Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. - SEMESTER – I • EXAMINATION – WINTER • 2013

Subject code: 710906N Date: 06-01-2014

Subject Name: Robust Design

Time: 10.30 am – 01.00 pm Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** For the given regression models, compare and interpret the nature of the response surface as well as the contour plots (i)$y=\beta_0+\beta_1x_1+\beta_2x_2$ (ii) $y=\beta_0+\beta_1x_1+\beta_2x_2+\beta_{12}x_1x_2$. **07**

(b) The impurity in a chemical product is affected by two factors-pressure and temperature. The data from a single replicate of a factorial experiment is given **07**

Temperature	Pressure				
	25	30	35	40	45
100	5	4	6	3	5
125	3	1	4	2	3
150	1	1	3	1	2

Calculate, using basic equations, the sum squares of factors and total.

Q.2 **(a)** Why coded variables are used in factorial designs, while developing regression models? With the help of a suitable example explain how to code. **07**

(b) An experiment was done in semiconductor fabrication plant in an effort to increase the yield. Three factors, each at two levels were studied. The factors were A= aperture setting (small, large), B= exposure time (20% below nominal, 20% above nominal), C= development time (30s, 40s). The un-replicated 2^2 design is given below. Write down the regression model relating yield to process variables. (1) = 7, a=9, b=34, ab=55, c=16, ac=20, bc=40, abc=60 **07**

OR

(b) An experiment was done in semiconductor fabrication plant in an effort to increase the yield. Two factors, each at two levels were studied. The factors were A= aperture setting (small, large), B= exposure time (20% below nominal, 20% above nominal). The un-replicated 2^2 design is given below. (1) = 7, a=9, b=34, ab=55. Suppose that the experimenter had run 4 center points in addition to the 4 trials. The yield obtained at the center points runs were 68, 69, 68 and 70. Check whether quadratic curvature effect is present or not. **07**

Q.3 **(a)** Explain, citing suitable example, why fractional factorial designs are used instead of full factorial design. **07**

(b) Taking a 2^3 design as an example, explain confounding in two blocks. **07**

OR

Q.3 **(a)** What do you mean by ANOVA? Explain various elements of the ANOVA table. How it could be used to establish significance of factors and interactions? **07**

(b) Construct a 2^{5-1} design. Show how the design may be run in two blocks of eight observations each. Are any main effects or two-factor interactions confounded with blocks **07**

Q.4 **(a)** A spin coater is used to apply photoresist to a bare silicon wafer. Four variables are used in the experiment and are given below. The experimenter decides to use a 2^{4-1} design, with the defining relation I=ABCD. Develop the design matrix and discuss the alias relationships in the design **07**

(b) Three factors are studied using the design matrix and responses given below. Calculate the factor effects and interactions using CONTRAST. Also fit a mathematical model. **07**

Std order	A	B	C	y
1	–	–	–	16
2	+	–	–	18
3	–	+	–	27
4	+	+	–	16
5	–	–	+	14
6	+	–	+	19
7	–	+	+	18
8	+	+	+	23

OR

Q.4 **(a)** For the design matrix given below fit a linear regression model, using X matrix and Y matrix. **07**

Std order	A	B	C	y
1	–	–	–	11
2	+	–	–	15
3	–	+	–	9
4	+	+	–	16
5	–	–	+	10
6	+	–	+	12
7	–	+	+	10
8	+	+	+	15
9	0	0	0	12
10	0	0	0	9
11	0	0	0	10
12	0	0	0	14

(b) For the data given in question OR 4(a), check whether curvature effect exists or not. If curvature exists, what modifications do you suggest? **07**

Q.5 **(a)** For the fitted model $\hat{y} = 27.5 + 4x1 – 2.5x2$, using coded variables $(-1 \leq x1 \leq +1)$ & $(-1 \leq x2 \leq +1)$. Identify the path of steepest ascent. Only find 10 steps. Factors are x1 (low =15%, high = 25%) and x2 (low =1, high = 5) **07**

(b) Explain various designs suitable for fitting the second-order models **07**

OR

Q.5 **(a)** Giving suitable examples, explain resolution IV and V designs. **07**

(b) Explain the response surface approach to robust design **07**

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