Seat No.: _____ *Enrolment No._____*

GUJARAT TECHNOLOGICAL UNIVERSITY

M.E Sem-I Examination January 2010

Subject code: 710906 **Subject Name: Robust Design**
Date: 27 / 01 / 2010 **Time: 12.00 – 2.30 pm**
Total Marks: 60

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 neat schematics differentiate between the following quality loss functions: step function and quadratic loss function. **06**

A solid state welding process is producing parts with population mean impact strength of 300Nm, and variance is 100. The part is encountering a 10% failure rate in the field. It is proposed that increasing the welding temperature from 500° to 600° will increase the impact strength. Six parts were made on the welder at600° with impact strength: 310, 311, 300, 290, 320 and 306Nm, respectively. State the hypothesis to be tested and suggest whether to increase the temperature or not. Take $\delta=1\sigma$; $U_\alpha=1.645$, $U_\beta=1.282$.

(b) An experiment was run to determine whether three specific temperatures affect the density o a certain type of brick. The experiment led to the following data: **06**

Temperature	Density		
100	21.8	21.9	21.7
125	21.7	21.4	21.5
150	21.9	21.8	21.8
175	21.9	21.7	21.8

Does the firing temperature affect the density of the bricks? Use $\alpha=0.05$. $F_{0.05,3,8} = 4.07$; $F_{0.05,4,8} =3.84$; $F_{0.05,3,12}= 3.49$; $F_{0.05,4,12} = 3.26$
Use Tukey's method to compare pairs of treatment means. $q_{0.05}(4,8) = 4.53$; $q_{0.05}(4,8) = 4.33$; $q_{0.05}(4,12) = 4.20$

Q.2 **(a)** Though either a two level full factorial or a two level half fractional factorial design can be used as a screening experiment fractional factorial design is preferred. Evaluate this statement. **06**

Explain, with the help of a suitable example, why central points are added to a 2^k experimental design?

(b) A chemist wishes to test the effect of four chemical agents on the strength of a particular type of cloth. Because there might be variability between bolts (= a roll of cloth of specific length), the chemist decides to use a randomized block design, with the bolts of cloth considered as blocks. She selects four bolts. The resulting tensile strength is: **06**

Chemical	Bolts			
	1	2	3	4
1	73	68	74	71
2	73	67	75	72
3	75	68	78	73
4	73	71	75	75

Analyse the data from this experiment for $\alpha = 0.05$ and check whether the chemical affects the strength of the cloth. $F_{0.05,3,9} = 3.86$; $F_{0.05,3,12} = 3.49$

OR

(b) An industrial engineer is investigating the effect of four assembly methods (A,B,C,D) on the assembly time for a colour television component. Four operators are selected for the study. Furthermore, the engineer knows that each assembly produces such fatigue that the time required for the last assembly may be greater than the time required for the first, regardless of the method. To account these sources of variability, the engineer uses the Latin square design shown below. Analyse the data for $\alpha = 0.05$ and draw conclusions. $F_{0.05,3,6} = 4.76$; $F_{0.05,3,7} = 4.35$ **06**

Order of Assembly	Operator			
	1	2	3	4
1	C=10	D=14	A=7	B=8
2	B=7	C=18	D=11	A=8
3	A=5	B=10	C=11	D=9
4	D=10	A=10	B=12	C=14

Q.3 **(a)** Explain why confounding is required in experiments. **06**

An investigator has to use a 2^4 design for his experiments. But the raw material required for this is available from two batches. Develop a plan to conduct the experiment such that effects ABC & BCD are confounded. Use defining contrast method for confounding.

(b) A mechanical engineer is studying the thrust force developed by the drill press. He suspects that the drilling speed and the feed rate of the material are the most important factors. He selects four feeds and two drill speeds to represent the extreme operating conditions. Use $\alpha = 0.05$ in the analysis. **06**

Drill speed	Feed rate			
	0.015	0.030	0.045	0.060
125	2.70	2.45	2.60	2.75
	2.78	2.49	2.72	2.86
200	2.83	2.85	2.86	2.94
	2.86	2.80	2.87	2.88

Identify significant factors. Is there any interactive effect?
Also fit an appropriate model relating feed and speed. $F_{0.05,1,8} = 5.32$; $F_{0.05,3,8} = 4.07$; $F_{0.05,2,8} = 4.46$; $F_{0.05,4,8} = 3.84$

OR

Q.3 **(a)** Consider the three-factor model **06**

$y_{ijk} = \mu + \tau_i + \beta_j + \gamma_k + (\tau\beta)_{ij} + (\beta\gamma)_{jk} + \varepsilon_{ijk}$

where i=1,2……..,a

j=1,2……..,b

k=1,2……..,c

There is only one replicate. Assuming all factors are fixed, write down the analysis of variance table, the expected mean squares. What would you use as the experimental error to test hypothesis?

(b) The yield of a chemical process is being studied. The Two factors of interest are temperature and pressure. Three levels of each factor are selected; however only nine runs can be completed in one day. The experimenter runs a complete replica of the design on each day. The data are shown in the following table. **06**

Temperature	Day1 Pressure			Day 2 Pressure		
	250	260	270	250	260	270
Low	86.3	84	85.8	86.1	85.2	87.3
Medium	88.5	87.3	89	89.4	89.9	90.3
High	89.1	90.2	91.3	91.7	93.2	93.7

Identify significant factors. Is there any interactive effect?

$F_{0.05,1,8} = 5.32$; $F_{0.05,1,9} = 5.12$; $F_{0.05,2,8} = 4.46$; $F_{0.05,4,8} = 3.84$

Q.4 **(a)** With the help of a suitable example bring out the most significant advantages of factorial design. **06**

With the help of frequency chart explain the term "six sigma quality"

(b) State the three key ides on which the whole concept of fractional factorial designs are based. **06**

Explain how you will generate a one-half fraction of the 2^5 design.

OR

Q.4 **(a)** Differentiate between first order and second order models. When will you go for a central composite design **06**

(b) 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 cutting tool. Two levels of each factor are chosen, and a 23 factorial deign is run. The results are: **06**

A	B	C	Treatment Combinations	Tool life In hours
–	–	–	(1)	22
+	–	–	a	32
–	+	–	b	35
+	+	–	ab	55
–	–	+	c	44
+	–	+	ac	40
–	+	+	bc	60
+	+	+	abc	39

Use ANOVA and identify the most significant factor. Write down the regression model for predicting tool life in hours based on the results of this experiment.

Q.5 **(a)** Explain briefly the concepts: parametric and tolerance design **06**

Citing a suitable example explain how robustness can be attained in a product.

(b) A chemical engineer is investigating the yield of a process. The process variables of interest are: temperature, pressure, and catalyst concentration. Each variable can be run at a low level and a high level and the engineer decides to run a 2^3 design with 4 centre points. The design and the resulting yield are given below. Fit a linear regression model for main effects. **06**

Process variables				Coded variables			Yield y
Run	Temp	Pressure	Conc.	x1	x2	x3	
1	120	40	15	–	–	–	32
2	160	40	15	+	–	–	46
3	120	80	15	–	+	–	57
4	160	80	15	+	+	–	65
5	120	40	30	–	–	+	36
6	160	40	30	+	–	+	48
7	120	80	30	–	+	+	57
8	160	80	30	+	+	+	68
9	140	60	22.5	0	0	0	50
10	140	60	22.5	0	0	0	44
11	140	60	22.5	0	0	0	53
12	140	60	22.5	0	0	0	56

OR

Q.5 **(a)** Explain the usefulness of method of steepest ascent. **06**
With the help of frequency chart explain the term six sigma quality.

(b) The region of experimentation for 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 to a molecular weight response, yielding the following model: **06**

$\hat{y} = 2000+125x_1+40x_2$

Find the path of steepest ascent.

It is desired to move to a region where molecular weights are above 2500. Based on the information estimate how many steps along the path of steepest ascent might be required to move to the region of interest?

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