2006 MEC 623 SIX SIGMA – FINAL TEST

Time: 180 minutes Max marks: 50

Use of approved Six Sigma Tables is permitted

1) The mileage for two makes of vehicles was tested, with the following results:

Mari	14.7	16.5	15.9	15	13.9	15.7	16	13.8	14.1	14.2
	14.6	14.8	15.2	14.9	16.4	16.2	15.3	14.4	13	15.6
Hai	15.6	18.9	13.5	17.2	17.6	14.3	16.5	17.6	15.3	15.8
	16.4	16	14.5	16.1	14.7	16.7	16.5	15.7	13.8	15.1

Make a comparative stem and leaf plot and draw conclusions.

(3 marks)

2) The lives of ten bulbs in a reliability test are given below. Make a normal probability plot of the data and interpret.

24	9	90	3	1	55	26	14	28	22

(5 marks)

3) The weights of medicine in bottles filled by machine A have a standard deviation of 10g while that filled by machine B a standard deviation of 12g. A sample of 4 bottles filled by machine A and 8 bottles filled by machine B are chosen randomly. Determine the ratio of standard deviations for these samples such that the probability of this happening by chance is greater than 0.05?

(3 marks)

4) Explain why correlation does not mean causation.

(2 marks)

5) An experiment was conducted to study the effect of engine speed, load and temperature on fuel efficiency with results as follows. The effects and interactions have been calculated. Identify the factors which are statistically significant.

A: Speed (rpm)	B: Load (Nm)	C: Temperature (^{o}C)	Replicate 1	Replicate 2	Effects	
1000	50	30	35	38	39.625	1
2000	50	20	40	36	4.75	A
1000	150	20	51	48	10.25	B
2000	150	20	47	45	-2.75	AB
1000	50	40	27	23	-5.75	C
2000	50	40	37	40	5.75	AC
1000	150	40	40	36	-0.25	BC
2000	150	40	46	45	-0.25	ABC

(5 marks)

6) It is planned to conduct a replicated 2^4 factorial experiment to determine factors affecting tool life. A variation in tool life of 5minutes is considered to be economically significant. If the standard deviation of tool life is estimated to be 4minutes, how many replications would you recommend?

(3 marks)

7) An experiment was conducted to study the effects of feed and nose radius on surface roughness in machining. Since raw material of one batch was sufficient for only eight runs, this was treated as a blocking factor. Develop a model equation for surface finish in terms of coded variables.

Feed	Nose radius	Matl Batch	Surface finish
-1	-1	1	4
1	-1	1	6
-1	1	1	4
1	1	1	8
-1	-1	2	6
1	-1	2	9
-1	1	2	4
1	1	2	10

(5 marks)

PTO

8) Determine the alias structure of the 2^{5-2} design with the generators D=AC, E=BC.

(3 marks)

9) What is meant by Design Resolution? Why are Resolution II designs not usually used?

(3 marks)

10) Three fertilizers A, B & C were tested in four fields each. The crop in one field got eaten up by cattle. The yield from the three remaining fields are given in table below. Is there a significant difference between the three fertilizers?

A	78	80	86	90
B	84	78	76	82
C	72	74	78	

(5 marks)

11) An operation has 2 CTQs. 450 units of product were sent to the process. On inspecting the result, 15 units had to be scrapped while 30 required to be reworked. There were a total of 55 defects including scrapped and reworked units. Determine the Yield, First Time Yield, and Throughput Yield. Assume that all reworked items are completely acceptable.

(3 marks)

12) The surface finish of a component is specified as Ra 5μm max. A sample of 30 parts, on measurement, gave the following results. Calculate Cpk assuming that the process is stable, and that a reciprocal transformation y=1/x will make the distribution normal.

2.6	1.4	2.1	1.5	2.8	1.7	1.9	1.5	2.1	3.3
2.6	2.4	1.6	2.1	1.6	1.9	2.2	1.9	1.8	2.1
1.5	1.3	1.9	1.7	1.5	2.2	1.6	1.7	1.5	2.2

(5 marks)

13) The specification limits for the centre distance of a hole are 20+/-0.1. A sample of 20 parts had a mean of 19.98 with standard deviation 0.042. Determine a 95% confidence interval for Cp.

(3 marks)

14) An MSA study was carried out by two operators using the same instrument to measure 10 parts twice in random order. The results are:

Part Number	Operator A		Operator B	
	Trial 1	Trial 2	Trial 1	Trial 2
1	42	44	43	45
2	55	56	56	54
3	52	53	51	54
4	53	52	54	53
5	57	58	58	57
6	53	55	54	55
7	56	53	55	53
8	44	42	43	43
9	53	54	52	53
10	58	59	57	58

Estimate the repeatability and reproducibility of the instrument. If the specifications are 50+/-10, comment on the gage capability.

(5 marks)

SOLUTIONS TO NUMERICALS:

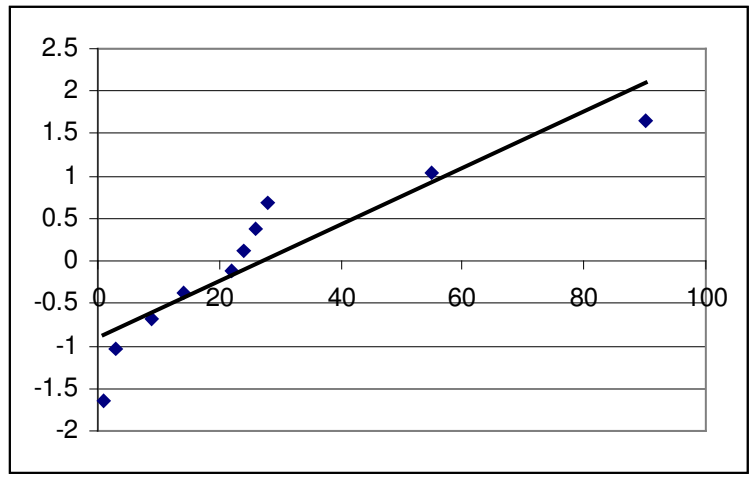
1. d

	12	
85	13	980
753	14	7126894
1783	15	907236
5710456	16	5042
662	17	
9	18	

The two makes appear to be significantly different.

2.

j	x(j)	(j-0.5)/10	zj
1	1	0.05	-1.645
2	3	0.15	-1.036
3	9	0.25	-0.674
4	14	0.35	-0.385
5	22	0.45	-0.126
6	24	0.55	0.126
7	26	0.65	0.385
8	28	0.75	0.674
9	55	0.85	1.036
10	90	0.95	1.645



Does not appear to be normal

3.

	sigma	n	s
A	10	4	
B	12	8	
F			4.347
Ratio		1.73742	0.576

5.

Var		t
4.5	1	35.44168
8	A	4.248529
4.5	B	9.167879
2	AB	-2.459675
8	C	-5.142956
4.5	AC	5.142956
8	BC	-0.223607
0.5	ABC	-0.223607

sp^2	5
sE	1.11803

No evidence that BC and ABC are significant

6.

sp	4
delta	5
nF	40.96
r	2.56

Round up to 3 replications

7.

Surface finish	Col 1	Col 2	Col 3	Effects	Factors	t	p value
4	10	22	51	6.375	1		
6	12	29	15	3.75	F	5.9604	0.027013
4	15	6	1	0.25	R	0.39736	0.729499
8	14	9	5	1.25	FR	1.9868	0.185312
6	2	2	7	1.75	B		
9	4	-1	3	0.75	FB		
4	3	2	-3	-0.75	RB	sE	0.629153
10	6	3	1	0.25	FBR	tcrit	3.182449

Model Equation: Ra=6.375+(3.75/2)Feed

8.

D=AC, E=BC
I=ACD, I=BCE
ACD.BCE=ABDE

I=ACD=BCE=ABDE
A=CD=ABCE=BDE
B=ABCD=CE=ADE
C=AD=BE=ABCDE
D=AC=BCDE=ABE
E=ACDE=BC=ABD

10.

	Total	n		
A	334	4		
B	320	4		
C	224	3		
G	878			
N	11			
SS	70364			
G2/N	70080		MSF	66.9848
CSST	283.64		MSE	18.7083
CSSF	133.97		FO	3.58048
CSSE	149.67		Fcrit	4.45897

No evidence that the three fertilizers are different.

11.

Units	450
CTQ	2
Opp	900
Scrap	15
RW	30
Defects	55
Yield	0.96667
FTY	0.9
Through put Yield	0.93889

12.

Transforming x*=1/x,

0.38462	0.71429	0.47619	0.66667	0.35714	0.58824	0.52632	0.66667	0.47619	0.30303
0.38462	0.41667	0.625	0.47619	0.625	0.52632	0.45455	0.52632	0.55556	0.47619
0.66667	0.76923	0.52632	0.58824	0.66667	0.45455	0.625	0.58824	0.66667	0.45455

USL*	0.2
xbar*	0.54106
s*	0.11508
Cpk	0.98792

13.

USL	20.1	Cp	0.79365
LSL	19.9	ChiL	32.8523
n	20	ChiU	8.90651
xbar	19.98	UCLCp	1.0436
s	0.042	LCLCp	0.54338

14.

A		B	
Average	Range	Average	Range
43	2	44	2
55.5	1	55	2
52.5	1	52.5	3
52.5	1	53.5	1
57.5	1	57.5	1
54	2	54.5	1
54.5	3	54	2
43	2	43	0
53.5	1	52.5	1
58.5	1	57.5	1
52.45	1.5	52.4	1.4

Rbarbar	1.45
srepeat	1.28546
Rxbarbar	0.05
srepro	0.04433
sgauge	1.28623
USL	60
LSL	40
P/T	0.38587