SIX SIGMA FINAL : NOV 2004

Time: 180 minutes Maximum Marks: 100

Use of Six Sigma / statistical tables is permitted. Choose significance level 0.05 where necessary. Assume suitable data where necessary. Graph sheets will be provided.

1. Describe the origin and development of the Six Sigma methodology.
(5 marks)
2. The marks of 14 students in a test were: 12, 11, 13, 10, 12, 12, 9, 14, 16, 10, 8, 10, 4 and 1 (Max 20). Make a normal probability plot of the data and interpret.
(10 marks)
3. The average mark of a class was 54 with a standard deviation of 6. If the pass mark is 40, calculate the percentage of students likely to fail assuming that the marks are normally distributed.
(5 marks)
4. What is the Central Limit theorem? Explain its significance in practical problems.
(5 marks)
5. Please refer to Problem 2. The marks of the same 14 students in a second test (**in the same order of students**) were: 16, 12, 15, 10, 12, 10, 11, 17, 16, 14, 11, 8, 12 and 3 (Max 20). Test whether the second test was significantly easier than the first test.
(5 marks)
6. An experiment was conducted to determine the best combination of factors for serving a soft drink. The factors considered were: Water temperature (A), Quantity of sugar (B), Quantity of concentrate (C), and Quantity of syrup (D). The response variable was a score from 1 to 10 allotted by a group of tasters. Calculate all the main effects and interactions from this factorial experiment if the average score of four replications were: (1)=6, a=2, b=7, ab=6, c=5, ac=4, bc=7, abc=7, d=5, ad=5, bd=8, abd=8, cd=5, acd=4, bcd=8, abcd=8.
(10 marks)
7. Another experiment was conducted to model the factors that influence the taste of a fast food. 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.
(10 marks)
8. An engineer is studying the effect of feed and speed on surface finish in a metal cutting operation. A 2^2 experiment with two replications and three centre points was conducted with results as below:

Speed	Feed	Surface Finish Ra microns
-1	-1	4, 3
+1	-1	6, 9
-1	+1	12, 14

+1	+1	18, 16
0	0	14, 15, 14

Determine the curvature and test for significance.

(10 marks)

9. An experiment was conducted to determine the effect of air voids on percentage retained strength of asphalt. The air voids were controlled at three levels: low, medium and high. The results are given below:

Air voids	Retained strength (%)				
Low	102	84	98	90	
Medium	90	80	94	76	85
High	78	86	64	74	

Is there a significant difference between the levels?

(10 marks)

10. What is a spilt plot experiment? When is it used?

(5 marks)

11. A 2^{5-2} fractional factorial design is generated using D=AB and E=AC. Determine the alias pattern for the design.

(5 marks)

12. The data on defects at an organization for one month is given below:

Product	Opportunities per Unit	No of units produced	No of defects detected
C45	450	12300	15
C63	580	8500	17
C95	715	5600	22

Determine the overall sigma level of the organization.

(10 marks)

13. The dimension of a part is specified as 60.00+/-0.5mm. A sample of 20 parts gave the following results: 60.11, 60.09, 60.06, 60.19, 60.25, 60.24, 60.43, 60.14, 60.23, 60.00, 60.26, 60.31, 60.11, 60.03, 60.30, 60.15, 60.06, 60.21, 60.29, 60.13. Calculate Cp, Cpk, and Cpm. Also determine a 95% confidence interval for Cp. Assume that the process is in control and normally distributed.

(10 marks)

14. Two operators use the same instrument to measure 10 parts two times each. The results are:

Part Number	Operator A		Operator B	
	Trial 1	Trial 2	Trial 1	Trial 2
1	100	99	100	98
2	102	102	101	101
3	103	100	104	102
4	99	101	98	100
5	98	99	98	99
6	102	100	102	100
7	101	101	101	100
8	102	100	103	98
9	100	101	101	98
10	97	96	96	97

Estimate the repeatability and reproducibility of the instrument. If the specifications are 100+/-10, comment on the gage capability.

(10 marks)