INDIAN STATISTICAL INSTITUTE
SQC & OR Unit, Hyderabad

MS in Quality Management Science : 2015-17

III SEMESTER : MID-TERM EXAMINATION

Subject : Industrial Experimentation

Date : 07th September 2016 Max. Marks : 100 & Time : 120 minutes

Instructions : This paper carries 120 marks. You need to answer all the questions and maximum marks you can score is 100. You need to provide all the answers on the normal answer booklet (Hardcopy). You may provide graphs/charts/diagrams etc. (if any) on the soft answer booklet [word file : Mid-Term Answer Booklet (Student name).doc] by clearly writing your name on the answer sheet as well as file name.

1. State whether the following statements are correct or wrong with justification for your answer. (maximum 3 lines) (10x3 = 30)

    a. Industrial Experimentation (DOE) is a continuous improvement technique for achieving the desired performance in Products/Processes, beating competition and maximizing customer satisfaction.

    b. Need for conducting Industrial Experiments arises when the improvements could not be achieved through the application of other statistical methods.

    c. One Factor at a Time (OFAT) experiments are widely used in industry because it is efficient in terms of number of trials, ease of design, conducting & analysis.

    d. To successfully conduct Industrial Experiments, the experimenter, need to be very good in Statistical Methodology and should have some working knowledge on the study domain.

    e. The three cardinal principles of Industrial experimentation - Randomization, Replication & Local control help in managing the experimental error effectively.

    f. Interaction effect between two factors will be negligible when they are not very important factors in the whole design and may not contribute significantly to the effect.

    g. Latin Square Design is preferred over CRD & RBD as three factors each with more than two levels can be studied simultaneously.

h. An Industrial Experiment without any replications is not amenable to statistical analysis and it will not be possible to draw appropriate inferences to arrive at an optimum combination.

i. Factorial Designs are most powerful designs as all possible combinations are tried out and also numbers of trials conducted are more for optimal results.

j. ANOVA technique is a widely used technique to analyze the Industrial Experimentation data as it can estimate and compare the effects efficiently.

2. An R&D establishment conducted preliminary experiments to determine the influence of process parameters on the Response, Whiteness of Rayon (Y). Analyze the data for maximizing whiteness using appropriate Statistical/Industrial Experimentation techniques and suggest important process parameters, their respective levels and possible interactions between factors which can be considered for a detailed scientifically designed experimentation study subsequently. (40 Marks)

Sl. No	Acid Temp.	Acid Conc.	Water Temp.	Sulfide Conc.	Amount of Bleach	Whiteness (Y)
1	35	0.7	88	0.3	0.5	99.5
2	45	0.5	85	0.25	0.2	71
3	45	0.1	85	0.25	0.4	77.2
4	55	0.3	82	0.2	0.5	89.4
5	45	0.5	91	0.25	0.4	71.2
6	35	0.7	82	0.3	0.3	99.8
7	45	0.5	85	0.15	0.4	77.5
8	55	0.3	82	0.3	0.3	97.5
9	35	0.3	88	0.3	0.3	120.2
10	55	0.7	82	0.3	0.5	111.5
11	35	0.7	82	0.2	0.5	123.2
12	55	0.7	88	0.2	0.5	102.3
13	45	0.5	79	0.25	0.4	71.5
14	45	0.5	85	0.35	0.4	72,2
15	35	0.3	82	0.3	0.5	111.6
16	55	0.7	88	0.3	0.3	108.1
17	45	0.9	85	0.25	0.4	71.1
18	45	0.5	85	0.25	0.6	73.2
19	35	0.3	82	0.2	0.3	95.8
20	55	0.7	82	0.2	0.3	115.2
21	25	0.5	85	0.25	0.4	70.1
22	35	0.7	88	0.2	0.3	120.4
23	35	0.3	88	0.2	0.5	118.3
24	55	0.3	88	0.3	0.5	108.7
25	65	0.5	85	0.25	0.4	69.2
26	55	0.3	88	0.2	0.3	103.2

3. A micro oven manufacturing company has conducted an experiment to optimize the efficiency (heating capacity) of its oven by studying different types micro oven container specific factors/parameters.

   The following tables gives the factors and their respective levels selected for study.

Factor	Level 1	Level 2
Type of Material	Plastic	Glass
Shape	Cylinder	Rectangle
Color	Clear	Opaque
Cover	Open	Closed

   It was decided to conduct a full factorial experiment (2^4). The experimenter also was interested to know the effect of type of cooking material (Water & Milk) used for conducting the experiment therefore the experiment was carried out in two blocks Response of the study was "Difference in Temperature" (Degrees Centigrade) when heated for 1 minute.

   The experimental data is given in a table in the next page.

   All the experiments were conducted in a random order within a block and the experimenter forgot to record the standard order.

   Answer the following questions.

   a. Arrange the experimental data as per the standard order.

   b. Perform suitable graphical analysis for identifying the dominant effects.

   c. Perform suitable statistical analysis for identifying the significant effects (α=0.05).

   d. Check for significance of block, if it is significant what inference can be drawn.

   e. Find the contribution % of all the effects.

   f. How the insignificant effects are addressed while building prediction model.

   g. Fit a suitable prediction model. Perform the necessary diagnostics

   h. Suggest the optimum combination for getting maximum temp. Difference.

   i. Any other interesting observations/findings.

(50)

Micro Oven Experimentation Data (Question – 3)

Expt. No	Block	Material	Shape	Color	Cover	Before	After	Difference
1	Water	Glass	Cylinder	Opaque	Closed	26.4	85.2	58.8
2	Water	Glass	Rectangle	Clear	Closed	24.4	75.7	51.3
3	Water	Plastic	Rectangle	Clear	Open	24.1	83	58.9
4	Water	Plastic	Cylinder	Opaque	Open	23.6	85.2	61.6
5	Water	Plastic	Rectangle	Opaque	Closed	26.7	81	54.3
6	Water	Plastic	Cylinder	Opaque	Closed	23.5	85.5	62
7	Water	Plastic	Rectangle	Clear	Closed	22.4	83.6	61.2
8	Water	Plastic	Cylinder	Clear	Closed	20	92.9	72.9
9	Water	Glass	Cylinder	Clear	Closed	23.8	80.1	56.3
10	Water	Glass	Cylinder	Clear	Open	23.6	83.3	59.7
11	Water	Plastic	Rectangle	Opaque	Open	16.7	76	59.3
12	Water	Plastic	Cylinder	Clear	Open	15.5	94.9	79.4
13	Water	Glass	Rectangle	Opaque	Open	23.3	81.9	58.6
14	Water	Glass	Cylinder	Opaque	Open	26.5	85.9	59.4
15	Water	Glass	Rectangle	Clear	Open	25	77.5	52.5
16	Water	Glass	Rectangle	Opaque	Closed	23.9	78.1	54.2
17	Milk	Glass	Cylinder	Clear	Open	24	86.6	62.6
18	Milk	Glass	Rectangle	Opaque	Open	21	87.5	66.5
19	Milk	Plastic	Cylinder	Opaque	Closed	13.4	82.3	68.9
20	Milk	Glass	Rectangle	Clear	Closed	14.9	74	59.1
21	Milk	Glass	Rectangle	Clear	Open	16.6	79	62.4
22	Milk	Plastic	Cylinder	Clear	Open	16.6	98.4	81.8
23	Milk	Plastic	Cylinder	Opaque	Open	16.2	85.4	69.2
24	Milk	Glass	Cylinder	Opaque	Open	19.1	81.4	62.3
25	Milk	Plastic	Rectangle	Clear	Open	19.2	86.2	67
26	Milk	Glass	Rectangle	Opaque	Closed	18.7	84.3	65.6
27	Milk	Glass	Cylinder	Opaque	Closed	19.3	83.3	64
28	Milk	Plastic	Cylinder	Clear	Closed	19.5	95.5	76
29	Milk	Plastic	Rectangle	Opaque	Open	15.2	76.9	61.7
30	Milk	Glass	Cylinder	Clear	Closed	19.9	80.5	60.6
31	Milk	Plastic	Rectangle	Opaque	Closed	17.2	80.1	62.9
32	Milk	Plastic	Rectangle	Clear	Closed	18.5	82.7	64.2