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FIRST SEMESTER 2022-2023
ME F443 Quality Control, Assurance and Reliability
Comprehensive Examination (Closed Book)

DATE: 27/12/2022 **Maximum Marks: 100 (weightage 40%)**
Time: 1.5 Hours

Instructions:

- All parts of a question must be answered in sequence.
- Support your answers with neat plots wherever required
- Printed statistical tables and charts are not required.

Data: $Z_{-0.4}$=0.0.6554, $Z_{\mathbf{-2.0}}$=0.0228, $t_{0.05, 18}$=1.734, $t_{0.025, 18}$=2.101, $F_{0.05, 1, 16}$ = 4.49

Q.1 a) Explain Deming's *k-p* rule for inspection of incoming materials and final products with suitable example.
b) Discuss four components of Deming's System of Profound Knowledge for continuous quality improvement. Correlate the same with the Deming's 14-point philosophy. **[5+5=10]**

Q.2 a) The outside diameter of a part used in a gear assembly is known to be normally distributed with a mean of 40 mm and standard deviation of 2.5mm. The specifications of the part are given as 38±3 mm, which means that parts dimensions falling in the above range are acceptable. The unit cost of rework is Rs. 20 while that of Scrap is Rs. 40. If the daily production is 2000 such parts, what is the cost of rework and scrap? **[5]**
b) Two Magnesium alloys are tested for their Brinell hardness values and observations are noted in **Table-1.**
At 0.05 level of significance test the null hypothesis that both alloys possess same hardness against an alternative that alloy 1 has less hardness than alloy 2.
Draw the box plots for the hardness of both the alloys adjacent to each other and indicate important statistical parameters on the same. Comment on the same by observing the overlap of these plots. **[2x5=10]**

Table-1 Brinell hardness values of Mg alloys

Alloy No.	Brinell Hardness									
1	66.3	63.5	64.9	61.8	64.3	64.7	65.1	64.5	68.4	63.2
2	71.3	60.4	62.6	63.9	68.8	70.1	64.8	68.9	65.8	66.2

Q.3. Nanoscale Calcium Carbonate ($CaCO_3$) is an important filler in a polymer composite material and its amount needs to be carefully controlled to maintain desired quality level during manufacturing of the composite. The target value of $CaCO_3$ in one of the composites is 26.5%. In an inspection plan, a random sample size of five is selected and average percentage of $CaCO_3$ is found. The data values of 15 samples is tabulated in **Table -2**. From the past data, it is known that the process standard deviation of $CaCO_3$ is 0.2%. It is decided to detect the shift in average percentage of $CaCO_3$ of 0.1%. **a)** Which type of Control chart will be used to detect this shift quickly? Tabulate your findings with upward and downward drift of the process mean. Take allowance (slack value) halfway between the target and shift (of 0.1%). Decision interval can be taken as 5 times the sample std. deviation.
b) Based on the above information plot the control charts and infer on the sample from which the upward and downward shift of the process has commenced, if any. **[5+15=20]**

Table-2 Average percentage of $CaCO_3$ in a composite

Sample No.	**Average $CaCO_3$**	**Sample No.**	**Average $CaCO_3$**	**Sample No.**	**Average $CaCO_3$**	**Sample No.**	**Average $CaCO_3$**
1	25.5	5	27.5	9	26.4	13	26.2
2	26	6	25.9	10	26.3	14	26.8
3	26.6	7	27	11	26.9	15	26.6
4	26.8	8	25.4	12	27.8		

Q.4 Microprocessor Chips used in computers are manufactured from the wafers using a process called *photolithography*. Using this process, transistors and circuit and signal pathways are created in semiconductors by depositing different layers of various materials on the chip, one after the other. A semiconductor industry producing such microprocessors wishes to increase the yield (in %). The factors that affect processor yields are Temperature, Pressure, Doping amount and Deposition rate. The operating conditions for the above factors are shown in **Table - 3**:

Table-3 Factors and their levels for *photolithography*.

Factor	Level 1	Level 2	Level 3
Temperature (^{o}C)	100	150	200
Pressure (bar)	2	5	8
Doping amount (%)	4	6	8
Deposition rate (mg/s)	0.1	0.2	0.3

Experiments were carried out using Taguchi's L_9 orthogonal array with three replicates of each experiment under different noise factors and yield was calculated. (Designated as Y_1, Y_2 and Y_3). The experimental run and results are shown in **Table-4**

a) Determine the S/N ratios and Strong effects (Means) by drawing the response tables.
b) Draw the S/N ratio and main effect graphs.
c) What values of factor settings you recommend to maximize the yield? **[10+6+4=20]**

Table-4 Experimental Plan and Results

Ex. No.	Temp	Pressure	Doping	Deposition Rate	Y_1	Y_2	Y_3
1	100	2	4	0.1	70.7	82.3	87.3
2	100	5	6	0.2	63.2	70.7	74.8
3	100	8	8	0.3	45.7	54.9	56.5
4	150	2	6	0.3	62.3	78.2	79.8
5	150	5	8	0.1	54.9	76.5	77.3
6	150	8	4	0.2	83.2	87.3	89.0
7	200	2	8	0.2	55.7	62.3	64.8
8	200	5	4	0.3	87.3	93.2	99.0
9	200	8	6	0.1	63.2	74.0	75.7

Q.5 A machinist is interested in the effects of cutting speed (A), depth of cut (B) and tool geometry (C) on the tool life. Two levels of each factor are chosen and three replicates of a 2^3 factorial design are run. The results are shown in **Table-5**

a) Use ANOVA to estimate the factor effects and their interactions. Plot your results and interpret your findings. Assume that variations due to replicates are insignificant and can be neglected.

b) Develop a regression equation considering only significant factors and interactions to predict the tool life in terms of the above factors. **[15+5=20]**

Table 5 Machining Experiments

Treatment combination	*Tool Life*		
	I	*II*	*III*
(1)	22	31	25
a	32	43	29
b	35	34	50
ab	55	47	46
c	44	45	38
ac	40	37	36
bc	60	50	54
abc	39	41	47

Q.6 50 electronic components are tested for their reliability over a span of 12 months. The observations are given in **Table-6.**

a) Complete the table by calculating the Failure density, Hazard rate and Reliability of the components.
b) Plot the Hazard rate and Reliability Vs Time (in months).
c) What is Mean Time to Failure (MTTF) of the components? **[6+6+3=15]**

Table-6 Failure Data for electronic components

Months	1	2	3	4	5	6	7	8	9	10	11	12
No. of Failures	6	6	7	3	2	1	2	4	6	7	3	3
Failure density												
Hazard Rate												
Reliability												