MANICALAND STATE UNIVERSITY OF APPLIED SCIENCES

FACULTY OF ENGINEERING, APPLIED SCIENCES AND TECHNOLOGY

DEPARTMENT OF APPLIED STATISTICS

OPERATIONS AND QUALITY CONTROL SYSTEMS

CODE: ASTA 413

SESSIONAL EXAMINATIONS

APRIL 2024

DURATION: 3 HOURS

EXAMINER: MR I.ZVAWANDA

INSTRUCTIONS

1. *Answer **ALL** questions from Section A*
2. *Answer any **three** questions from Section B*
3. *Total: 100 Marks*

REQUIREMENTS

Statistical tables;
Non-programmable scientific calculator

Graph paper
Quality control tables

SECTION A [40 MARKS]

Answer **ALL** Question in this Section

A1

a) Define the following terms as used in operations and quality control systems:

i. reliability; ii. acceptance sampling; iii. quality; iv. Statistical Process control.

(b)(i) The Control charts have a long history of use in industry. State and explain any five reasons for their popularity. **[2, 2, 2, 2, 10]**

A2

Consider a process monitored using an R chart with the following information in Table 1.

Table 1

Sample	R
1	4.2
2	3.9
3	2.4
4	2.2
5	3.5

The process has Upper Specification Limit (USL) and Lower Specification Limit (LSL) of 3. Find the capability of the process and interpret your answer to a layman. **[7]**

A3

Three bottling machines at Pepsi are being evaluated for their capability. The data are shown in Table 2.

Table 2

Bottling machine	Standard Deviation
A	0.05
B	0.1
C	0.2

If the specifications are set between 299.5 ml and 300.01 ml, determine which of the machines are capable of producing within the specifications? **[7]**

A4

Consider a component whose failure distribution is given by the exponential function $f(x) = \frac{1}{\beta} e^{-x/\beta}$.

Find the failure rate and show that the system have either an increasing failure rate or a decreasing failure rate**.** **[8]**

SECTION B

ANSWER ANY **THREE (3)** QUESTIONS IN THIS SECTION

B5

a) The number of weekly customer complained are members at a large Hotel. Develop a 3 sigma c chart using the following data recorded over 20 weeks. The data are shown in Table 3.

Table 3

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

b) Reliability components can be arranged into four items. Explain the four component arrangements.

c) Three subsystems are connected in series and make up as system. The subsystem has reliability as follows $R_1 = 0.99$; $R_2 = 0.98$ and $R_1 = 0.97$. What is the overall reliability of the system? **[6, 10, 4]**

B6

a) Joel Wyne's three children , John, Karen and Terry want to earn some money to take care of personal expense during a school trip to the local zoo. Mr Wyne has chosen 3 chores for his children that is mowing the lawn, painting the garage door and washing the family cars. To avoid the anticipated sibling competition, he asked them to submit secret bids for what they feel is fair pay for each of the 3 chores. The undertaking is that all 3 children will abide by their father's decision as to who get which chore. The Table 4 summarizes the bids received.

Table 4

	Mowing	**Painting**	**Washing**
John	$15	$10	$9
Karen	$9	$15	$10
Terry	$10	$12	$8

Based on this information, how should Mr Wyne assign the chores?

Hint: Apply the Hangarian Method.

b) Suppose that a series system has 2 components and that the components function independently of each other uniformly distributed over interval [0, 100]. Find:

i) the systems failure rate function;
ii) the expected life.

c) Define process capability as a critical aspect of quality control and interpret it if: i) it is less than 1; ii) it is more than 1;

iii) it is equal to 1. **[8, 3, 3, 2, 2, 2]**

B7

a) (i) Define Statistical Process Control;

ii) Outline the major tools of Statistical Process Control.

b) Consider a system of six pumps of which at least four must function properly for system success. Each pump has 85% reliability of success. What is the probability of success of the whole system? **[3, 12, 5]**

B8

a) A process is being controlled with a fraction non conforming control chart. The process average has been shown to be 0.07.The 3δ control units are used and the procedure call for taking daily samples of 400 items.

i) Calculate upper control and lower control unit;

ii) Calculate the β-risk for this process if the mean of the process shifts to 0.10.

b) A quality control inspector at Delta soft drinks company has taken 10 samples with 4 observations each of the volume of bottles filled .The data is shown in Table 5. Use this information to develop the control limits of 3 standard deviation for the bottling operation.

Table 5

Sample	1	2	3	4
1	15	16	16	15.9
2	16.1	16	15.8	16
3	16	15.9	15.9	15.8
4	16.2	15.8	15.7	15.9
5	15.7	15.8	16.2	16.1
6	15.9	16	16.1	16
7	15.8	16.2	16	15.9
8	15.8	15.9	16	15.9
9	16.0	15.9	15.8	15.9
10	15.6	15.8	15.9	15.8

[**3, 3, 14**]

END OF PAPER

Appendix VI Factors for Constructing Variables Control Charts

Observations in Sample, n	Chart for Averages: Factors for Control Limits A	A_2	A_3	Chart for Standard Deviations: Factors for Center Line c_4	$1/c_4$	Factors for Control Limits B_3	B_4	B_5	B_6	Chart for Ranges: Factors for Center Line d_2	$1/d_2$	Factors for Control Limits d_3	D_1	D_2	D_3	D_4
2	2.121	1.880	2.659	0.7979	1.2533	0	3.267	0	2.606	1.128	0.8865	0.853	0	3.686	0	3.267
3	1.732	1.023	1.954	0.8862	1.1284	0	2.568	0	2.276	1.693	0.5907	0.888	0	4.358	0	2.575
4	1.500	0.729	1.628	0.9213	1.0854	0	2.266	0	2.088	2.059	0.4857	0.880	0	4.698	0	2.282
5	1.342	0.577	1.427	0.9400	1.0638	0	2.089	0	1.964	2.326	0.4299	0.864	0	4.918	0	2.115
6	1.225	0.483	1.287	0.9515	1.0510	0.030	1.970	0.029	1.874	2.534	0.3946	0.848	0	5.078	0	2.004
7	1.134	0.419	1.182	0.9594	1.0423	0.118	1.882	0.113	1.806	2.704	0.3698	0.833	0.204	5.204	0.076	1.924
8	1.061	0.373	1.099	0.9650	1.0363	0.185	1.815	0.179	1.751	2.847	0.3512	0.820	0.388	5.306	0.136	1.864
9	1.000	0.337	1.032	0.9693	1.0317	0.239	1.761	0.232	1.707	2.970	0.3367	0.808	0.547	5.393	0.184	1.816
10	0.949	0.308	0.975	0.9727	1.0281	0.284	1.716	0.276	1.669	3.078	0.3249	0.797	0.687	5.469	0.223	1.777
11	0.905	0.285	0.927	0.9754	1.0252	0.321	1.679	0.313	1.637	3.173	0.3152	0.787	0.811	5.535	0.256	1.744
12	0.866	0.266	0.886	0.9776	1.0229	0.354	1.646	0.346	1.610	3.258	0.3069	0.778	0.922	5.594	0.283	1.717
13	0.832	0.249	0.850	0.9794	1.0210	0.382	1.618	0.374	1.585	3.336	0.2998	0.770	1.025	5.647	0.307	1.693
14	0.802	0.235	0.817	0.9810	1.0194	0.406	1.594	0.399	1.563	3.407	0.2935	0.763	1.118	5.696	0.328	1.672
15	0.775	0.223	0.789	0.9823	1.0180	0.428	1.572	0.421	1.544	3.472	0.2880	0.756	1.203	5.741	0.347	1.653
16	0.750	0.212	0.763	0.9835	1.0168	0.448	1.552	0.440	1.526	3.532	0.2831	0.750	1.282	5.782	0.363	1.637
17	0.728	0.203	0.739	0.9845	1.0157	0.466	1.534	0.458	1.511	3.588	0.2787	0.744	1.356	5.820	0.378	1.622
18	0.707	0.194	0.718	0.9854	1.0148	0.482	1.518	0.475	1.496	3.640	0.2747	0.739	1.424	5.856	0.391	1.608
19	0.688	0.187	0.698	0.9862	1.0140	0.497	1.503	0.490	1.483	3.689	0.2711	0.734	1.487	5.891	0.403	1.597
20	0.671	0.180	0.680	0.9869	1.0133	0.510	1.490	0.504	1.470	3.735	0.2677	0.729	1.549	5.921	0.415	1.585
21	0.655	0.173	0.663	0.9876	1.0126	0.523	1.477	0.516	1.459	3.778	0.2647	0.724	1.605	5.951	0.425	1.575
22	0.640	0.167	0.647	0.9882	1.0119	0.534	1.466	0.528	1.448	3.819	0.2618	0.720	1.659	5.979	0.434	1.566
23	0.626	0.162	0.633	0.9887	1.0114	0.545	1.455	0.539	1.438	3.858	0.2592	0.716	1.710	6.006	0.443	1.557
24	0.612	0.157	0.619	0.9892	1.0109	0.555	1.445	0.549	1.429	3.895	0.2567	0.712	1.759	6.031	0.451	1.548
25	0.600	0.153	0.606	0.9896	1.0105	0.565	1.435	0.559	1.420	3.931	0.2544	0.708	1.806	6.056	0.459	1.541

For $n > 25$

$$A = \frac{3}{\sqrt{n}}, \quad A_3 = \frac{3}{c_4\sqrt{n}}, \quad c_4 \simeq \frac{4(n-1)}{4n-3},$$

$$B_3 = 1 - \frac{3}{c_4\sqrt{2(n-1)}}, \quad B_4 = 1 + \frac{3}{c_4\sqrt{2(n-1)}},$$

$$B_5 \simeq c_4 - \frac{3}{\sqrt{2(n-1)}}, \quad B_6 \simeq c_4 + \frac{3}{\sqrt{2(n-1)}}.$$