GX577

OLLSCOIL NA hÉIREANN, GAILLIMH
NATIONAL UNIVERSITY OF IRELAND, GALWAY

Summer Examinations 2000

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B.E. Degree : Industrial Engineering & Information Systems

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*IE426:**Quality***

Dr. Wright,
Prof. O'Kelly,
Dr. Sheil.

Time allowed: ***Three*** hours

Attempt ***four*** questions: any ***two*** from **A1, A2, A3, A4**;
any ***two*** from **B1, B2, B3, B4**.

Cambridge Statistical Tables supplied.
Mathematical('log') Tables available

Section A

A1.

(i) State the *Central Limit Theorem* and briefly explain its relevance to the theory underlying $\bar{x}$ control charts. [2 marks]

Consider an $\bar{x}$ control chart having an upper control limit only, at the value A. Let μ, σ^2 represent the current process mean and variance for the measured characteristic X and let the subgroup size be n.
Show that the probability that individual $\bar{x}$ values fall below this limit is given, at least approximately by $\Phi(\frac{A-\mu}{\sigma/\sqrt{n}})$, where $\Phi(.)$ is the Standard Normal cdf. [5 marks]

If the target value and process standard deviation for X are 201, 0.5 respectively, and $n = 9$:
(a) what value must A have, so that the probability of *false alarms* is 0.002; [5 marks]
(b) if the process has been incorrectly centered at 205.2, how much time would you expect to elapse before this error is signalled by the control chart - you may assume that the control chart is updated hourly? [5 marks]

(ii) $\bar{x}$, R charts based on subgroups of size 3, 4 or 5 will be used to monitor a number of machines and subprocesses throughout a plant. Design a generic form upon which to record data and plot the charts. This form should be capable of customisation for use by relevant personnel in the areas concerned. [8 marks]

A2.

How are CUSUM charts (i) constructed, (ii) visually interpreted? [4 marks]

If $S_j = \sum_{i=1}^{j}(x_i - m)$, show that x_j may be expressed: $x_j = m + S_j - S_{j-1}$. [2 marks]

Hence deduce that $\frac{1}{n}\sum_{i=r+1}^{n} x_i = m + \frac{S_n - S_r}{n}$. [3 marks]

What use can be made of this result, when analysing CUSUM plots? [2 marks]

The scrap rate associated with the output of a foundry is under investigation. Based on past experience, management has set a target of 20% for the average rate of scrap. Past experience has also shown that when the foundry is operating normally, the standard deviation of day-to-day variation in the scrap rate is approximately 0.5%. Scrap rates(%) for the past 20 days of production were as follows: 19.2, 21.4, 21.3, 20.3, 21.0, 20.0, 22.0, 21.0, 20.1, 18.2, 19.7, 19.5, 19.4, 19.8, 20.5, 20.7, 20.6, 21.2, 20.3, 21.1. Analyze this data with respect to the target set by management. [14 marks]

A3.

Why conduct *Process Cabability Studies, Gauge Capability Studies*? [5 marks]

Small Components Ltd. produce aluminium components. The company operates two eight hour shifts per day and production operators monitor their own work.
A dimension of a component which will be produced on one of the company's machines, carries the specification 202±4. In a carefully controlled prototype run, 20 such components were produced from this machine. Both operators associated with the machine, twice measured each of the 20 parts for the dimension of interest, using the designated gauge - the order in which the 80 measurements involved were conducted, was randomised. The following table presents the readings recorded.

Part No.	Operator 1		Operator 2	
1	202	202	203	201
2	203	201	202	202
3	201	200	199	200
4	206	207	206	208
5	200	201	199	200
6	199	199	200	199
7	202	201	201	201
8	202	200	200	201
9	201	201	199	201
10	204	203	203	203
11	201	202	200	201
12	200	199	200	198
13	202	201	203	201
14	203	202	203	203
15	203	201	204	202
16	205	206	205	207
17	201	200	200	201
18	204	204	204	202
19	202	203	201	202
20	202	201	201	203

(a) Quantify *gauge repeatability* and *gauge reproducability* and comment [12 marks]
[Note: $d_2 = 1.128$].

(b) Estimate *gauge capability*. [3 marks]

(c) Comment on machine/process capability. [5 marks]

A4.

Define each of the following, in the general context of Acceptance Sampling.
acceptance number, *operating characteristic*(*OC*), *AQL* and *RQL/LTPD*, *producer's* and *consumer's risks*, *rectifying inspection* [5 marks]

Show, using standard notation, that when a single attributes sampling plan is used in conjunction with rectifying inspection, the average amount of inspection per lot is

$I(\theta) = N - (N - n).P(\theta)$ [3 marks]

Hence, deduce that the average outgoing quality(AOQ) which results is

$$A(\theta) = \frac{(N-n)}{N}\theta P(\theta)$$ [3 marks]

A single sampling plan with $n = 100$, $c = 2$ is used for receiving inspection.
Lots contain 1000 items and 'rejected' lots are screened/rectified by the vendor.

(i) Sketch the OC-Curve $P(\theta)$ for this plan and estimate the quality level θ at which batches will be rejected 90% of the time. [5 marks]

(ii) Sketch the AOQ and estimate the AOQL. [5 marks]

(iii) For a single sampling plan with c = 0, how large should n be, if the AOQL is to be the same as that for the $n = 100$, $c = 2$ plan above? [4 marks]

Section B

B1.

When judged on the basis of its approach to quality management, an organisation may be broadly classed as either a *QC Organisation*, a *QA Organisation* or a *TQM organisation.* What particular feature(s) of their approaches to quality management characterise organisations belonging to each of these three general classes? [9 marks]

Joynson & Forrestor offer the opinion that ISO9000 is:

"*A paperwork system to record all the procedures to be followed within the organisation. It should in theory ensure we produce a consistent product, good or bad*"

(Joynson, S. & Forrestor, A., *Sid's Heroes*, BBC Books, 1995).

Drawing upon your knowledge of quality management systems and the ISO9000 series, produce **separate** arguments to (i)**support** and (ii)**refute** this opinion. [16 marks]

B2. (answer all five of (a) - (e) below: 5 marks in each case)

(a) Differentiate (either verbally, or by providing an appropriate examples) between so-called *attribute*, *variables* and *defect location* checksheets.

(b) List 5 pitfalls to be avoided during *brainstorming* sessions.

(c) Analysis of errors traced to a particular keypunch operator led to the following data, which details the numbers of occurrences of different types of errors:

	Date(all Feb., 2000)																
Error Type	7	8	9	10	11	14	15	16	17	18	21	22	23	24	25	28	29
typos	4	4	1	2	5	2	1	4	3	2	5	1	2	1	0	3	5
math. errors	5	2	2	6	4	1	3	0	1	0	4	1	2	0	0	2	1
missing data	0	1	1	2	2	1	0	0	2	0	2	1	3	2	1	0	1
spelling	9	10	8	5	9	8	9	11	3	6	5	7	7	11	9	10	10
wrong box	0	1	0	0	1	0	2	0	0	1	1	0	0	2	0	0	0
other	1	0	0	1	0	0	0	0	0	2	0	0	0	0	1	0	0

Construct a Pareto diagram from this data.
If you were to seek a reduction in these errors, which error type(s) would you focus initial attention on? Why?

(d) What is meant by *process* benchmarking?
How would you go about identifying an appropriate benchmark(partner) for process benchmarking?

(e) Write a short technical note under the heading "Catagorising Quality Cost Elements"

B3.

"Purchasing organisations should treat their suppliers as long-term business partners"....
....develop this point. [5 marks]

Broadly speaking, why conduct *Supplier Audits*? [2 marks]
Under what circumstances should a supplier be audited? [3 marks]

As the first Quality Manager in your organisation you have found it necessary to develop documentation/procedures for many activities. You are currently working on supplier audits, and have decided to develop a procedure which specifies the steps to be followed in the (i)preparation for, (ii)conduct of, and (iii)follow-up to, such audits. List these steps, in the order in which they will appear in your procedure. [15 marks]

B4.

(i) In a study designed to determine whether the concentration of hardwood in paper pulp influences the (average)strength of the resulting paper, six batches of pulp were prepared for each of four levels of hardwood concentration. Readings were obtained for the average strength of the resulting 24 batches of paper. These readings, in psi units, are recorded below.

	Strengths(psi)					
% hardwood	1	2	3	4	5	6
5	7	8	15	11	9	10
10	12	17	13	18	19	15
15	14	18	19	17	16	18
20	19	25	22	23	18	20

Complete the following ANOVA table and hence comment on the influence of hardwood concentration on the paper strength.

Source	d. f.	Sum of Squares	Mean Square	F-value
concentration				
error				
Total	23	513		

[15 marks]

(ii) What are *factorial* experiments? [2 marks]

Write short explanatoty notes on each of the following, in the context of the design and analysis of factorial experiments:

main effects and *interactions*
2^k *designs*
blocking/confounding
fractional factorial designs. [8 marks]