NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF HEALTH AND APPLIED SCIENCES

DEPARTMENT OF MATHEMATICS AND STATISTICS

QUALIFICATION: Bachelor of science Honours and Applied and Statistics	
QUALIFICATION CODE: 08BSSH	**LEVEL:** 8
COURSE CODE: SQC801S	**COURSE NAME:** STATISTICAL QUALITY CONTROL
SESSION: JULY 2019	**PAPER:** THEORY
DURATION: 3 HOURS	**MARKS: 100**

SUPPLEMENTARY/SECOND OPPORTUNITY MEMORANDUM	
EXAMINER	Dr CR. KIKAWA
MODERATOR:	PROF SATHIYA APPUNNI

INSTRUCTIONS
1. Answer ALL the questions in the booklet provided. 2. Show clearly all the steps used in the calculations. 3. All written work must be done in blue or black ink and sketches must be done in pencil.

PERMISSIBLE MATERIALS

1. Non-programmable calculator without a cover.
2. Attachments: Table of factors for control charts, Inverse normal and standard normal tables

THIS QUESTION PAPER CONSISTS OF 5 PAGES (Including this front page)

NAMIBIA UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF MATHEMATICS AND STATISTICS
STATISTICAL QUALITY CONTROL: SQC801S

SUPPLEMENTARY/SECOND OPPORTUNITY EXAMINATION: JULY 2019

Time-3 Hrs **Attempt all Questions** **Maximum Marks - 100**

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1. **Question (20 marks)**

   (a) Outline the guidelines for Implementing Control Charts **(10 marks)**

   (b) Explain any five considerations under which the $\bar{x}$ and R variable control charts may be used. **(5 marks)**

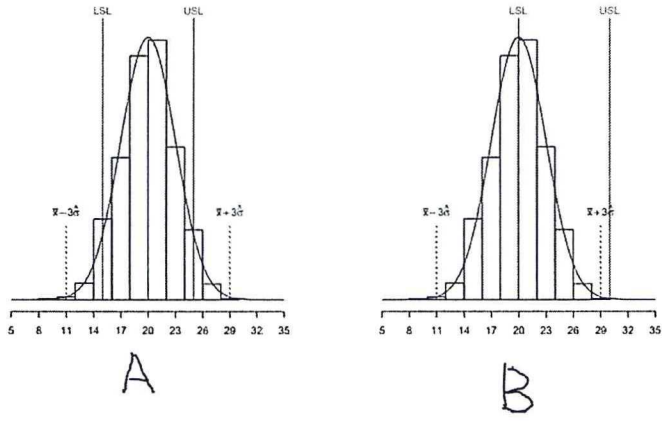
   (c) Describe five considerations under which the p-charts, c-charts, and u-charts as attribute control charts may be used. **(5 marks)**

2. **Question (20 marks)**

(a) Define the following concepts as employed in process and measurement management capability analysis; (a) quality; (b) quality management system; (c) Process capability; (d) Specification. **(8 marks)**

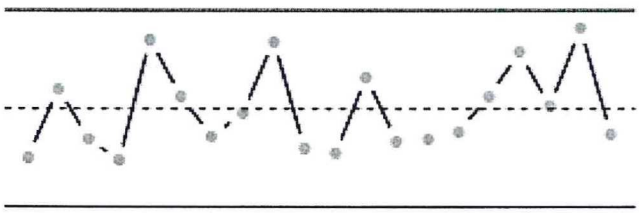
(b) Study the processes in Figure 1 and note that, the two distributions have the same characteristics as far as shape, position and dispersion are concerned. The limit spread is the same. Required to discuss their capabilities. **(4 marks)**

Figure 1: Process Capability Analysis



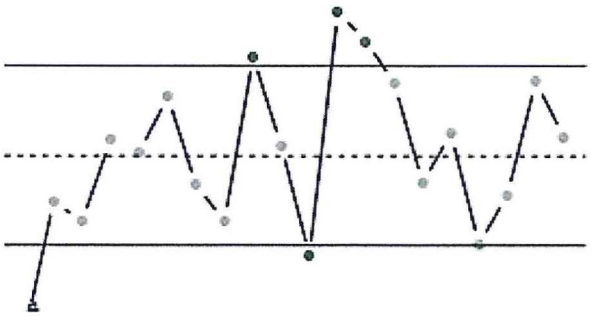
(c) Based on Figure 2 which is a result of the process in Figure 1 comment on the statistical control of the process and its capability. **(4 marks)**

Figure 2: Control chart



(d) Based on Figure 3 which is a result of the process in Figure 1 comment on the statistical control of the process and its capability. **(4 marks)**

Figure 3: Control chart



3. **Question (20 marks)**

(a) Summarize the steps for creating a CUSUM chart as stated by Ryan (2011). **(10 marks)**

(b) Consider an in control ARL (ARL_0), and that the actual process is in control, that is H_0 is true. You are required to prove that;

$$ARL_0 = \frac{1}{\alpha},$$

that is, α=p[a shewhart chart signals on a given sample-H_0 is true] **(10 marks)**

4. **Question (20 marks)**

(a) Suppose m samples are available each containing n observations on the quality characteristics. Typically n will be small. Now, if we have $\{\bar{x}_1, \bar{x}_2, ..., \bar{x}_m\}$ as the average of each sample, the best estimator for μ, is the grand average.
Describe the steps for constructing the control limits for the $\bar{x}$-chart for process monitoring using the range method. **(12 marks)**

(b) A hard-bake process is used in conjunction with photo-lithography in semiconductor manufacturing. We wish to establish statistical control of the flow width of the resist in this process using $\bar{x}$ and R charts. All parameters concerning the collected data were duly computed. Assuming that the flow width is a normally distributed random variable, with $\mu = 1,5056$ and $\sigma = 0.1398$, the specification limits on the flow width are 1.50 ± 0.5microns. The control chart may be used to describe the capability of the process to produce wafers relative to the specifications. You are required to estimate the fraction of nonconforming, p, wafers produced in the process using

$$p = Pr\{x < 1.00\} + Pr\{x > 2.00\}$$

(8 mark)

5. **Question (20 marks)**

(a) A cement consignment of N=25 contains 3 non-conforming units. What is the probability that a sample of five units selected at random contains one or more non-conformances **(5 marks)**

(b) Surface-finish defects in a small electric appliance occur at random with a mean rate of 0.2 defects per unit. Find the probability that a randomly selected unit will contain at least one surface-finish defect. **(5 marks)**

(c) If four samples (items) are chosen from a population with a defective rate of 0.1, what is the probability that;
(a) exactly one of the items is defective
(b) at most one is defective **(5 marks)**

(d) The tensile strength of a metal part is normally distributed with mean 40 lb and a standard deviation of 5 lb. If 50 000 parts are produced, how many would you expect to fail to meet a minimum specification limit of 35 lb tensile strength? **(5 marks)**

END

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 Averages: Factors for Center Line c_4	$1/c_4$	Chart for Standard Deviations: Factors for Control Limits B_3	B_4	B_5	B_6	Chart for Ranges: Factors for Center Line d_2	$1/d_2$	Chart for Ranges: 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	2.574
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	2.114
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 $n > 25$.

$$A = \frac{3}{\sqrt{n}} \qquad A_3 = \frac{3}{c_4\sqrt{n}} \qquad c_4 \cong \frac{4(n-1)}{4n-3}$$

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

$$B_5 = c_4 - \frac{3}{\sqrt{2(n-1)}} \qquad B_6 = c_4 + \frac{3}{\sqrt{2(n-1)}}$$

Table 5 Normal distribution — inverse cumulative distribution function

0.50	0.0000	0.60	0.2533	0.70	0.5244	0.80	0.8416	0.90	1.2816	0.99	2.3263
0.51	0.0251	0.61	0.2793	0.71	0.5534	0.81	0.8779	0.91	1.3408	0.991	2.3656
0.52	0.0502	0.62	0.3055	0.72	0.5828	0.82	0.9154	0.92	1.4051	0.992	2.4089
0.53	0.0753	0.63	0.3319	0.73	0.6128	0.83	0.9542	0.93	1.4758	0.993	2.4573
0.54	0.1004	0.64	0.3585	0.74	0.6433	0.84	0.9945	0.94	1.5548	0.994	2.5121
0.55	0.1257	0.65	0.3853	0.75	0.6745	0.85	1.0364	0.95	1.6449	0.995	2.5758
0.56	0.1510	0.66	0.4125	0.76	0.7063	0.86	1.0803	0.96	1.7507	0.996	2.6521
0.57	0.1764	0.67	0.4399	0.77	0.7388	0.87	1.1264	0.97	1.8808	0.997	2.7478
0.58	0.2019	0.68	0.4677	0.78	0.7722	0.88	1.1750	0.975	1.9600	0.998	2.8782
0.59	0.2275	0.69	0.4958	0.79	0.8064	0.89	1.2265	0.98	2.0537	0.999	3.0902

STANDARD NORMAL DISTRIBUTION: Table Values Represent AREA to the LEFT of the Z score.

Z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.50000	.50399	.50798	.51197	.51595	.51994	.52392	.52790	.53188	.53586
0.1	.53983	.54380	.54776	.55172	.55567	.55962	.56356	.56749	.57142	.57535
0.2	.57926	.58317	.58706	.59095	.59483	.59871	.60257	.60642	.61026	.61409
0.3	.61791	.62172	.62552	.62930	.63307	.63683	.64058	.64431	.64803	.65173
0.4	.65542	.65910	.66276	.66640	.67003	.67364	.67724	.68082	.68439	.68793
0.5	.69146	.69497	.69847	.70194	.70540	.70884	.71226	.71566	.71904	.72240
0.6	.72575	.72907	.73237	.73565	.73891	.74215	.74537	.74857	.75175	.75490
0.7	.75804	.76115	.76424	.76730	.77035	.77337	.77637	.77935	.78230	.78524
0.8	.78814	.79103	.79389	.79673	.79955	.80234	.80511	.80785	.81057	.81327
0.9	.81594	.81859	.82121	.82381	.82639	.82894	.83147	.83398	.83646	.83891
1.0	.84134	.84375	.84614	.84849	.85083	.85314	.85543	.85769	.85993	.86214
1.1	.86433	.86650	.86864	.87076	.87286	.87493	.87698	.87900	.88100	.88298
1.2	.88493	.88686	.88877	.89065	.89251	.89435	.89617	.89796	.89973	.90147
1.3	.90320	.90490	.90658	.90824	.90988	.91149	.91309	.91466	.91621	.91774
1.4	.91924	.92073	.92220	.92364	.92507	.92647	.92785	.92922	.93056	.93189
1.5	.93319	.93448	.93574	.93699	.93822	.93943	.94062	.94179	.94295	.94408
1.6	.94520	.94630	.94738	.94845	.94950	.95053	.95154	.95254	.95352	.95449
1.7	.95543	.95637	.95728	.95818	.95907	.95994	.96080	.96164	.96246	.96327
1.8	.96407	.96485	.96562	.96638	.96712	.96784	.96856	.96926	.96995	.97062
1.9	.97128	.97193	.97257	.97320	.97381	.97441	.97500	.97558	.97615	.97670
2.0	.97725	.97778	.97831	.97882	.97932	.97982	.98030	.98077	.98124	.98169
2.1	.98214	.98257	.98300	.98341	.98382	.98422	.98461	.98500	.98537	.98574
2.2	.98610	.98645	.98679	.98713	.98745	.98778	.98809	.98840	.98870	.98899
2.3	.98928	.98956	.98983	.99010	.99036	.99061	.99086	.99111	.99134	.99158
2.4	.99180	.99202	.99224	.99245	.99266	.99286	.99305	.99324	.99343	.99361
2.5	.99379	.99396	.99413	.99430	.99446	.99461	.99477	.99492	.99506	.99520
2.6	.99534	.99547	.99560	.99573	.99585	.99598	.99609	.99621	.99632	.99643
2.7	.99653	.99664	.99674	.99683	.99693	.99702	.99711	.99720	.99728	.99736
2.8	.99744	.99752	.99760	.99767	.99774	.99781	.99788	.99795	.99801	.99807
2.9	.99813	.99819	.99825	.99831	.99836	.99841	.99846	.99851	.99856	.99861
3.0	.99865	.99869	.99874	.99878	.99882	.99886	.99889	.99893	.99896	.99900
3.1	.99903	.99906	.99910	.99913	.99916	.99918	.99921	.99924	.99926	.99929
3.2	.99931	.99934	.99936	.99938	.99940	.99942	.99944	.99946	.99948	.99950
3.3	.99952	.99953	.99955	.99957	.99958	.99960	.99961	.99962	.99964	.99965
3.4	.99966	.99968	.99969	.99970	.99971	.99972	.99973	.99974	.99975	.99976
3.5	.99977	.99978	.99978	.99979	.99980	.99981	.99981	.99982	.99983	.99983
3.6	.99984	.99985	.99985	.99986	.99986	.99987	.99987	.99988	.99988	.99989
3.7	.99989	.99990	.99990	.99990	.99991	.99991	.99992	.99992	.99992	.99992
3.8	.99993	.99993	.99993	.99994	.99994	.99994	.99994	.99995	.99995	.99995
3.9	.99995	.99995	.99996	.99996	.99996	.99996	.99996	.99996	.99997	.99997