INDIAN STATISTICAL INSTITUTE
First Semester Examination: 2025-26
Course Name: M. Tech. (QROR) II Year
Subject Name: Six Sigma

Date: 17/11/2025 Maximum Marks: 100 Duration: 3 hours

Answer all questions. It's a closed note examination. However, calculators are allowed.

1.

a) A company producing pumps works 5 days a week with 3 shifts a day. Every shift is of 480 minutes. The break for lunch is 30 minutes. In the period of 13 weeks, the customer's request is 4768 pumps. Calculate the Takt time in the period.

b) The table below contains shift data for a motor part. Calculate the OEE and conclude from the perspective of lean management.

Item	Data
Potential Production Time	8 hours = 480 mins
Tea Time	2×15 mins = 30 mins
Lunch Break Duration	1×30 mins = 30 mins
Quality Stop (Downtime)	47 mins
Hourly Standard	60 parts per min
Total Output	19,271 parts
Scrap Parts	423 parts

c) The following table provides these information after an FMEA study of the motorcars of a particular make. Prioritize the failure modes based on your rationale.

Failure Mode	Ratings of		
	Severity (S)	Occurrence (O)	Detectability (D)
1) Pedal break system	10	8	2
2) Insufficient cooling by the cooling system	3	4	4
3) Malfunction of the clutch system	6	5	5
4) Contaminated air filter	3	5	6
5) Gear box	8	6	5

[5+(8+2)+5=20]

2. Consider the three-stage nested design shown below for tensile strength.

Alloy 1						Alloy 2					
Heat 1		Heat 2		Heat 3		Heat 1		Heat 2		Heat 3	
Ingot 1	Ingot 2	Ingot 1	Ingot 2	Ingot 1	Ingot 2	Ingot 1	Ingot 2	Ingot 1	Ingot 2	Ingot 1	Ingot 2
40	27	95	69	65	78	22	23	83	75	61	35
63	30	67	47	54	45	10	39	62	64	77	42

a) Write the model to be adopted to analyze the above data on tensile strength.

b) Find the expected mean squares for the sources of variation thus considered.

c) Analyze the data assuming that alloys and heats are fixed while ingots are random.

d) Draw your conclusion from the analysis.

[3+5+20+2=30]

3. a) A normally distributed random variable has an unknown mean μ and a known variance $\sigma^2 = 9$. Find the sample size required to construct a 95% confidence interval on the mean, which has a total width of 1.0.

b) The time to repair an electronic instrument is a normally distributed random variable measured in hours. The repair times for 16 such instruments chosen at random are as follows:

Hours			
159	280	101	212
224	379	179	264
222	362	168	250
149	260	485	170

i) Does it seem reasonable that the true mean repair time is greater than 225 hours?

ii) Determine a 95% confidence interval on the true mean repair time.

c) The following are the burning times of flares of two different design types those follow the normal distribution. The design engineers are interested in both the mean and variance of the burning times.

Type 1		Type 2	
65	82	64	56
81	67	71	69
57	59	83	74
66	75	59	82
82	70	65	79

i) Test the hypothesis that the two variances are equal. Use $\alpha = 0.05$.

ii) Using the results of i), test the hypothesis that the mean burning times are equal.

[5+(6+4)+(5+5)=25]

4. An experiment involves finding a method to assemble an elastometric connector to a nylon tube that would deliver the required surface roughness performance to be suitable for use in an automotive engine application. The specific objective of the experiment is to minimize surface roughness. Four controllable factors have been identified. These factors are defined in the following.

Factors and Levels for the Parameter Design

Controllable Factors		Levels		
A.	Interference	Low (1)	Medium (2)	High (3)
B.	Connector wall thickness	Thin (1)	Medium (2)	Thick (3)
C.	Insertion depth	Shallow (1)	Medium (2)	Deep (3)
D.	Percent adhesive in connector pre-dip	Low (1)	Medium (2)	High (3)

The observed surface roughness is reported in the table below.

Run	A	B	C	D	Surface Roughness							
1	1	1	1	1	15.6	9.5	16.9	19.9	19.6	19.6	20.0	19.1
2	1	2	2	2	15.0	16.2	19.4	19.2	19.7	19.8	24.2	21.9
3	1	3	3	3	16.3	16.7	19.1	15.6	22.6	18.2	23.3	20.4
4	2	1	2	3	18.3	17.4	18.9	18.6	21.0	18.9	23.2	24.7
5	2	2	3	1	19.7	18.6	19.4	25.1	25.6	21.4	27.5	25.3
6	2	3	1	2	16.2	16.3	20.0	19.8	14.7	19.6	22.5	24.7
7	3	1	3	2	16.4	19.1	18.4	23.6	16.8	18.6	24.3	21.6
8	3	2	1	3	14.2	15.6	15.1	16.8	17.8	19.6	23.2	24.2
9	3	3	2	1	16.1	19.9	19.3	17.3	23.1	22.7	22.6	28.6

Based on an appropriately chosen signal-to-noise ratio (SN), analyze the above data and plot the SN graph to find the optimum levels of the controllable factors that are least influenced by the noise factors and that provide minimum surface roughness.

[25]