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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Second Semester M.Tech Degree (S, FE) Examination January 2024 (2022 Scheme)

Discipline: MECHANICAL ENGINEERING

Course Code & Name: 222TME100 DESIGN OF EXPERIMENTS

Max. Marks: 60 Duration: 2.5 Hours

Use of statistical tables is permitted

PART A

Answer all questions. Each question carries 5 marks Marks

1 An electronics company manufactures resistors that have a mean resistance of 100 ohms and a standard deviation of 10 ohms. The distribution of resistance is normal. Find the probability that a random sample of 25 resistors will have an average resistance less than 95 ohms. (5)

2 Ten individuals have participated in a diet-modification programme to stimulate weight loss. Their weight (in kg.), both before and after participation in the programme, is shown below. Is there evidence to support the claim that the programme is effective in producing a mean weight reduction? (5)

Participant	1	2	3	4	5	6	7	8	9	10
After	85	88	100	86	79	89	90	100	126	129
Before	88	97	112	91	85	95	98	112	133	141

3 Describe the use of residual plots in adequacy checking of models? (5)

4 Explain the role of randomization and blocking in the design of experiments. (5)

5 Describe confounding and alias structure in fractional factorial design. (5)

PART B

Answer any 5 questions. Each question carries 7 marks

6 a The test scores of 15 students are as follows. Represent the data as a box plot. (3)

91, 95, 54, 69, 80, 85, 88, 73, 71, 70, 66, 90, 86, 84, 73

b Ten observations on the effective service life in minutes of batteries used in an electronic device are as follows: (4)

176, 191, 214, 220, 205, 192, 201, 190, 183, 185.

Construct a normal probability plot of the data. Does it seem reasonable to

assume that the service life is normally distributed?

7 a What are the features of software packages used for designing and analysing experiments? (3)

b A bulb manufacturer claims that the average life of bulbs made by the company is not lower than 850 hours. Ten bulbs are selected at random, and the life in hours is tested. The result is as follows: (4)

850, 900, 690, 800, 950, 700, 890, 670, 800, 880

Test whether the company's claim is true or not. Use 5% significance level.

8 a The impact strength of gears used in a laser printer is an important characteristic. A random sample of 10 gears from supplier 1 has a standard deviation of 15 Nm, while another random sample of 16 gears from the second supplier gave a standard deviation of 30 Nm. Is there sufficient evidence to conclude that the variance of impact strength is different for the two suppliers? Take level of significance = 0.05 (4)

b What is the use of response surface methodology? (3)

9 A brick manufacturer uses four types of clays (*A*, *B*, *C* and *D*) to make bricks. A single-factor experiment is designed to test the breaking strength of the bricks. Five samples of bricks have been made with each type of clay. The breaking strength measured in kg/cm^2 is given in the table below. Analyze the data to determine whether the type of clay has any effect on the breaking strength of bricks. Use $\alpha = 0.05$. (7)

10 An agricultural officer wants to study the effect of four different fertilizers on the yield (in tons) of a specific crop. Since there might be variability from one plot to another plot, he decides to use the randomized complete block design. The data are presented in the table. (7)

Fertilizer	**Plot**			
	1	**2**	**3**	**4**
A	100	80	68	125
B	150	70	90	138
C	120	110	85	60
D	70	100	78	124

Test whether the type of fertilizer used has significant effect on the yield of the crop. Use $\alpha = 0.05$.

11 The time taken for an engine to reach stable operation was studied using a 2 level factorial experiment with three factors A, B and C. Two replications were carried out and the results are given below. Identify the significant variables and interactions. (7)

A	B	C	Replication 1	Replication 2
-1	-1	-1	12	14
1	-1	-1	37	32
-1	1	-1	9	9
1	1	-1	35	42
-1	-1	1	24	28
1	-1	1	26	43
-1	1	1	31	21
1	1	1	38	27

12 The following data refer to an experiment with three factors at two levels. Fit a first order response surface model to the data. (7)

Factors			Response Y
X1	X2	X3	
-1	-1	-1	61
1	-1	-1	83
-1	1	-1	51
1	1	-1	70
-1	-1	1	66
1	-1	1	92
-1	1	1	56
1	1	1	83