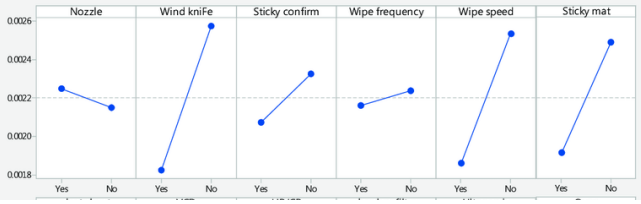
B

SRM Institute of Science and Technology
College of Engineering and Technology
B.Tech - Mechanical Engineering

Academic Year: 2022-23 **Semester: 6 /Even** **Mark: 50**
Subject Code: 18MEO113T **Title: Design of Experiments** **Duration: 100 mins**
Type of Test: CLA II

Q. No.	Part A (10 x 1 = 10)	M	BL	CO	PO	PI
1	The natural variability of a process is measured by _____. A. Sample standard deviation **B. Process standard deviation** C. Process mean D. Sample mean	1	1	1	3	3.1.6
2	How many levels of a factor are recommended for a qualitative experiment? A. one B. two C. three **D. three or more than three**	1	2	1	3	3.1.6
3	What is presented in this diagram?  A. Mutual exclusivity B. Cross-over effects **C. Main effects** D. Synergistic interactions	1	1	1	3	4.1.4
4	What plot describes average response values at all combinations of a process or design parameter settings? A. Pareto B. MPP C. Main Effects **D. Cube plots**	1	2	1	3	4.3.4
5	Strength of a machine - What Taguchi's design would you plot for this? A. Smaller the better **B. Larger the better** C. Nominal the better D. Everything's equal	1	2	1	3	4.3.4
6	What is the other name for nominal value? A. confidence interval B. probability limit **C. functional limit** D. probability limit	1	1	1	3	3.1.6

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7	What does the NPP plot convey? **A. Normal distribution compliance** B. mean C. variance D. R^2 value	1	2	1	3	3.1.6
8	Multiple values of control factors are called A. interactions B. noise C. signal **D. levels**	1	1	1	3	4.3.4
9	_____ occurs experimentation is done in a way to reduce bias. A. Interaction B. Error C. Replication **D. Randomization**	1	2	1	3	4.3.4
10	A formal way to seek the direction of minimum damage in optimisation process problems is called the _____. A. Tunneling B. Localisation **C. Method of steepest descent** D. Method of steepest ascent	1	1	1	3	4.3.4
	Part B - Answer any 2 out of 3 (2 x 4 = 8 marks)					
11	What is a screening design? Why is it needed? Give one example. • In many process development and manufacturing applications, the number of potential process or design variables or parameters (or factors) is large. • Screening reduces the number of process or design parameters (or factors) by identifying the key factors affecting product quality or process performance. • This reduction allows one to focus process improvement efforts on the few really important factors, or the 'vital few'. • Screening Designs expounded by R.L. Plackett and J.P. Burman in 1946 – hence the name Plackett–Burman designs (P–B designs). • The screening design has n-1 runs for n factors.	4	2	2	3	3.1.6
12	Briefly discuss the experimenter's role in the planning phase of DOE. 1. Problem Recognition and Formulation 2. Selection of Response or Quality Characteristic 3. Selection of Process Variables or Design Parameters	4	3	2	3	4.1.4

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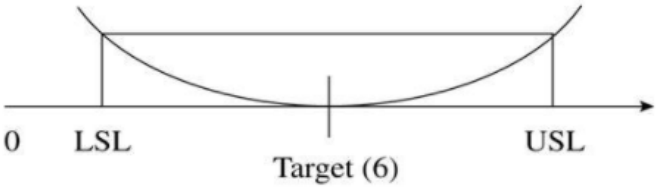
	4. Classification of Process Variables 5. Determining the Levels of Process Variables 6. All the Interactions of Interest *can briefly explain these steps*					
13	What is blocking? Explain with examples. A technique used to increase the precision of an experiment by breaking the experiment into homogeneous segments (blocks) in order to control block variability. It basically deals with noise factors. **Purpose:** the main purpose of the principle of blocking is to increase the efficiency of an experimental design by decreasing the experimental error. Eg: 1. Batches of raw materials 2. operators 3. time: shifts, days, etc. 4. Gender	4	3	2	3	4.1.4
	Part C - Answer any 2 out of 3 (2 x 4 = 8 marks)					
14	 What does this graph indicate? Discuss it. **Taguchi Quality Loss Function (QLF):** Taguchi defines Quality as "the loss imparted by the product to society from the time the product is shipped" LOSS = Cost to operate, Failure to function, maintenance and repair cost, customer satisfaction, poor design. Product to be produced "being within specification.	4	3	2	3	4.3.4
15	Briefly discuss nominal-the-best Taguchi's approach. Taguchi's loss function is given by $L(y) = k(y-m)^2$ (1) where **k** = a proportionality constant called *the quality loss coefficient* **m** = the target value of y **y** = the value of the quality characteristic **L(y)** = loss in dollars when the quality characteristic is equal to y **Note that L(y) = 0 when y = m.** • The **functional tolerance range of the quality characteristic is (m-Δ) and (m+Δ) which represents the maximum permissible variation**. If the **consumer's average loss is A when the quality characteristic is at the limit of the functional tolerance, then A represents the customer cost for repair or replacement of the product.** • The **proportionality constant k** is obtained from $A = k\Delta^2$ (2) or, $k = \frac{A}{\Delta^2}$ (3) • Then L(y) in Eq. (1) can be written as $L(y) = \frac{A}{\Delta^2}(y-m)^2$ (4)	4	2	2	3	4.3.4
16	What is a robust design? Describe disturbances types briefly.	4	2	2	3	3.1.6

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	In the design of a new product, any design activity can be called robust, if it leads the product; 1. To have longer life (higher reliability) 2. To be more consistent with use 3. To be more consistent from product to product 4. To perform consistently as temperature and other conditions change • Products and services should be designed to be inherently defect-free and high quality. • Meet customer's expectations also under non-ideal conditions • Disturbances are events that cause the design performance to deviate from its target value Taguchi divides disturbances into three categories 1. **External disturbances:** variation in the environment where the product is used 2. **Internal disturbances:** wear and tear inside a specific unit 3. **Disturbances in the production process:** deviation from target values					
	Part D - Answer either of the choices in each question. (2 x 12 = 24 marks)					
17	**A**. Write in detail about the barriers in the effective application of DOE. Some noticeable barriers are as follows: 1. Educational barriers 2. Management barriers 3. Cultural barriers 4. Communication barriers 5. Other barriers **OR** **B.** (i) What is Linear Regression? What are its types? The regression model predicts the response for different combinations of process parameters (or design parameters) at their best levels. Regression coefficients are estimates of the unknown population parameters and describe the relationship between a predictor variable and the response. In linear regression, coefficients are the values that multiply the predictor values.	12 2	3 4	2 2	3 3	3.1.6 4.1.4

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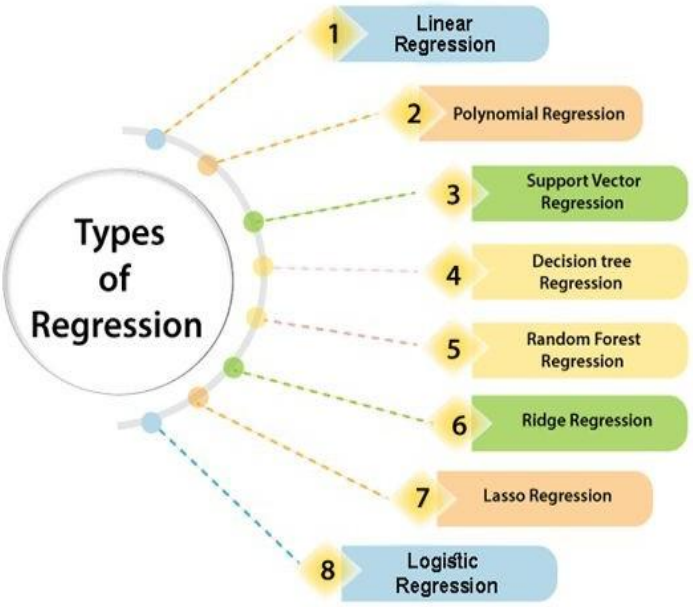

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(ii)A sample of the various prices for a particular product has been conducted in 16 stores selected randomly in a city's neighbourhood. The following prices were noted:

95, 108, 97, 112, 99, 106, 105, 100, 99, 98, 104, 110, 107, 111, 103, 110.

Assuming that the prices of this product follow a normal law of variance of 25 and an unknown mean:

1. What is the distribution of the sample mean?

$\bar{x}$ = (95 +108 + 97 + 112 + 99 +106 +105 +100 + 99 + 98 + 104 + 110 +107 + 111 + 103 + 110) / 16

= 104

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if the student wrote normal distribution is assumed, marks can be given.

2. Determine the confidence interval at 95% for the population mean.

N = 16

$$\mathbf{CI} = \bar{x} \pm 3\left\{\frac{SD}{\sqrt{N}}\right\}$$

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$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \overline{x})^2}$$

SD =

$$\sqrt{\frac{1}{16-1}\sum_{1}^{16}(95 - 104)^2 + \ldots\ldots\ldots + (110 - 104)^2}$$

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x	x - x bar	sq (x - x bar)
95	-9	81
108	4	16
97	-7	49
112	8	64
99	-5	25
106	2	4
105	1	1
100	-4	16
99	-5	25
98	-6	36
104	0	0
110	6	36
107	3	9
111	7	49
103	-1	1
110	6	36
sum sq (x - x bar) =	448	

$$SD = \sqrt{\frac{448}{15}} = 5.465$$

$$\therefore CI = 104 \pm 3\left\{\frac{5.465}{4}\right\}$$
$$= 104 \pm 3\{1.36625\}$$
$$= 104 \pm 4.09875$$

CI = [99.90125, 108.09875]

18	**A.** (i) What factors affect quality characteristics? Briefly discuss them. 1. Signal 2. noise and 3. Control factors *explanation is required for each* (ii) Write about the input and output variability parameters in great detail.	5 + 8	3 4	3 3	2 2	3.1.6 4.3.4

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	The quality of a measurement system is usually determined by the statistical properties of the data it generates over a period of time which captures both long- and short-term variation. Experimenters should be aware of the repeatability, reproducibility and uncertainty of the measurements prior to the execution of industrial experiments. It is advisable to make sure that the measurement system is capable, stable, robust and insensitive to environmental changes. Experimenters should define the measurement system prior to performing the experiment in order to understand what to measure, where to measure and who is doing the measurements, etc. so that various components of variation (measurement system variability, operator variability, part variability, etc.) can be evaluated. **Classification of Process Variables** After identification of process variables , classify them into controllable and uncontrollable variables Control variables are those which can be controlled by a process engineer/production engineer in a production environment. Uncontrollable variables (or noise variables) are those which are difficult or expensive to control in actual production environments. urement system, including human resources, equipments and measurement methods, is a fundamental aspect in planning experimental studies. It is important to ensure that equipment exists and is suitable, accessible and calibrated. **Selection of Process Variables or Design Parameters** Some possible ways to identify potential process variables are the use of engineering knowledge of the process, historical data, cause-and-effect analysis and brainstorming. It is a good practice to conduct a screening experiment in the first phase of any experimental investigation to identify the most important design parameters or process variables. **Classification of Process Variables** Variables such as ambient temperature fluctuations, humidity fluctuations, raw material variations, etc. are examples of noise variables. The effect of such nuisance variables can be minimized by the effective application of DOE principles such as blocking, randomization and replication.	7 3 1 1				

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	OR **B.** The following table gives the hardness values of 3 replicates of an L9 welding experiment with the aim of maximising hardness. There are 3 variables varied on 3 levels. Voltage Current Wire-Speed H1 H2 H3 20 150 180 163.3 139.3 170.0 20 180 200 156.0 131.3 138.0 20 200 250 136.3 134.5 140.5 23 150 200 131.3 131.5 145.0 23 180 250 186.5 176.5 180.5 23 200 180 140.5 179.3 200.5 25 150 250 153.5 145.5 140.5 25 180 180 180.5 170.5 190.5 25 200 200 190.0 174.5 180.0 Answers given in the separate mail pdf attachment Calculate (i) Main effects for all levels of all factors. (ii) Draw the main effects plots (iii) Identify which combination gives the maximum hardness. (iv) State which Taguchi's function is appropriate for this problem. Larger -the-better					

Prepared by: DSS

Outcome Alignment Matrix:

QUESTION NUMBER	CO distribution				
	CO1	CO2	CO3	CO4	CO5
1		x			
2		x			
3		x			
4		x			
5		x			
6			x		
7			x		
8			x		
9			x		
10			x		
11		x			
12		x			

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13		x			
14			x		
15			x		
16			x		
17A		x			
17B		x			
18A			x		
18B			x		
Total					
%		**50%**	**50%**		

"**Quality Matrix**":

Question No.	**BL Distribution**			
	L1	**L2**	**L3**	**L4**
1	x			
2		x		
3	x			
4		x		
5	x			
6		x		
7	x			
8		x		
9	x			
10		x		
11		x		
12			x	
13			x	
14			x	
15		x		
16		x		
17A			x	
17B				x
18A			x	
18B				x
Total				
%				

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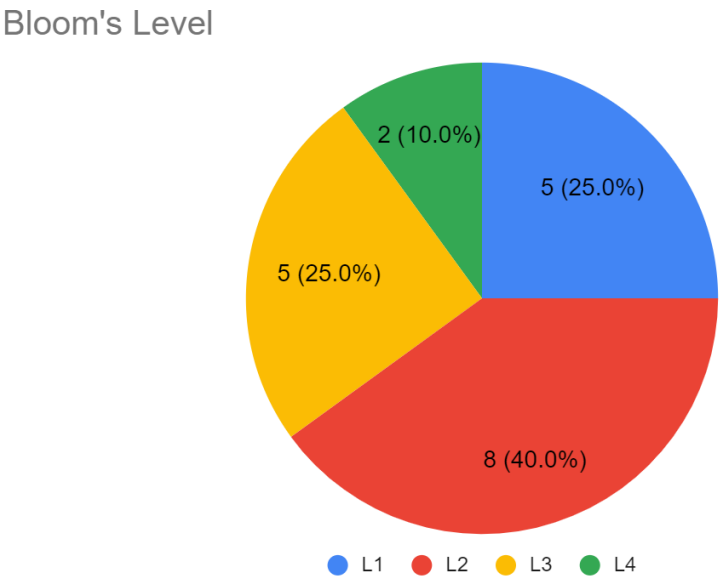

Prepared by and Course Coordinator

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