

GUJARAT TECHNOLOGICAL UNIVERSITY
M. E. - SEMESTER – I • EXAMINATION – WINTER 2012

Subject code: 710906N**Date: 16-01-2013****Subject Name: Robust Design****Time: 02.30 pm – 05.00 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) With the help of a neat sketch show the factorial points of a 2^3 design and explain how do you compute the main effects **07**
- (b) With the help of neat sketches explain the meaning and significance of interaction between factors **07**

- Q.2** (a) Students in a university electronics lab often complained about taking a measurement, and then retaking it sometime later and finding the reading had changed. The lab instructor decided to make a small study of the causes for variation in the electronic measurements. He setup a 2^3 factorial experiment to examine the effect of (i) ambient temperature, 22 to 32 °C (ii) voltmeter warming up time, 0.5 to 5 minutes (iii) time that power is connected, 0.50 to 5 minutes. The response is measured voltage in millivolts. Estimate the factor effects and interactions and hence develop a model for predicting the situation **07**

Run no	X1	X2	X3	Y millivolts	
1	–	–	–	705	680
2	+	–	–	620	651
3	–	+	–	700	685
4	+	+	–	629	635
5	–	–	+	672	654
6	+	–	+	668	691
7	–	+	+	715	672
8	+	+	+	647	673

- (b) Explain the term confounding, citing its usefulness in design of experiments. Give suitable example **07**

OR

- (b) Design an experiment to confound a 2^5 design in four blocks **07**

- Q.3** (a) Explain the three key ideas used to create fractional factorial designs. Also explain how do you create a one-half-fraction of a 2^3 design **07**
- (b) An experiment was performed to improve the yield of a chemical process. Four factors were selected, and a completely randomized experiment was run. The results are shown below **07**

Treatment Combination	Response	Treatment Combination	Response
(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

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 one-half fractional design and fit a predictive equation representing the situation

OR

- Q.3** (a) What do you mean by ANOVA? How it is useful in design of experiments? **07**
 (b) An experiment was performed to improve the yield of a chemical process. **07**
 Four factors were selected, and a completely randomized experiment was run. The results are shown below

Treatment Combination	Response	Treatment Combination	Response
(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

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. Carry out ANOVA and identify the significant factors.

$$F_{.05,1,3} = 10.13$$

- Q.4** (a) Why comparison of pairs of treatment means is carried out? Explain any one method used to compare them **07**
 (b) The yield of a chemical process is related to the concentration of the reactant and the operating temperature. An experiment has been conducted with the following results **07**

Yield	Concentration	Temperature
81	1.00	150
89	1.00	180
83	2.00	150
91	2.00	180
79	1.00	150
87	1.00	180
84	2.00	150
90	2.00	180

- (i) Suppose we wish to fit a main effects model to this data. Setup the $X'X$ matrix using the data exactly as it appears in the table. Is the matrix obtained is diagonal? Discuss
 (ii) Suppose we write our model in terms of the usual coded variables $x_1 = (\text{Conc} - 1.5)/0.5$ and $x_2 = (\text{Temp} - 165)/15$, setup the $X'X$ matrix of the model in terms of these coded variables. Is the matrix diagonal? Discuss

OR

- Q.4** (a) With the help of neat sketches. explain the terms CCD, rotatability, spherical CCD **07**
 (b) An engineer is interested in the effects of cutting speed (A), tool geometry **07**

(B), and cutting angle (C) on the life (in hours) of a machine tool. Two levels of each factors are chosen, and the results are:

A	B	C	Life
–	–	–	22
+	–	–	32
–	+	–	35
+	+	–	55
–	–	+	44
+	–	+	40
–	+	+	60
+	+	+	39

Write down the X matrix and Y vector. Using X matrix and Y vector, calculate the least square estimate the parameters (β 's). Fit a multiple linear regression model.

- Q.5** (a) Explain the following terms in the context of RSM (i) response surface (ii) method of steepest ascent **07**
 (b) Explain the terms (i) statistical hypothesis (ii) means model and effects model **07**

OR

- Q.5** (a) Explain the meaning and significance of the term robust design **07**
 (b) The region of experimentation for the two factors is temperature ($100 \leq T \leq 300$) and catalyst feed rate ($10 \leq C \leq 30$). A first order model in the usual ± 1 coded variables has been fit into a molecular weight response, yielding the following model: $\hat{y} = 2000 + 125x_1 + 40x_2$ **07**

Find the path of steepest ascent –at least ten points of the path
