SIX SIGMA

Maximum marks: 50

Time: 180 min

Answer any five questions, all questions carry equal marks.
Use of statistical tables is permitted
Assume suitable data if required and clearly mention the same.

1)

a) The goal of Six Sigma is "3.4DPMO". Explain how this figure is obtained.
b) Explain the DMAIC methodology with particular reference to the development of the CAT Scanner at GEMS.

2)

a) Two different hardening processes, saltwater quenching and oil quenching, are used on samples of a metal alloy and the results are as follows:

Oil	146	147	147	134	141	138	149	143	144	138		
Saltwater	153	139	151	150	151	151	149	153	148	152	149	150

Prepare boxplots comparing the two processes and give your conclusions.

b) Ten batteries were tested and their lives were obtained as 27.2, 26, 24.2, 25.4, 26.5, 22.9, 24.3, 21.7, 25.9, 25.8 hours. Construct a 95% lower confidence interval on the mean battery life.

3)

a) The diameters of eight balls were measured by two inspectors, with the same micrometer. Test the hypothesis that Unnikrishnan always reads *higher.* Use a 95% confidence level.

	Ball identification number							
Inspector	1	2	3	4	5	6	7	8
Mohandas	15.007	14.817	15.030	14.906	14.955	15.021	15.055	15.023
Unnikrishnan	15.009	14.817	15.031	14.907	14.955	15.022	15.056	15.023

b) A supplier has submitted 25 samples of a bush. The outer diameter has a specification 25.00-0.02mm. The samples were measured and $\bar{x} = 24.99$, $s = 0.002$. Determine a 95% confidence interval for the process capability index Cp.

4)

a) An experiment was conducted to compare the performance of nozzle shapes in waterjet cutting. Each nozzle type was used to make test cuts in a metal sheet. The experiment was repeated four times, and the time (in minutes) to make each test cut was recorded. The data are shown below:

Nozzle type	A	2.1	2.2	2.3	1.9
	B	2.4	2.3	2.1	2.2
	C	2.3	2.2	2.1	2.1
	D	2.4	2.5	2.2	2.3
	E	2	1.9	2.2	2

Is there a significant difference between nozzles at a 95% level?

b) Explain with an example why a one at a time experiment may not lead you to the real optimum in a two variable situation.

5)

a) A 2^3 factorial experiment was conducted to study the effect of cutting speed (A), metal hardness (B), and rake angle (C) on the life of a cutting tool. The

data from two replicates are given below. Identify the significant variables at 95% level. and develop a regression model for the tool life.

A	B	C	Replicate 1	Replicate 2
-1	-1	-1	221	311
1	-1	-1	325	435
-1	1	-1	354	348
1	1	-1	352	472
-1	-1	1	440	453
1	-1	1	406	377
-1	1	1	605	500
1	1	1	392	419

b) An experiment was conducted to model the factors that influence the taste of a soft drink. The results and calculated effects are shown below along with the run order next to each response:

A	B	C	Replicate 1	Run order	Replicate 2	Run order	Variable	Effect
-1	-1	-1	83	9	87	13	1	99.5
1	-1	-1	110	4	120	16	A	18.25
-1	1	-1	80	2	86	14	B	-0.5
1	1	-1	115	7	119	15	AB	2.25
-1	-1	1	99	6	98	3	C	-1
1	-1	1	102	11	99	8	AC	-13.75
-1	1	1	98	12	92	1	BC	-0.5
1	1	1	103	5	101	10	ABC	0.25

If only variable A and interaction AC had significant effects, develop a model equation for the taste and determine the residuals. Plot a graph of residuals vs run order and give your comments.

6)

a) A 2^2 factorial experiment was conducted to optimize the effect of pressure and temperature on Yield. To test for curvature, four additional replicates were made at a centre point. The results are tabulated below. Test for significance of curvature at 95% level.

Order	Pressure (bar)	Temp (^oC)	Yield %		Mean	Variance
1	1.2	60	57.5	59.3	58.4	1.62
2	1.6	60	54.7	51.7	53.2	4.5
3	1.2	90	60.1	63.7	61.9	6.48
4	1.6	90	60.3	57.0	58.65	5.445
	1.4	75	59.1	63.0	61.05	7.605
	1.4	75	59.6	63.4	61.5	7.22

b) Explain the situations in which a split plot experiment and a nested block experiment have to conducted.

7)

a) Write down any 2^{5-2} design and determine the confounding pattern.
b) Frequent adjustment leads to more variation. Describe an experiment to illustrate this.