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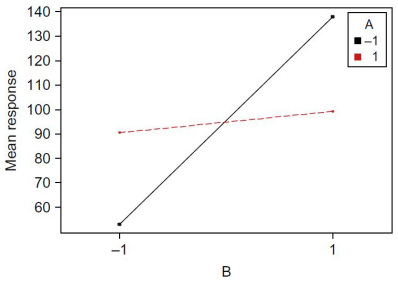
SRM Institute of Science and Technology
College of Engineering and Technology
B.Tech - Mechanical Engineering

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	What information does the sign of the main effect provide? **A. direction of the effect** B. Strength of the effect C. Magnitude of the effect D. Interaction strength	1	1	1	3	3.1.6
2	Which of these steps are not conducted when the design of experiment procedure is adopted? A. Determining which variable is most influential to output B. Determining where to set the influential controllable factors so that output is near the nominal requirement **C. Deleting the uncontrollable factors** D. Determining where to set the influential controllable inputs so that the variability in the output is smallest	1	2	1	3	3.1.6
3	What kind of interaction is presented in this diagram?  A. Mutually exclusive B. Cross over **C. Antagonistic** D. Synergistic	1	1	1	3	4.1.4
4	A formal way to seek the direction of maximum improvement in optimisation process problems is called the _____. A. Tunneling B. Localisation C. Method of steepest descent **D. Method of steepest ascent**	1	2	1	3	4.3.4

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5	What is the Hadamard matrix associated with? A. Taguchi's design **B. Screening Design** C. Confidence Level D. Full-factorial design	1	2	1	3	4.3.4
6	Taguchi's design makes _____ the focal point of his analysis. A. Control Factors B. Interactions C. Blocking **D. Noise**	1	1	1	3	3.1.6
7	Maximum permissible variations is called _____. A. Loss B. Quality **C. Tolerance** D. Function	1	2	1	3	3.1.6
8	In Orthogonal Array design of experiments, the inner array is for the design of _____. **A. Control Factors** B. Noise Factors C. Random factors D. Interactions	1	1	1	3	4.3.4
9	_____ occurs when the effect of one factor on a response depends on the level of another factor(s). **A. Interaction** B. Error C. Replication D. Randomization	1	2	1	3	4.3.4
10	In 3σ quality performance, the probability of producing a conforming product is _____. **A. 0.99** B. 0.95 C. 1 D. 0.94	1	1	1	3	4.3.4
	Part B - Answer any 2 out of 3 (2 x 4 = 8 marks)					
11	Give two differences between 'Characterisation' and 'Optimisation'. Characterisation: 1. to determine which factors (both controllable and uncontrollable) affect the occurrence of Optimisation: 1. determines which process variables affect the response 2. helps determine which region of	4	2	2	3	3.1.6

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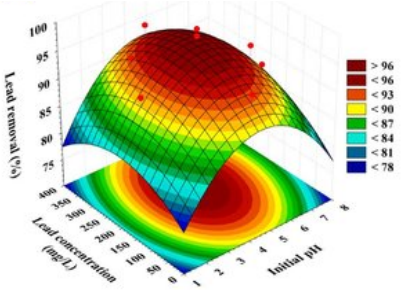
	defects 2. designs that tell magnitude and direction of controllable factors 3. also called screening design 4. mostly uses a fractional factorial design	these important factors to look at for the solution 3. Can use response surface methodology with contour plots					
12	 Write about this plot, key features and advantages. A formal way to seek the direction of improvement in optimisation process is called the method of steepest ascent or descent (depending on the nature of the problem at hand, i.e. whether one needs to maximize or minimize the response of interest). This is a response surface with contour plot. Key features: 1. tells where the maxima and minima are. 2. is a visual representation of the entire experimental range. Adv: able to predict responses in areas where experiments have not been done.	4	3	2	3	4.1.4
13	Differentiate between geometric and non-geometric designs. **Geometric** • 2N (N = 4, 8, 16, 32, etc.) • Geometric designs are identical to fractional factorial designs in which one may be able to study the interactions between factors. • If the process is suspected to be highly interactive **Non-geometric** • are multiples of four but are not powers of two. E.g. have runs of 12, 20, 24, 28, etc.	4	3	2	3	4.1.4

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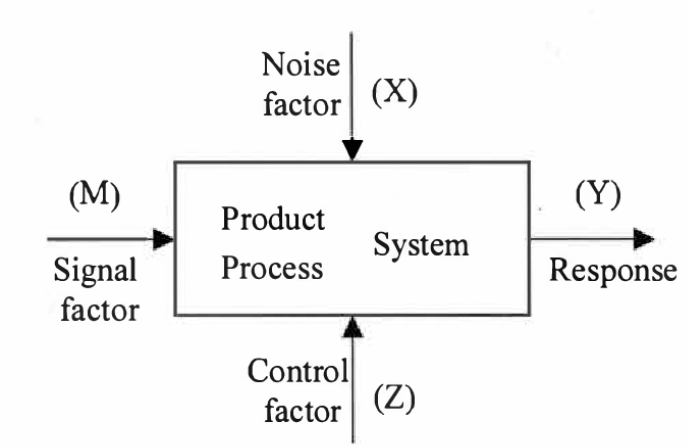
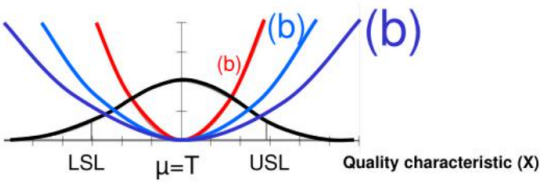
	• These designs do not have complete confounding of effects. • if interactions are of no concern to the experimenter					
	Part C - Answer any 2 out of 3 (2 x 4 = 8 marks)					
14	Schematically represent Taguchi's Terminology and state the response. The response is any CTQ (Critical to Quality) parameter that will increase in quality.  	4	3	2	3	4.3.4
15	What is 'Average Quality Loss'? The quality of a product is measured by estimating "the total loss to the customers due to variation in the product's functions. For ideal quality, loss is zero. Higher the loss, lower the quality.  **Quality Loss** $= b\,(x-T)^2$ **Average Quality Loss** $= b\,(\sigma^2+(\mu-T)^2)$ (Taguchi,1989) ↓ Loss coefficient	4	2	2	3	4.3.4

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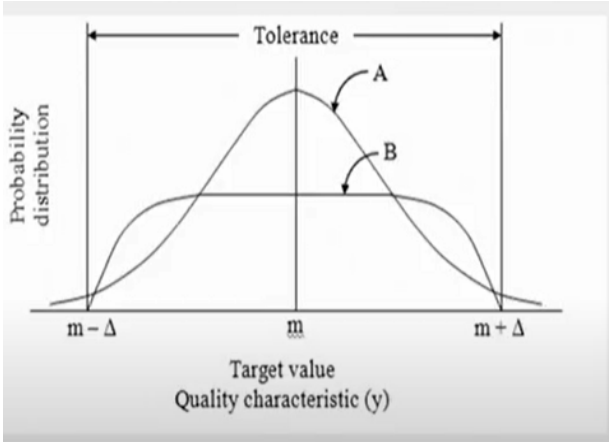
16	 Which of the two processes is better, and what can you infer from the two processes? Process A has normal distribution and is better, while process B has uniform distribution. The form of the distribution of the quality characteristics and has an influence of the expected loss. Process A has measured values closer to the nominal value (since it has ND, while the variance in process B is very high. m = nominal value; Δ = *standard deviation*	4	2	2	3	3.1.6
	Part D - Answer either of the choices in each question. (2 x 12 = 24 marks)					
17	**A**. Write in detail about the steps in the practical methodology of DOE. The methodology of DOE is fundamentally divided into four phases. 1. planning phase • The planning phase is made up of the following steps. • Problem Recognition and Formulation • Selection of Response or Quality Characteristic • Selection of Process Variables or Design Parameters • Classification of Process Variables • Determining the Levels of Process Variables • List All the Interactions of Interest 2. designing phase 3. conducting phase 4. analysing phase. **OR**	12	3 4	2 2	3 3	3.1.6 4.1.4

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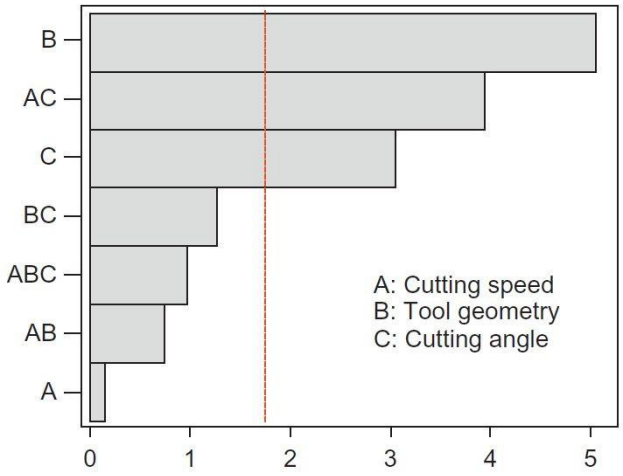
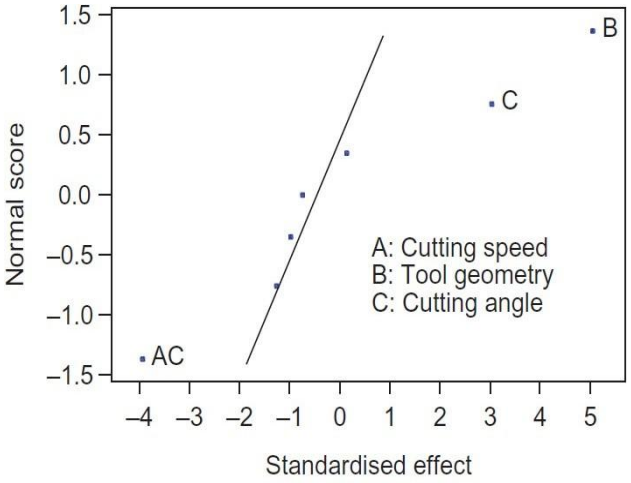
	B. Explain Pareto, NPP and cube plots with schematic examples.					



Pareto plot of the standardised effects.



NPP of effects for cutting tool optimisation example.

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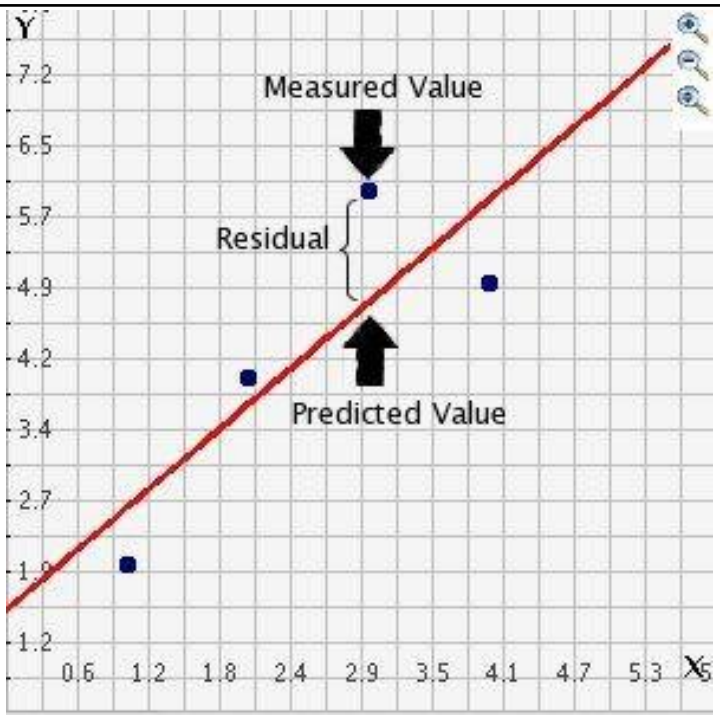
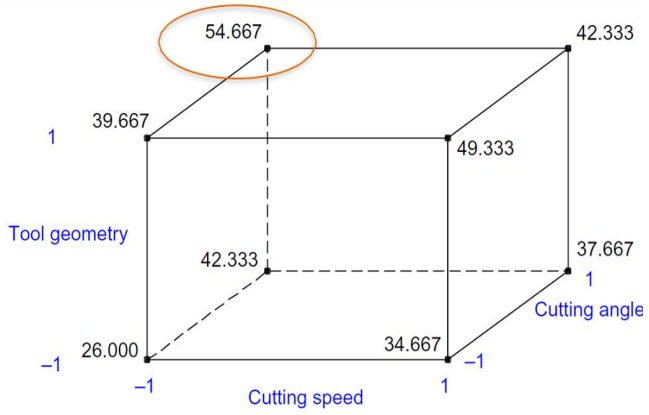

Y
7.2
6.5
5.7
4.9
4.2
3.4
2.7
1.9
1.2
0.6
1.2
1.8
2.4
2.9
3.5
4.1
4.7
5.3
X5
Measured Value
Residual
Predicted Value


54.667
42.333
39.667
1
49.333
Tool geometry
42.333
37.667
1
Cutting angle
26.000
34.667
–1
–1
–1
Cutting speed
1

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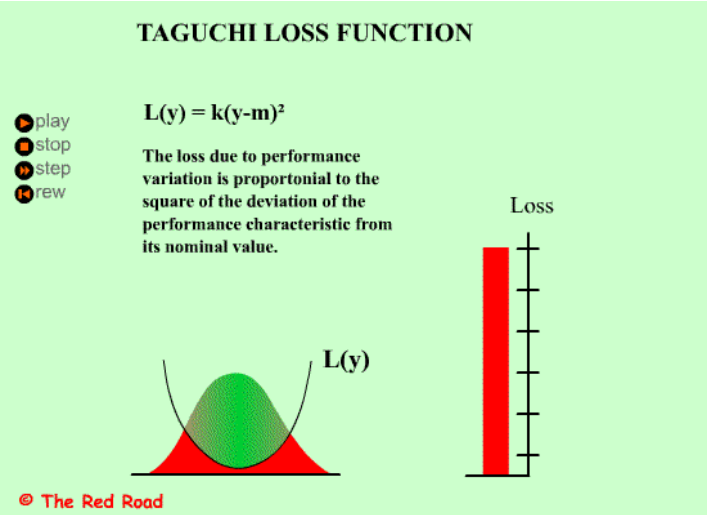
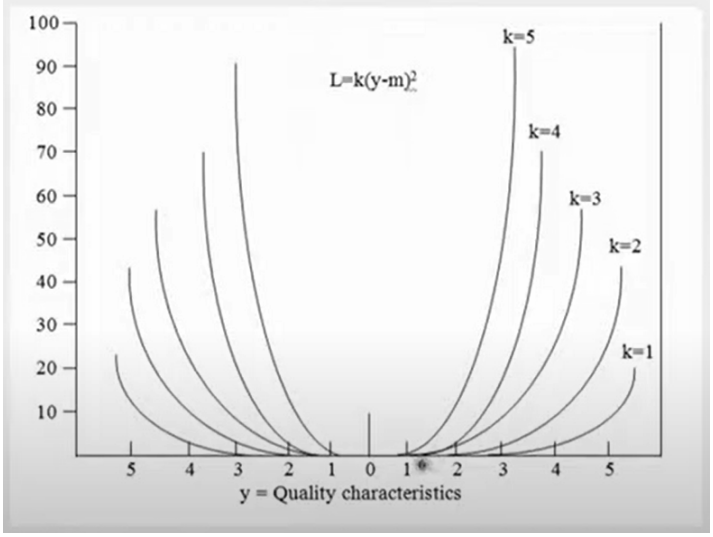
18	**A.** Discuss Taguchi's loss function in detail.  Where y is the critical performance parameter value, L is the loss associated with a particular parameter y, m is the nominal value of the parameter specification (ie. Target value of y), k is a constant that depends on the cost at the specification limits. (ie. Quality loss coefficient)  **OR** **B.** (i) Explain the categories of variability in input and output parameters in detail. **Planning Phase** 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	12 8 + 4	3 4	3 3	2 2	3.1.6 4.3.4

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	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.					

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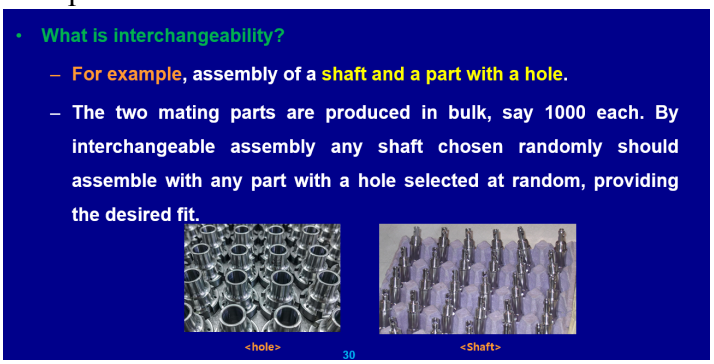
	(ii) What is 'Interchangeability'? Explain with an example.  					

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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			
13		x			

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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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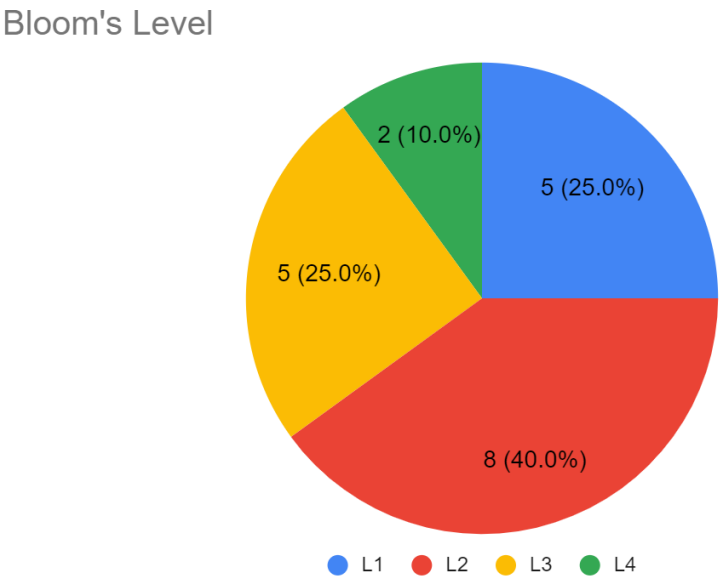

Prepared by and Course Coordinator

(Deborah Serenade Stephen)