ENR211 STATISTICS FOR ENGINEERS

Problem Set 5

Design Of experiments

1. What is a factorial design?
2. Why are factorial designs well suited to empirical studies? Suggest an application in your own field.
3. What is a $4^2 \times 3^3 \times 2$ factorial design? How many runs are there in this design? How many variables does it accommodate?
4. What is a two-level factorial design?
5. How many runs are contained in a two-level factorial design for four variables?
6. How many runs does a 2^6 design have? How many variables? How many levels for each variable?
7. Explain any two factorial designs with the help of suitable example.
8. Why Taguchi's approach is preferred as compared to Classical approach of experimental design? Explain with the help of a suitable example.
9. Why do we replicate our experimental runs?
   (a) So we can look for special causes
   (b) To obtain a better estimate of the error and look at interaction
   (c) To determine the factor levels.
   (d) So we can look at the same thing run again
10. If an experimenter is interested in looking at variables that effect the response, those variables are called
    (a) Treatments
    (b) Factors
    (c) Effects
    (d) Levels
11. Factors in a factorial design are the ______
    (a) The experimental variables
    (b) The independent variables
    (c) The dependent variables
    (d) The organismic variables
12. A team of researchers aimed to study the impact of Temperature (T), Concentration (C), and Catalyst (K) on the yield of a chemical reaction. They selected two levels for each factor: 160°C and 180°C for Temperature, 20% and 40% for Concentration, and Catalysts A and B. By conducting eight experimental runs with all possible factor combinations, they measured the average yield (%) for each setup. The experiment provided insights into how these factors influenced the reaction's efficiency.

Operational Levels of Factors

Run Number	**Temperature, T (°C)**	**Concentration, C (%)**	**Catalyst, K (A or B)**	**Yield, y (%)**
1	160	20	A	60
2	180	20	A	72
3	160	40	A	54
4	180	40	A	68
5	160	20	B	52
6	180	20	B	83
7	160	40	B	45
8	180	40	B	80

(a) Find main and interaction effects. Express the expected yield, $\hat{y}$ as a function of T, C and K.

(b) Find the yield for the following settings.

i. T=160°C, C=30%, B

ii. T=170°C, C=20%, A

iii. T=180°C, C=35%, B

You may use the following tables.

Temperature, T (°C)		Concentration, C (%)		Catalyst, K	
−	+	−	+	−	+
160	180	20	40	A	B

Coded Units of Factors

T	**C**	**K**	**Average Yield y from Duplicate Runs**
−	−	−	60
+	−	−	72
−	+	−	54
+	+	−	68
−	−	+	52
+	−	+	83
−	+	+	45
+	+	+	80

13. The purpose of a set of trials is to discover the effects of two alloying elements, namely, nickel and manganese on the breaking strength of a certain product. Data is shown below. Find the main and interaction effects.

Nickel (%)	**Manganese (%)**	**Breaking Strength (ft-lb)**
0	1	35
3	1	46
0	2	42
3	2	40

14. An engineer is interested in observing the effect 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:

A	B	C	**Treatment Combination**	**Replicate** 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

Table 1: Factorial Experiment Results

Find the main and interaction effects.