GX 753

OLLSCOIL NA hÉIREANN, GAILLIMH
NATIONAL UNIVERSITY OF IRELAND, GALWAY

Semester II Examinations 2003

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4BI121: B.E. Degree Industrial Engineering & Information Systems
4BJ121: B.E. Degree Management Engineering with Language

IE433: ***Quality Engineering***

Examiners:
Dr. Wright
Prof. Sheil

Answer **three** questions.

Time allowed: **Two** hours

Control Chart Factors, Tolerance Limit Factors appended.
Cambridge Statistical Tables available.

No. Pages: Cover + 4
Department: Industrial Eng

Q1.

Differentiate briefly between so-called *probability limits* and *3-sigma limits* for control charts. [2 marks]

A process is to be monitored/controlled for the value of a critical characteristic X of produced units. The following data relates to subgroups of 5 units taken at regular intervals from current production.

Subgroup	$\overline{X}$	R	Subgroup	$\overline{X}$	R
1	103	4	11	105	4
2	102	5	12	103	2
3	104	2	13	102	3
4	107	11	14	105	4
5	104	4	15	104	5
6	103	3	16	105	3
7	102	7	17	106	5
8	105	2	18	102	2
9	106	4	19	105	4
10	104	3	20	103	3
			21	104	4

(i) Find $\overline{\overline{X}}$ and $\overline{R}$. [4 marks]

(ii) Estimate the process standard deviation for X. [2 marks]

(iii) Identify centerlines and control limits for $\overline{X}$, R charts suitable for controlling future production. [8 marks]

(iv) Why should limits, such as those above, be subject to periodic review? [1 mark]

Q2.

What are the principal advantages of CUSUM charts over Shewhart charts? [3 marks]

Sets of four samples are taken at regular intervals from the output of a chemical production process and a measurement for the percentage impurity in each sample is obtained. From past experience, it is known that when the process is in control, the level of impurity is a random variable with mean 5% and standard deviation 0.4%. Past experience has also shown that when problems arise, it is the mean impurity level which is generally affected - variability tends to be stable.

Average impurity levels for a recent sequence of 20 such sets of samples were:

5.01, 4.89, 5.00, 4.97, 4.68, 5.08, 4.99, 5.27, 4.82, 5.00,
4.82, 5.45, 4.93, 5.35, 5.34, 4.87, 5.42, 5.25, 5.34, 5.64.

(i) Prepare a CUSUM plot of these values. [8 marks]

(ii) Interpret the plot produced under (i) above; use the *5-10-10 Rule* to test the significance of any apparent pattern changes. [6 marks]

Q3.

What properties of a control chart do the *Operating Characteristic* (OC) and *Average Run Length* (ARL) quantify? [2 marks]

Let P(.) represent the OC of a control chart. Show that the ARL is $1/(1 - P)$. [2 marks]

Distinguish between *np-charts*, *c-charts* and *demerits charts* on the basis of the circumstances under which they are employed. [2 marks]

(i) A textile company intends to monitor the number of flaws in the towels it produces. The proposed inspection unit is a bale of 10 towels. Initial inspection of 50 bales yielded a total of 200 flaws.

Devise a control chart for future use – state any assumptions you make.[3 marks]

If a production problem arises that leads to an average of 1 flaw per towel, find the average number of bales inspected before the chart signals it. [3 marks]

(ii) When operating normally, a high volume process produces 4% defective output. A control chart based on single daily samples of 100 items and deploying an upper control limit (UCL) only, will be used to monitor this process.

What type of chart should be used? [1 marks]

Calculate a value for the UCL. [1 marks]

If process performance suddenly disimproved to 6% nonconforming, how many days (on average) will elapse before the chart signals this change? [3 marks]

Q4.

What are Process Capability Studies? [1 marks]

Define the Capability Ratios C_p, C_{pl}, C_{pu}, C_{pk} [4 marks]
and, using diagrams or otherwise, indicate how they should be interpreted. [3 marks]
What critical assumption underlies the interpretation of these indices? [1 marks]

The specification on an important dimension of a machined part is 3 ± 0.004cm. A large sample of such parts yielded an average of 2.998cm and standard deviation 0.001cm for this dimension.

(i) Is the machine capable of meeting the specification. [1 marks]
Produce a numerical justification for your answer. [2 marks]

(ii) 'Good' parts are sold at a profit of \$1.00; parts over spec. are reworked and sold at a reduced profit of \$0.5, while parts under spec. are scrapped at a loss of \$2.50. Assuming the machine may be adjusted to produce to any nominal value for this dimension, what nominal value/setting would you choose in order to maximise the expected profit per item. You may assume that the dimension of interest is Normally distributed. [5 marks]

Q5.

What does the term *Acceptance Sampling* signify? [1 marks]

What performance property of a sampling plan does its *OC-curve* represent? [1 marks]

Consider a single (n, c) attributes sampling plan, used in conjunction with *rectifying inspection*. Let N, θ represent batch size and batch proportion defective respectively.

(i) When is $P(\theta) = \sum_{r=0}^{c} (n\theta)^r e^{-n\theta} / r!$ an acceptable approximation of the *OC*? [1 marks]

(ii) Show that the average number of items inspected per batch is
$I(\theta) = N - (N-n)P(\theta)$. [2 marks]

(iii) Deduce that the expected value for the batch proportion defective after inspection viz. the *Average Outgoing Quality*, is given by $A(\theta) = \frac{N-n}{N}\theta . P(\theta)$. [2 marks]

A company receives components from a vendor in batches of size $N = 2000$. When in control, the vendor's process average for batch proportion defective is $\bar{\theta} = 0.01$.

Determine sample sizes for single sampling plans, having acceptance numbers c = 0, 1 , 2, 3, 4 respectively, so that in each case the resulting plan accepts batches at the vendor's process average with probability (at least approximately) 0.95; use the Cumulative Poisson Tables. [5 marks]

Which of the five plans identified above minimises (i) $I(\bar{\theta})$, (ii) $A(\bar{\theta})$? [4 marks]

If you were associated with the process where this vendor's components are used, which of these two plans would you prefer? Why? [1 marks]