Roll No. | | | | | | | | | | |

ANNA UNIVERSITY (UNIVERSITY DEPARTMENTS)

B.E/ B.Tech (Full Time) - END SEMESTER EXAMINATIONS, MAY/JUNE 2024

INDUSTRIAL ENGINEERING

VI Semester

IE 5601 DESIGN OF EXPERIMENTS

(Regulation 2019)

(Use of Statistical Table is permitted)

Time:3hrs Max.Marks: 100

CO1	Understand the fundamental principles of Classical Design of Experiments.
CO2	Be able to apply single factor experiment for process parameter understanding and optimization.
CO3	Be able to apply Factorial Design principles for understanding of process parameters and its optimization
CO4	Will gain knowledge on Taguchi's approach to experimental design for attaining robustness
CO5	Be able to apply Response Surface Method and Shainin DOE to evaluate quality

BL – Bloom's Taxonomy Levels

(L1-Remembering, L2-Understanding, L3-Applying, L4-Analysing, L5-Evaluating, L6-Creating)

PART- A (10x2=20 Marks)

(Answer all Questions)

Q.No	Questions	Marks	CO	BL
1	Recall the usefulness of Normal Probability plot	2	CO1	L1
2	Summarize the Concept of Analysis of Variance	2	CO1	L2
3	Outline the utility of model adequacy checking	2	CO2	L2
4	Write Short note on Graeco Latin Square design	2	CO2	L1
5	Compare Fixed effect model and Random effect model	2	CO3	L2
6	Spell out the Purpose of Alias Structure in Fractional Factorial experiments	2	CO3	L1
7	Define Signal to Noise Ratio	2	CO4	L1
8	Show the layout of Inner/Outer Orthogonal Array Design for an example.	2	CO4	L2
9	When Central Composite Design is needed in Response Surface Method?	2	CO5	L1
10	Compare Classical Design of Experiment with Shainin Design of Experiments.	2	CO5	L2

PART- B (5x 13=65 Marks)

<table>
<tr><th>Q.No</th><th>Question</th><th>Marks</th><th>CO</th><th>BL</th></tr>
<tr><td>11 (a)</td><td>The life of an electric bulb (hours) is of interest. Ten bulbs are selected randomly and tested and the following results are obtained.
850, 900, 690, 800, 950, 700, 890, 670, 800, 880
Identify whether the mean life of bulbs exceed 850 hours (Use level of significance = 0.05) and construct a 99% confidence interval on the mean life of bulbs.</td><td>13</td><td>CO1</td><td>L3</td></tr>
<tr><td colspan="5">OR</td></tr>
<tr><td>11 (b)</td><td>A gym claims that their 5 month weight reduction exercise program will significantly reduce the weight. The table below gives the weight of 7 participants selected randomly from a group undergoing this program. Identify whether the weight reduction exercise has any effect. Consider level of significance of 0.05.
<table>
<tr><td>Before</td><td>81</td><td>75</td><td>89</td><td>91</td><td>110</td><td>70</td><td>90</td></tr>
<tr><td>After</td><td>75</td><td>73</td><td>87</td><td>85</td><td>90</td><td>65</td><td>80</td></tr>
</table></td><td>13</td><td>CO1</td><td>L3</td></tr>
<tr><td>12 (a)</td><td>An oil company tested four different types of fuel (indicated by letters A, B, C & D) for fuel efficiency according to a Latin square design in order to control for the variability of four different drivers and four different models of cars. Fuel efficiency was measured in Kilometers per liter after driving cars over a standard distance. Analyze the data and draw your conclusion. Consider level of significance of 0.05.
<table>
<tr><td></td><td></td><td colspan="4">Car Model</td></tr>
<tr><td></td><td></td><td>I</td><td>II</td><td>III</td><td>IV</td></tr>
<tr><td rowspan="4">Driver</td><td>1</td><td>D 15</td><td>B 33</td><td>C 13</td><td>A 29</td></tr>
<tr><td>2</td><td>B 16</td><td>C 26</td><td>A 19</td><td>D 22</td></tr>
<tr><td>3</td><td>C 10</td><td>A 31</td><td>D 17</td><td>B 30</td></tr>
<tr><td>4</td><td>A 14</td><td>D 34</td><td>B 19</td><td>C 21</td></tr>
</table></td><td>13</td><td>CO2</td><td>L4</td></tr>
<tr><td colspan="5">OR</td></tr>
</table>

12 (b)	Four different fuels are being evaluated based on the emission rate. For this purpose, four Internal Combustions engines have been used in the study. The experimenter has used a completely randomized block design and obtained data are given in the following table. Analyze the data and draw appropriate conclusions. Use level of significance = 0.05. Engine (Block) Fuel Type | 1 | 2 | 3 | 4 1 | 25 | 21 | 15 | 52 2 | 45 | 36 | 81 | 66 3 | 50 | 76 | 54 | 61 4 | 28 | 14 | 11 | 30	**13**	CO2	L4
13 (a)	An experiment was conducted to study the effect of type of tool and depth of cut on the power consumption. Data obtained are given in the following table. Analyze the data and draw appropriate conclusions. Use level of significance = 0.05. Type of tool (m/min) | Depth of cut (mm/rev) 1 | 2 1 | 5.0 4.8 | 11.1 11.4 2 | 5.2 5.4 | 12.1 12.3 3 | 5.8 5.9 | 14.0 14.5	**13**	CO3	L4
	OR			
13 (b)	An Industrial engineer has conducted a study on the effect of temperature (A), pressure (B) and catalyst (C) on the reaction time. Each factor was studied at two levels and three replications were obtained. The results obtained are given in the following table. Examine the factor effects and comment on the results. Treatment combination | Reaction Time R_1 | R_2 | R_3 1 | 53 | 51 | 71 a | 83 | 81 | 64 b | 17 | 55 | 50 ab | 72 | 62 | 62 c | 60 | 60 | 51 ac | 71 | 72 | 71 bc | 50 | 52 | 48 abc | 62 | 60 | 75	**13**	CO3	L4

14 (a)	Experimenter is interested to study effect of four factors namely Water/binder ratio [A], Fly ash (%) [B], M Sand (%) [C], Sisal Fiber (%) [D] on the compressive strength of Concrete. The experiments were designed using L_9 Orthogonal Array and the data were collected. The coded data is presented in the following table. Analyze the data using ANOVA and draw conclusions. Use level of significance = 0.05.	**13**	CO4	L4

Experiment Number	Factor				Response	
	A	B	C	D	R1	R2
1	1	1	1	1	13	15
2	1	2	2	2	22	25
3	1	3	3	3	24	25
4	2	1	2	3	33	35
5	2	2	3	1	23	25
6	2	3	1	2	25	24
7	3	1	3	2	18	21
8	3	2	1	3	29	30
9	3	3	2	1	23	24

OR

14 (b)	An experiment was conducted with three main factors A, B and interaction C using L_4 OA and the following data was collected. Assuming larger the better type quality characteristics, compute S/N ratio and analyze the data using ANOVA and draw conclusions. Use level of significance = 0.05.	**13**	CO4	L4

Trial no.	Factors/ Columns			Response	
	A 1	B 2	C 3	R_1	R_2
1	1	1	1	111	111
2	1	2	2	212	212
3	2	1	2	313	313
4	2	2	1	412	413

15 (a)	Explain about the steps involved in the Response Surface Methodology for finding the optimum parameter setting.	**13**	CO5	L2
	OR			
15 (b)	Explain about the problem Solving Algorithm used in Shainin's Design of Experiments.	**13**	CO5	L2

PART- C (1x 15=15 Marks)

(Q.No.16 is compulsory)

Q.No	Question	Marks	CO	BL
16.	An experimenter wants to study the effect of five main factors A, B, C, D, and E each at two-level and two-factor interactions AC, BC, AD, AE, and BE. Design an Orthogonal Array experiment.	**15**	CO4	L6