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Dubai Campus

SECOND SEMESTER 2012- 2013

IV Year Mechanical **ME C443 Quality control, Assurance & Reliability**
Comprehensive Examination **Date: 4.6.13**
Weightage: 40% **Marks: 80** **Time: 180 min.**

Answer all Questions
Use of statistical tables are permitted
Assume suitable data, if required.

1. Yash works at a computer store. He also recorded the number of sales he made each month. In the past 12 months, he sold the following numbers of computers:

51, 17, 25, 39, 7, 49, 62, 41, 20, 6, 43, 13.

Construct a box plot using the data and write your inference [8]

2. Check the normal data in question no. 1 for normal distribution using probability plot. [8]

3. The following data represents the number of defectives, the sample size for an IC manufacturing unit.

Sample	Defectives	Sample Size
1	12	500
2	7	300
3	10	500
4	11	200
5	22	600
6	13	550
7	10	400
8	52	1000
9	9	500
10	8	450

Construct a suitable chart for the above case, and comment on the chart. [8]

4. Consider a single sampling plan with lot size N= 2,000 and sample size n = 120 & c=3. We assume that defective batteries found during inspection are replaced by good ones. Construct AOQ chart for the data and determine AOQL. [8]

5. The products from a soft drink bottling unit are inspected using a sampling plan where the sample size is 150 from a lot of size 1800. Under the sampling plan, a lot is accepted if the number of defectives is less or equal to 5. Construct a chart for the total number of components inspected for different proportion defectives. [8]

6. A manufacturing process produces a certain part with a mean diameter of 1.99 m and a standard deviation of 0.03 m. The lower and upper engineering specification limits are 1.90 m and 2.05 m. Determine (i) the process capability if the process is not centered and (ii) the amount of rejection. [8]

7. Consider a process which is in-control with mean= 30 and standard deviation =1. Sample size is 5. If the mean is shifted to 32, determine the type I &type II errors. [8]

8. The fire protection system fails due to the failure of either fire detection system or water deluge system. Water deluge system failure is caused due to pump failure or nozzle blockage. Simultaneous failure of Smoke detector as well as heat detector may lead to fire detection system failure. Construct the fault tree for the problem and determine the minimum cut sets. The probability of base event occurrence for all events for 1000h may be assumed as 0.02. Determine the probability of top event. [8]

9. Using the data in Question 6, construct the reliability block diagram and determine the system reliability. [8]

10. The L9 orthogonal array based experimental results are given in the following table. The results are related to number of defects/ cm^2 in chemical vapour deposition system. To improve the performance of the system, determine the optimum levels of the parameters considered for the study. Also, rank the parameters based on the significance. Hint: During optimization, you have to consider the sign also.

	1	2	3	4	
Experiment	Temperature	Pressure	Settling Time	Cleaning Method	Defect Density
	A	B	C	D	d/cm2
1	1	1	1	1	10
2	1	2	2	2	3
3	1	3	3	3	33
4	2	1	2	3	17
5	2	2	3	1	173
6	2	3	1	2	1,700
7	3	1	3	2	170
8	3	2	1	3	1,700
9	3	3	2	1	3,100

[8]

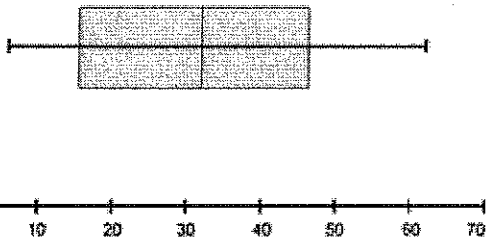
ME C443 Quality control assurance & reliability **Date: 4.6.13**

Comprehensive Examination Solutions

A-1

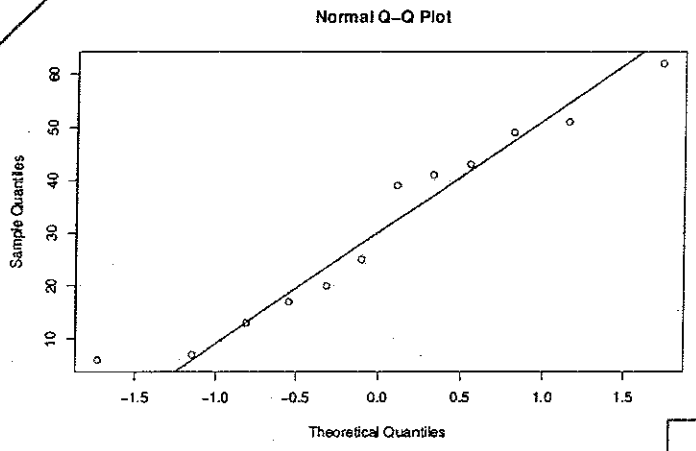
Step 1
First, put the data in ascending order. Then find the median.
6, 7, 13, 17, 20, 25, 39, 41, 43, 49, 51, 62.
Median = (25 + 39) ÷ 2 = 32
Step 2
There are six numbers below the median, namely: 6, 7, 13, 17, 20, 25.
Q_1 = the median of these six items = (13 + 17) ÷ 2 = 15
Step 3
There are six numbers above the median, namely: 39, 41, 43, 49, 51, 62.
Q_3 = the median of these six items = (43 + 49) ÷ 2 = 46

The five-number summary for Mike's sales is 6, 15, 32, 46, 62.



[8]

A-2



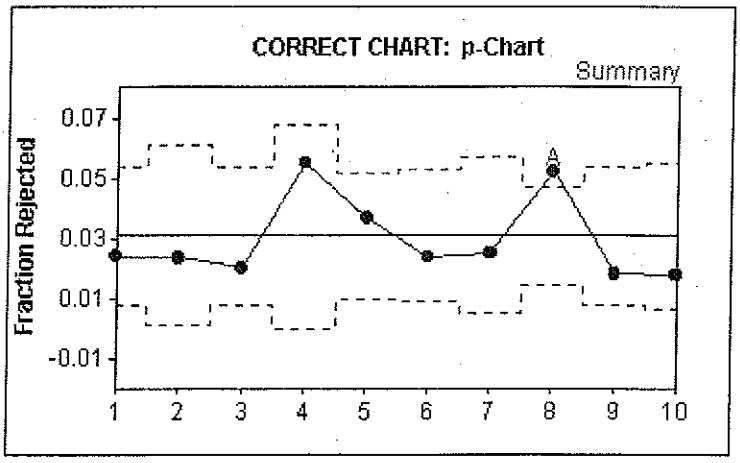
[8]

A-3

$$UCL = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n_i}}$$

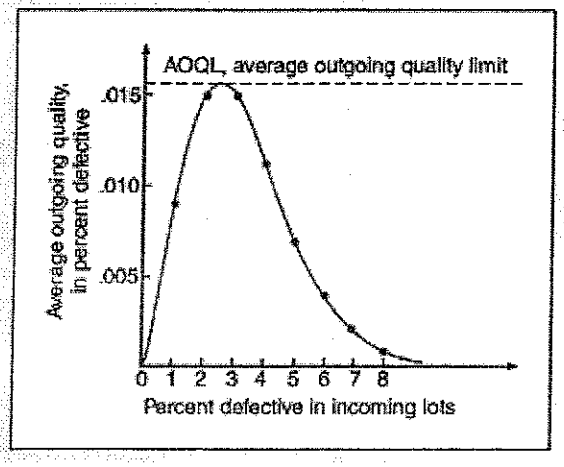
$$CL = \bar{p}$$

$$LCL = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n_i}}$$



[8]

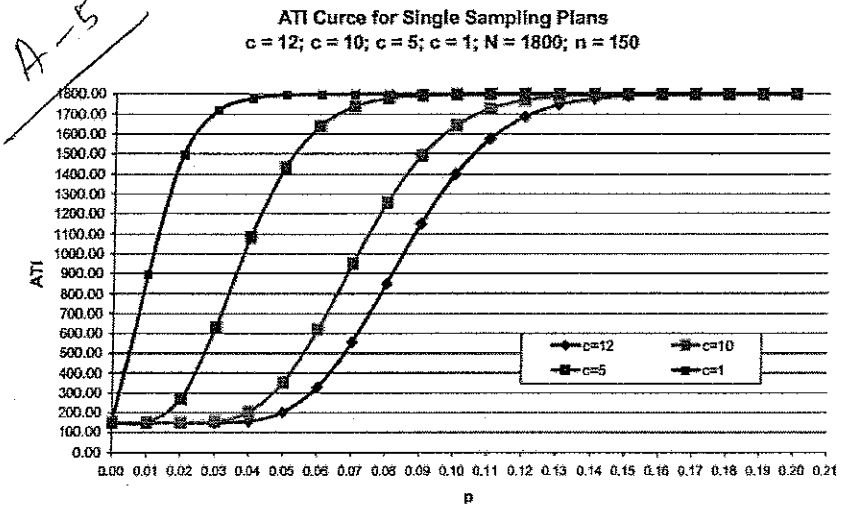
A-4



P_d	×	P_a	×	$(N-n)/N$	=	AOQ
.01		.966		.94		.009
.02		.779		.94		.015
.03		.515		.94		.015
.04		.294		.94		.011
.05		.151		.94		.007
.06		.072		.94		.004
.07		.032		.94		.002
.08		.014		.94		.001

[8]

A-5



	$P_a(p)$	AOQ	ATI
		c=5	
)	1.0000	0.0000	150.00
)	0.9976	0.0091	154.00
;	0.9269	0.0170	270.54
)	0.7084	0.0195	631.07
)	0.4355	0.0160	1081.41
'	0.2227	0.0102	1432.60
;	0.0982	0.0054	1637.89
)	0.0385	0.0025	1736.47
'	0.0137	0.0010	1777.41
)	0.0045	0.0004	1792.60
;	0.0014	0.0001	1797.74
;	0.0004	0.0000	1799.35
)	0.0001	0.0000	1799.82
'	0.0000	0.0000	1799.95
;	0.0000	0.0000	1799.99
)	0.0000	0.0000	1800.00
'	0.0000	0.0000	1800.00
(	0.0000	0.0000	1800.00
;	0.0000	0.0000	1800.00
)	0.0000	0.0000	1800.00
)	0.0000	0.0000	1800.00

A-6

$$C_{pk} = \min\left[\frac{\overline{X} - LSL}{3\sigma}, \frac{USL - \overline{X}}{3\sigma}\right]$$

[8]

Cpk = ~~0.56~~ 0.66.

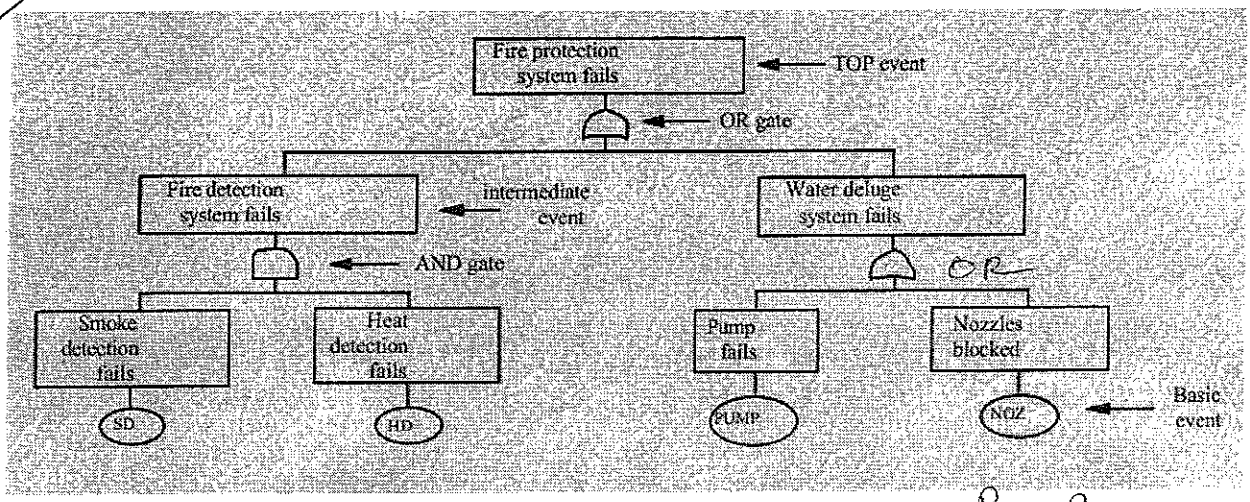
$$Z_1 = \frac{LSL - \mu}{\sigma} = -3 \text{ ε}$$

$$Z_2 = \frac{USL - \mu}{\sigma} = 2$$

% rejection = 2.41 %.

[8]

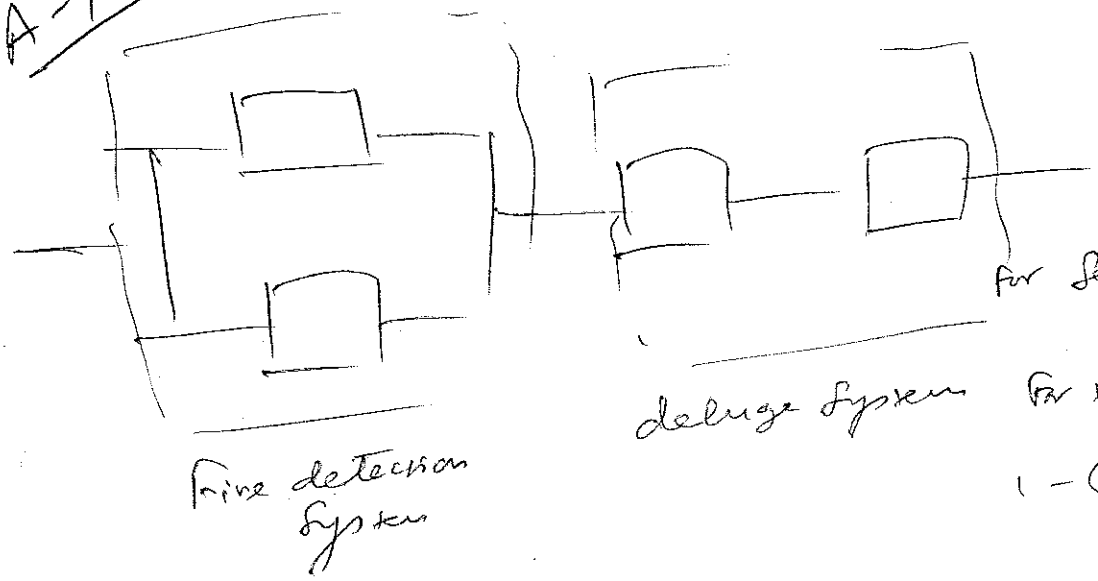
A-8



$P = 0.02$, AND gate, $P_1 \times P_2$

OR gate, $1 - (1-P_1)(1-P_2)$

A-9



Fire detection system

deluge system

Component Reliability

$= 1 - 0.02$

$= 0.98$.

For Series System / $R_1 \times R_2$ *

For Parallel System / $1 - (1-R_1)(1-R_2)$

A-9

$UCL = \mu_0 + 3\sigma/\sqrt{n} = 31.38$

$LCL = \mu_0 - 3\sigma/\sqrt{n} = 28.662$

$Z_1 = \frac{x - \mu_0}{\sigma/\sqrt{n}} = \frac{UCL - \mu_0}{\sigma/\sqrt{n}} = +3$

$Z_2 = \frac{LCL - \mu_0}{\sigma/\sqrt{n}} = -3$

$\alpha = 0.0026$

$\mu_0 = 30$

$\mu_1 = 32$

$\mu = \mu_1 = 32$

$Z_1 = 1.48$

$Z_2 = -7.48.$

[8]

A-10

Measure = - 10 log (Defect Density^2)

	1	2	3	4			
Experiment	Temperature	Pressure	Settling Time	Cleaning Method	Defect Density	Measure	
	A	B	C	D	d/cm2	symbol	dB
1	1	1	1	1	10	n1	-20
2	1	2	2	2	3	n2	-10
3	1	3	3	3	33	n3	-30
4	2	1	2	3	17	n4	-25
5	2	2	3	1	173	n5	-45
6	2	3	1	2	1,700	n6	-65
7	3	1	3	2	170	n7	-45
8	3	2	1	3	1,700	n8	-65
9	3	3	2	1	3,100	n9	-70

	Level		
	1	2	3
A Temperature	-20	<u>-45</u>	-60
B Pressure	-30	<u>-40</u>	-55
C Settling Time	<u>-50</u>	-35	-40
D Cleaning Method	<u>-45</u>	-40	-40

[8]

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SECOND SEMESTER 2012- 2013

IV Year Mechanical ME C443 Quality control, Assurance & Reliability Test 2
Date: 28.4.13 Weightage: 20% Marks: 20 Time: 50 min.

1. A quality control manager at a manufacturing facility has taken 4 samples with 4 observations each of the diameter of a part. Check whether the data is randomly distributed or not using a proper procedure. Use 90% confidence level for the case. Use up and down slopes for comparison. [4]

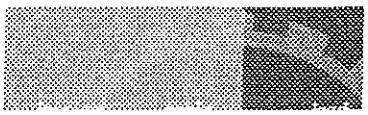
Samples of Part Diameter in Inches

1	2	3	4
5.8	6.2	6.1	6.0
5.9	6.0	5.9	5.9
6.0	5.9	6.0	5.9
6.1	5.9	5.8	6.1

2. The requirements & importance ratings of good remote control (RC) are Easy to hold A (3), Easy to find B(6), Buttons easy to see C (2),Tactile sense to buttons D(4), Attractive E(5) & Multi function buttons F(1). The product features their importance weigntages to meet the requirements are Dimensions of RC- H(4), Size of buttons -I (4), Colour of RC -J (3), Colour of buttons -K (3), No. of buttons -L (5) & Press/return mechanism of buttons M- (4). The relationship weightage between the requirements and features given in the table. Strong positive relation exists between (H&I and H&L) and negative relation exists between (I&L and J&K). Enter the data in the QFD chart and calculate the weighted score for each product feature and rank them. [4]

	A	B	C	D	E	F
H	9					
I	3		9			
J	1	9			9	
K						9
L			3		1	
M		3				

3. The possible failures in hotel service are analyzed and the results are shown below. The severity of A and B are high whereas C and D are very high. The frequency of failure modes A & B are 1 in 20 whereas the failure modes C & D occur 1 in 5000. Detection of failure modes A & C is high whereas B & D is remote. Construct the FMEA table for the problem and write your inference. After taking corrective action, the frequency of failure modes A& C are reduced by two levels and the detection of B & D is improved by two levels. Construct the FMEA table for the problem and write your inference.



Process	Potential Failure Mode	Potential Failure Effect	Potential Causes	Current Controls
Register guest	Cannot Register in time (A)	Complaints	Lack of language and communicati on skills	No plan on training content
Provide Guest Services	Lack of barrier-free facility (B)	Inconvenien ce and injury	Cannot provide barrier-free facility	Providing barrier-free facility
Provide Meals	Food goes bad (C)	Disease or injury	Past shelf life	No control of raw material
Provide Medical Service	Service not in time (D)	Illness changes for worse	No 24 Hour service	12 hour service

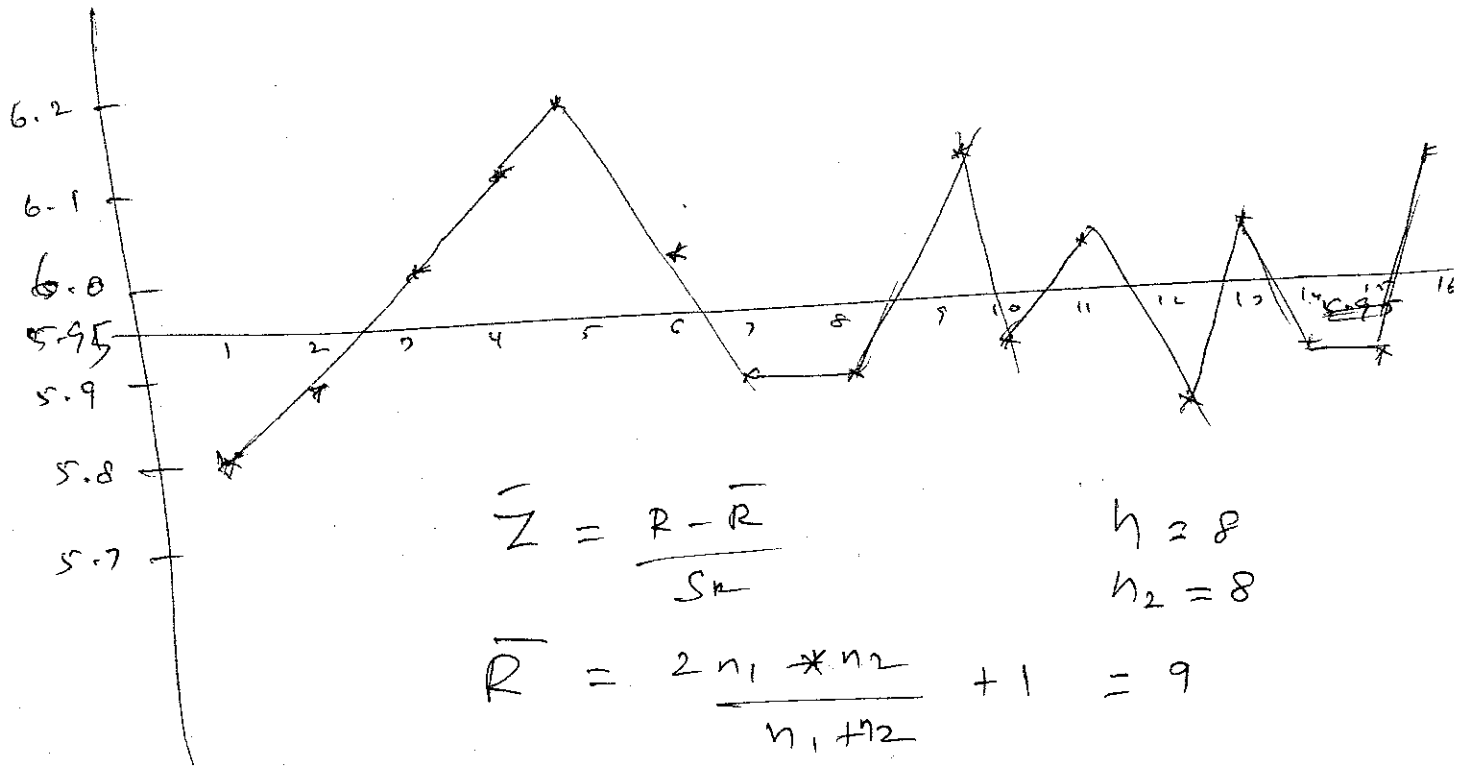
4. The titanic disaster took place due to three main reasons: Inefficient passenger evacuation, iceberg collision and collapsed structure. The passengers are not evacuated properly due to anyone of the following reasons: Insufficient life boats, time constraint and lack of emergency procedure. The ship collided with the iceberg due to poor visibility or high speed. The visibility may be poor due to bad outlook and the absence of binoculars. The ship structure would have collapsed due to the inappropriate material or manufacturing defect. The material selection would have gone wrong due to lack of material testing and poor quality control. Construct fault tree for the case. Assuming the probability of base events as 0.01 determine the probability of such top event. Using the data, construct the reliability block diagram and determine the system reliability. [4+4].

Answer scheme

A-1

Median 5.95

No of runs = 9



$$\bar{Z} = \frac{R - \bar{R}}{S_R} \qquad n_1 = 8 \qquad n_2 = 8$$

$$\bar{R} = \frac{2 n_1 * n_2}{n_1 + n_2} + 1 = 9$$

$$S_R = \sqrt{\frac{2 n_1 n_2 (2 n_1 n_2 - n_1 - n_2)}{(n_1 + n_2)^2 (n_1 + n_2 - 1)}}$$

$$= 1.932$$

$$Z_{\alpha/2} = Z_{0.05} = 1.645$$

$\bar{Z} < Z$ Hence the chart is randomly distributed.

House of Quality

A-2

House of Quality (HOQ)

		H	I	J	K	L	M
A	3	9	3	1			
B	6	8		9			3
C	2	#	9			3	
D	4						
E	5			9		1	
F	1				9		
weight		4	4	3	3	5	4
		27	27	102	9	11	18
		108	108	306	27	55	72
		(2)	(2)	(1)	(6)	(5)	(4)

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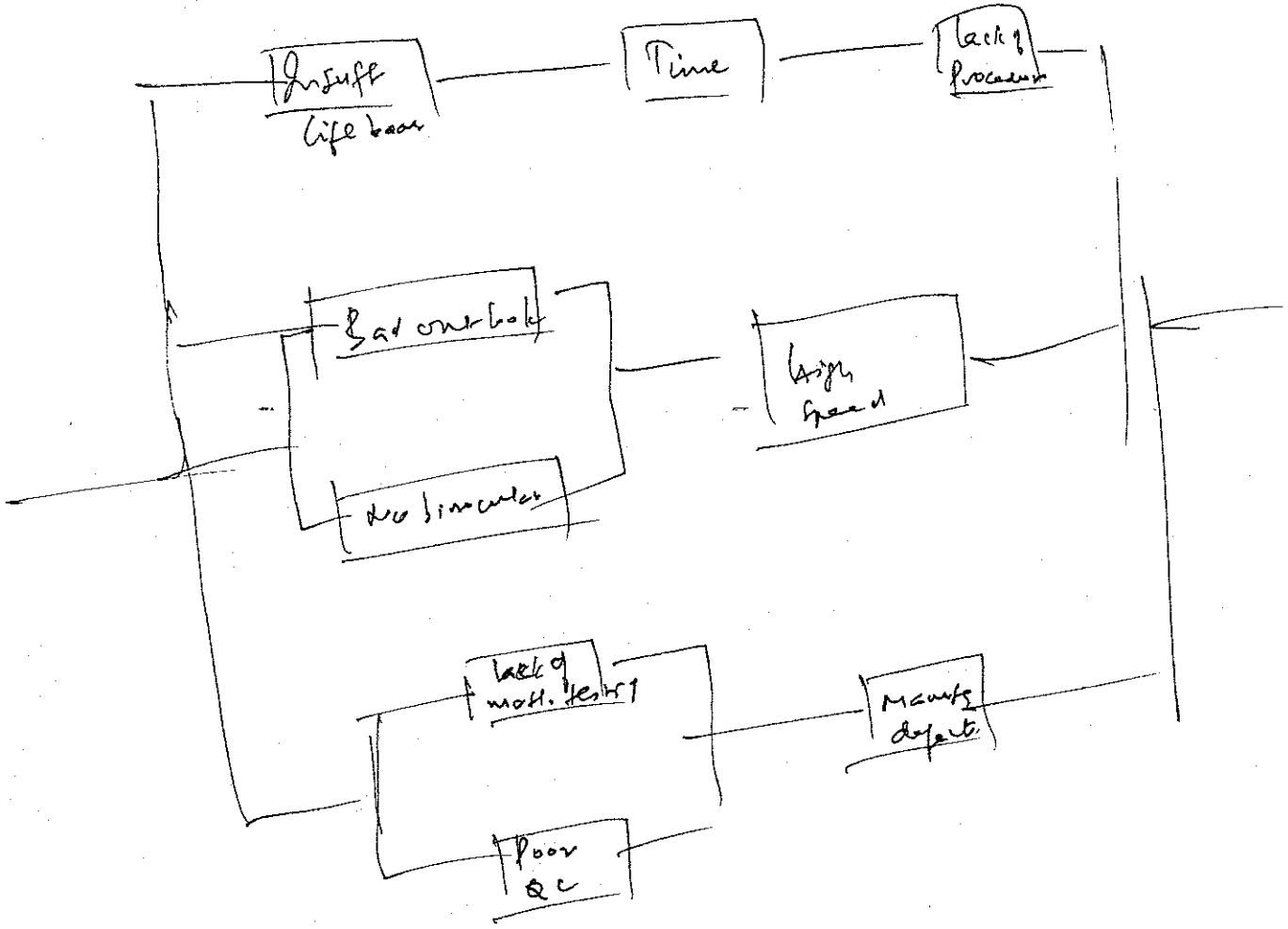
A-3

Process	Potential Failure Mode	Potential Failure Effect	Potential Causes	Current Controls	S	O	D	RPN	PS	PO	PD	PRPN
Register guest	Cannot Register in time (A)	Complaints	Lack of language and communication skills	No plan on training content	7	7	3	147	7	5	3	105
Provide Guest Services	Lack of barrier-free facility (B)	Inconvenience and injury	Cannot provide barrier-free facility	Providing barrier-free facility	7	7	8	392	7	7	6	294
Provide Meals	Food goes bad (C)	Disease or injury	Past shelf life	No control of raw material	8	3	3	72	8	1	3	24
Provide Medical Service	Service not in time (D)	Illness changes for worse	No 24 Hour service	12 hour service	8	3	8	192	8	3	6	144

[4]

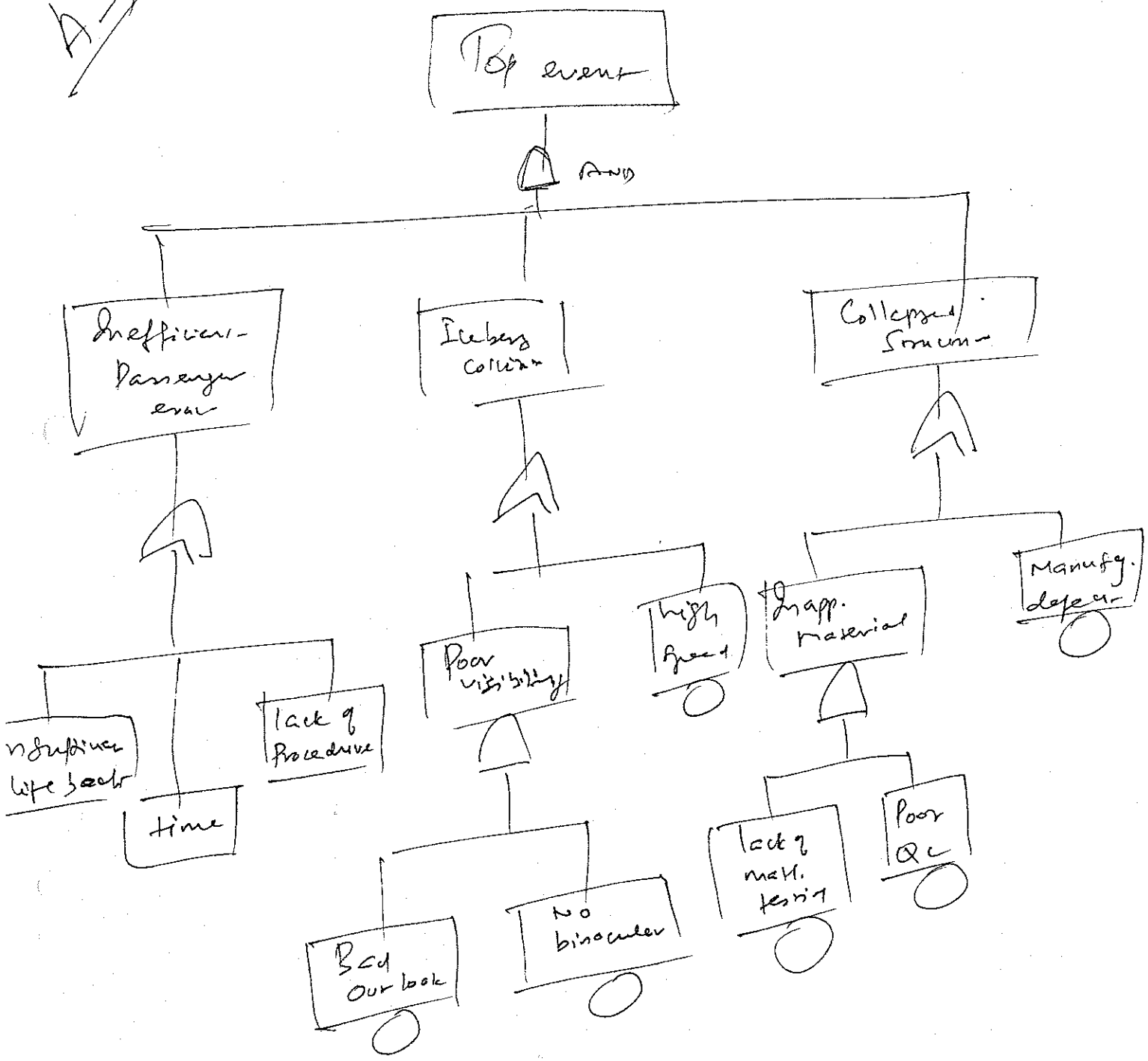
A-45



$R = 0.9999697$

[4]

A-4c



$P(top) = 3.029 \times 10^{-6}$

[4]

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SECOND SEMESTER 2012- 2013

IV Year Mechanical | ME C443 Quality control, Assurance & Reliability | Test 1
Date: 10.3.13 | Weightage: 25% | Marks: 25 | Time: 50 min.

1. The number of weekly customer complaints is monitored at a large hotel. 100 feedback forms are issued weekly. Complaints from customers have been recorded over the past twenty weeks. Determine the control limits and center line for the control chart. [5]

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Complaints	3	2	3	1	3	3	2	1	3	1	3	4	2	1	1	1	3	2	2	3

2. Three bottling machines of a cool drinks company are being evaluated for their capability:

Machine	Standard Deviation	Mean
A	.05	15.99
B	.1	15.95
C	.2	15.90

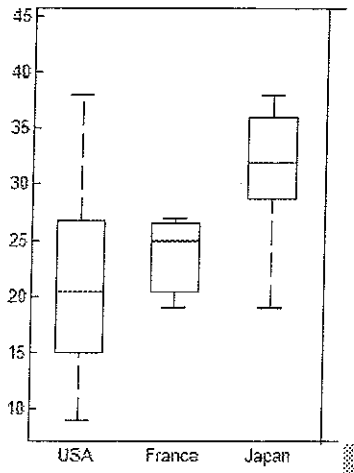
If specifications are set between 15.8 and 16.2 ounces, determine which of the machines are capable of producing within specifications. Determine the %rejection for each machine. Assume that the process is not centered. [5]

3. A production manager at Ultra Clean Dishwashing Company is monitoring the quality of the company's production process. There has been concern relative to the quality of the operation to accurately fill the 16 ounces of dishwashing liquid. The company collected the following sample data on the production process.

Sample	Observation
1	16.40
2	15.97
4	16.20
5	15.87
6	15.43
7	16.43
8	15.50
9	16.13
10	15.68

Determine the center line and control limits for the recommended charts. [5]

4. (i) Compare the mileage of three cars based on box plot characteristics. [3]



(ii) Differentiate

a. Internal failure cost & External failure cost [1]
b. Design spread & process Spread [1]

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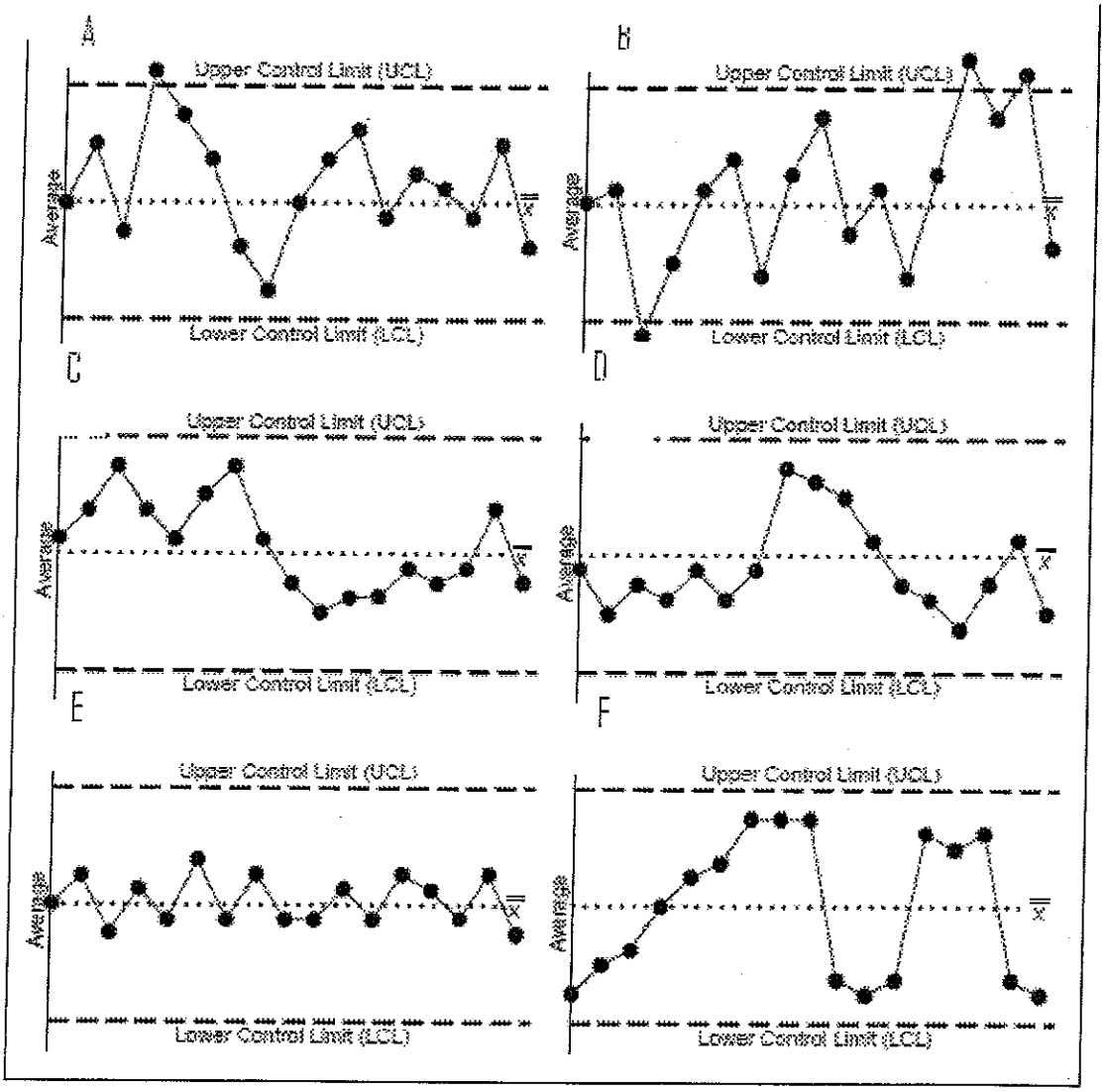
5. Identify the out of control signals/ patterns in the charts shown below and specify them. [5]



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ME C443 Quality control, Assurance & Reliability Test 1 Solutions

A-1

Computations for a C-Chart	
c bar =	2.2
Z-value for control charts =	3
Sigma_c =	1.4832397
CL: Center Line =	**2.20**
LCL: Lower Control Limit =	**0.00**
UCL: Upper Control Limit =	**6.65**

[5]

A-2

$$C_{pk} = \min\left\{\frac{USL - \mu}{3\sigma}, \frac{\mu - LSL}{3\sigma}\right\}$$

Machine	Cpk	ppm
A	1.267	63
B	0.5	45500
C	0.15	317311

[5]

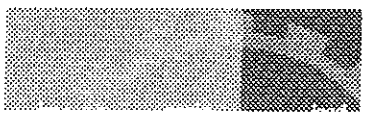
Xbar and MR charts:

A-3

$$UCL = \bar{x} + 3\frac{\overline{mr}}{d_2}$$
$$CL = \bar{x}$$
$$LCL = \bar{x} - 3\frac{\overline{mr}}{d_2}$$

$$UCL = D_4\,\overline{mr}$$
$$CL = \overline{mr}$$
$$LCL = D_3\,\overline{mr}$$

[5]



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A-4

Internal failure costs are incurred when products, components, materials, and service fail to meet quality requirements prior to the transfer of ownership to the customer. Internal failure costs include scrap and rework costs for the materials

External failure costs are incurred when the product does not perform satisfactorily after ownership is transferred to the customer. Such costs include those due to customer complaints, which include the costs of investigation and adjustments, and those associated with receipt, handing, repair, and replacement of nonconforming products. [2]

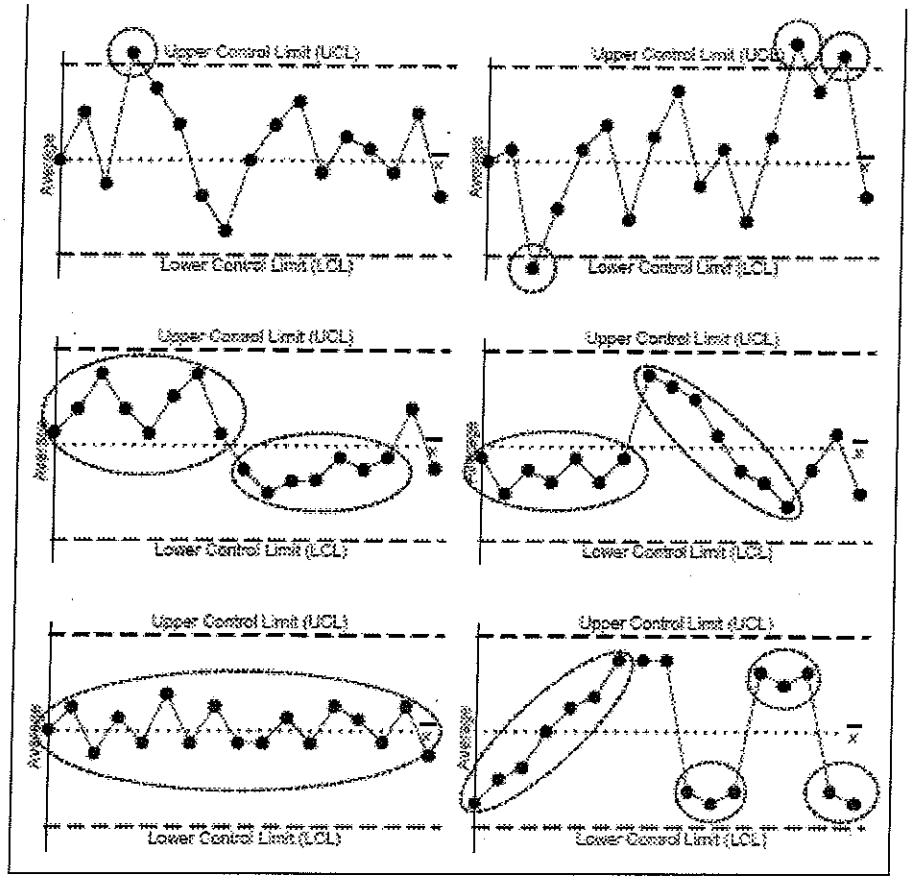
Design spread= USL-LSL

Process spread=UCL-LCL [1]

Characteristics	USA	France	Japan
Median	low	medium	High
Tail	long	short	Long
Dispersion	more	less	more
Symmetry	Right skewed	symmetric	Left skewed

[3]

A-5



[5]

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Q/C

SECOND SEMESTER 2012- 2013

IV Year Mechanical ME C443 Quality control, Assurance & Reliability Quiz 2

Name: ID No. Date: 19.5.13

Time: 20 min. Marks: 14 Weightage: 7%

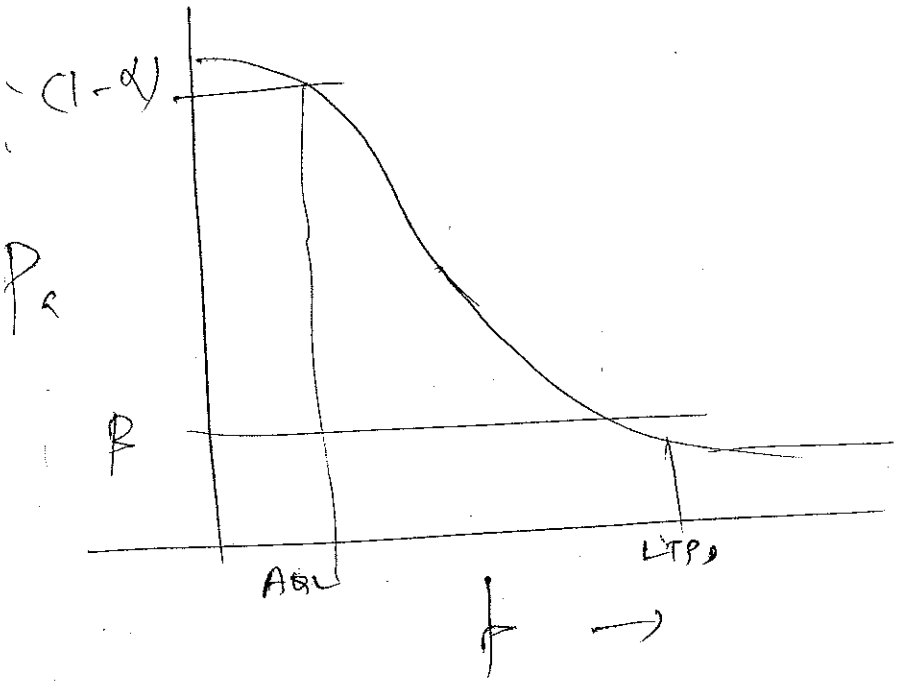
1. Construct the OC curve for the following single sampling plan: n=50 & c=2; Determine the producer's risk if the AQL = 2% and consumer's risk if RQL = 10%. [6]
2. Determine the ASN value for the following plan for a proportion defective of 5% : n1=50; c1=2 and n2=100;c2=5. [4]
3. Construct the chart required for the Sequential sampling plan with following data: α = 5% and β=15% for AQL = 3% & RQL = 20%. [4]

x	α 0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
0	0.0065	0.3679	0.2231	0.1353	0.0821	0.0498	0.0302	0.0183	0.0111	0.0067
1	0.9098	0.7358	0.5578	0.4060	0.2873	0.1991	0.1359	0.0916	0.0611	0.0404
2	0.9856	0.9197	0.8088	0.6767	0.5438	0.4232	0.3208	0.2381	0.1736	0.1247
3	0.9982	0.9810	0.9344	0.8571	0.7576	0.6472	0.5366	0.4335	0.3423	0.2650
4	0.9998	0.9963	0.9814	0.9473	0.8912	0.8153	0.7254	0.6288	0.5321	0.4405
5	1.0000	0.9994	0.9955	0.9834	0.9580	0.9161	0.8576	0.7851	0.7029	0.6160
6	1.0000	0.9999	0.9991	0.9955	0.9858	0.9665	0.9347	0.8893	0.8311	0.7622
7	1.0000	1.0000	0.9998	0.9989	0.9958	0.9881	0.9733	0.9489	0.9134	0.8666
8	1.0000	1.0000	1.0000	0.9998	0.9989	0.9962	0.9901	0.9786	0.9597	0.9319
9	1.0000	1.0000	1.0000	1.0000	0.9997	0.9989	0.9967	0.9919	0.9829	0.9682
10	1.0000	1.0000	1.0000	1.0000	0.9999	0.9997	0.9990	0.9972	0.9933	0.9863
11	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9997	0.9991	0.9976	0.9935
12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9997	0.9992	0.9980
13	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9997	0.9993
14	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9998
15	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999
16	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Quiz 2 — Solutions ME C443

A-1

p	p_a
0.02	0.9197
0.04	0.676
0.06	0.4272
0.08	0.2381
0.1	0.1241



[6]

A-2

$\lambda = 2.5$

$A_{SN} = n_1 + n_2 (1 - p')$

$p' = p(x \neq 2) + 1 - p(x > 5)$

$A_{SN} = 92$

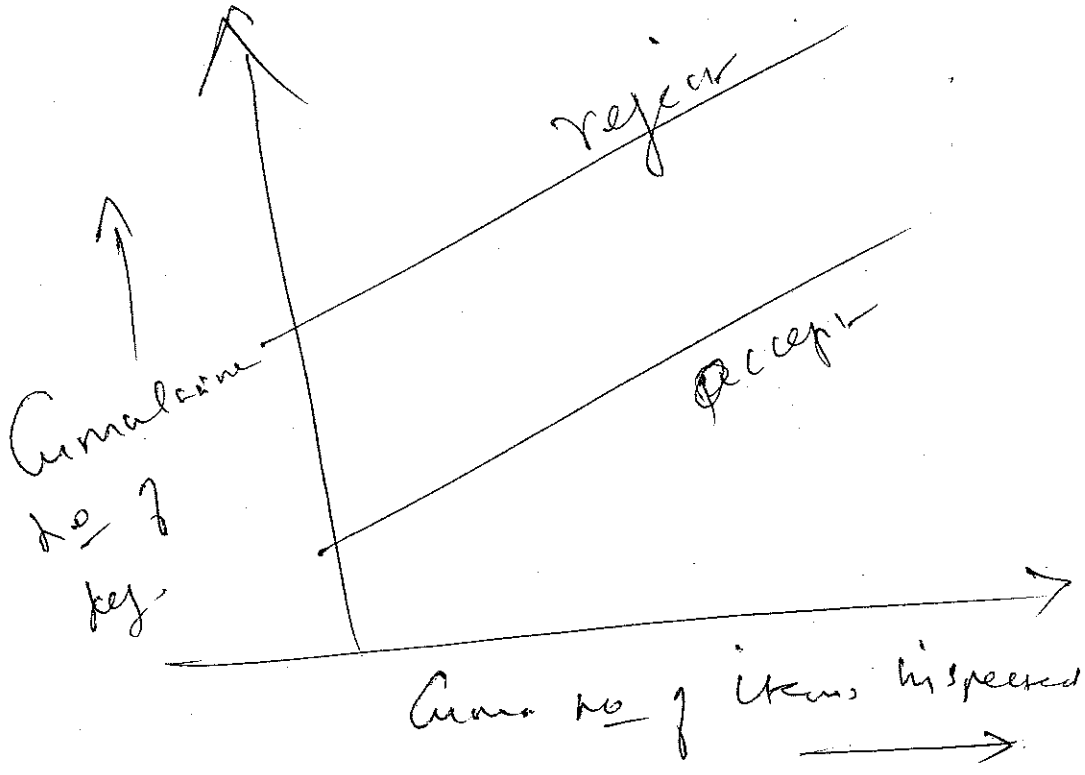
[4]

A-3

$$h_1 = \frac{\log\left(\frac{1-\alpha}{\beta}\right)}{\log\left(\frac{p_2}{p_1}\right) + \log\left(\frac{1-p_1}{1-p_2}\right)} = 0.8831$$

$$h_2 = \frac{\log\left(\frac{1-\beta}{\alpha}\right)}{\log\left(\frac{p_2}{p_1}\right) + \log\left(\frac{1-p_1}{1-p_2}\right)} = 1.351$$

$$s = \frac{\log\left(\frac{1-p_1}{1-p_2}\right)}{\log\left(\frac{p_2}{p_1}\right) + \log\left(\frac{1-p_1}{1-p_2}\right)} = 0.0915$$



[4]

BITS Pilani
Dubai Campus

SECOND SEMESTER 2012- 2013

Name: **ID No.:**

IV Year Mechanical **ME C443 Quality control assurance & reliability**
Date: 24.2.13 **Quiz 1** **Weightage: 8%** **(8 Marks)** **Time: 20 min.**

Answer all the questions

1. Construct the box plot for the following data related to price of various printers in dollars and comment on the characteristics.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
45	105	68	89	76	89	72	95	128	118	182	52	68	120	108	89	48	99

2. Construct the stem leaf plot for the following data related to tensile strength in MPa related to plastic components and comment on the results. Divide each stem in to two parts for detailed understanding.

   42, 54, 65, 47, 59, 40, 53, 66, 58, 47, 52

3. Number of defects for an automobile component is recorded as below. Construct a pareto chart for the % contribution of each class of defects.

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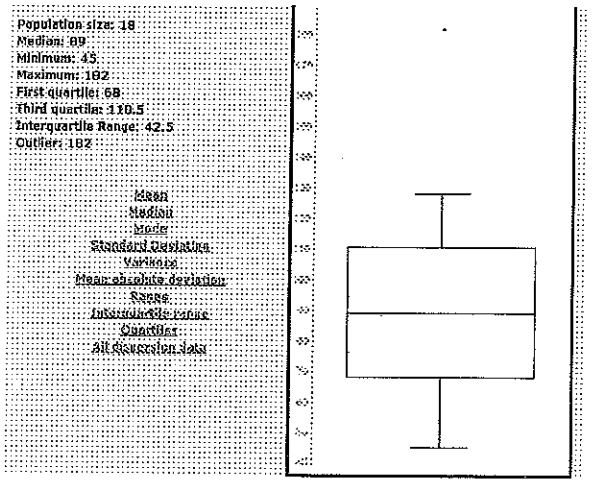
ME C443 Quality control assurance & reliability **Quiz 1 Solution**

A-1



A-2

Stem	Leaf
4	0 2
4	7 7
5	2 3 4
5	8 9
6	
6	5 6

A-3

Pareto Calculation Metrics -

Values	Relative Values (%)|	Cumulative Values (%)
34	39.08	39.08
21	24.14	63.22
13	14.94	78.16
12	13.79	91.95
7	8.05	100
87	100	372.41