - and + signs for the levels. Show the complete confounding table.

b) List the experiments and random run orders if the half fraction is to be run in 2 blocks. What is the block effect confounded with?

7.5 An experiment is to be performed in order to determine which factors affect the wear of a slider pump[3] . It was desired to study five factors at two levels each in eight runs, and two interactions were thought to be important.

Factors:
A. Material
B. Weight
C. Surface roughness
D. Clearance
E. Slide material

Determine which columns of Table B.1-5 Factors A-E should be assigned to in order to estimate all effects in the requirement set (A, B, C, D, E, AB, AC). Determine which columns of Table B.1-5 will be used to estimate the interaction effects AB and AC.

[3]Taguchi, Genichi, *Introduction to Quality Engineering*, Asian Productivity Association, Tokyo, Chapter 7.

7.6 You are trying to help an ice cream vendor to be able to predict how many ice cream cones he will sell in a given afternoon (so that he knows how much ice cream to buy). He decides, with your help, to run a half fraction of a 2^5 to study the influence of several factors on sales. The data are given below:

X_1	X_2	X_3	X_4	X_5	No. of Cones Sold
-	-	-	-	+	105
+	-	-	-	-	122
-	+	-	-	-	92
+	+	-	-	+	149
-	-	+	-	-	106
+	-	+	-	+	153
-	+	+	-	+	111
+	+	+	-	-	113
-	-	-	+	-	100
+	-	-	+	+	146
-	+	-	+	+	105
+	+	-	+	-	125
-	-	+	+	+	105
+	-	+	+	-	126
-	+	+	+	-	94
+	+	+	+	+	156

The factors studied and their levels are:

Factor		Low Value (-)	High Value (+)
X_1 =	temperature (F)	75	85
X_2 =	weather	Cloudy	Sunny
X_3 =	# of flavors	5	10
X_4 =	cone type	Regular	Waffle
X_5 =	personality	Surly	Happy

From the data given above, is a prediction equation justified? If so, what is it? Justify your answers.

7.7 An important property of electrical tape is the Percent Elongation at break. You decide to study a number of factors that may influence this property using a quarter fraction of a 2^6 design. The data are given below:

X_1	X_2	X_3	X_4	X_5	X_6	Percent Elongation
-	-	-	-	-	-	96
+	-	-	-	+	-	89
-	+	-	-	+	+	97
+	+	-	-	-	+	91
-	-	+	-	+	+	100
+	-	+	-	-	+	95
-	+	+	-	-	-	105
+	+	+	-	+	-	95
-	-	-	+	-	+	112
+	-	-	+	+	+	106
-	+	-	+	+	-	114
+	+	-	+	-	-	108
-	-	+	+	+	-	120
+	-	+	+	-	-	116
-	+	+	+	-	+	120
+	+	+	+	+	+	118

The factors studied and their levels are:

	Factor	Low Value (-)	High Value (+)
X_1 =	% of Plasticizer	20%	40%
X_2 =	Time of Compounding	5 min	15 min
X_3 =	Temp of Compounding	200 F	350 F
X_4 =	Extruder Speed	200 rpm	400 rpm
X_5 =	Thickness of Tape	5 mil	8 mil
X_6 =	Source of Plasticizer	A	B

(a) Analyze the data above and determine if any of the factors have a significant effect on the response.

(b) From your analysis, what operating conditions would give a maximum Percent Elongation? What operating conditions would give a minimum Percent Elongation?

7.8 Consider the 2^{5-2} fractional factorial design with generators: 4 = 12 and 5 = 123. Specify the factor level combinations for this design and determine the complete confounding pattern. Note the resolution of the design.

7.9 The 2_{III}^{7-4} design in Table B.1-5 is one particular fraction of the full 2^7 factorial design with the generators: 4 = 12, 5 = 13, 6 = 23, and 7 = 123. Consider another fraction of the design which is obtained by changing all the signs in Table B.1-5.

(a) What are the generators for the new design? What are the defining relations?

(b) Ignoring all interactions of third order or higher, what is the confounding pattern for the new design?

7.10 In creating an 8 run fractional 4×2^4 design using the method of pseudo factors and Table B.1-5:

a) Show why a two-level factor cannot be assigned to column X_4 if columns X_1 and X_2 are used to define the four-level factor.

b) Show why a two-level factor cannot be assigned to column X_1 if columns X_6 and X_7 are used to define the four level factor.

7.11 Using the pseudo factor method along with the L18 (Table B.1-15):

a) Create an 18 run 6×3^3 design.

b) Using dummy levels, change the design you created in Part (a) to a 18 run $6\times3\times2^2$ design.