GENERAL SIR JOHN KOTELAWALA DEFENCE UNIVERSITY

Faculty of Engineering

Department of Mathematics

BSc Engineering Degree

Semester 5th Examination – April 2021

(Intake 36 – All steams)

MA 3102 – APPLIED STATISTICS

Time allowed: **2 (Two)** hours 05th April, 2021

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ADDITIONAL MATERIAL PROVIDED

Statistical tables are provided

INSTRUCTIONS TO CANDIDATES

This paper contains 4 questions on 7 pages

Answer **all** questions

This is a closed book examination

This examination accounts for 70% of the module assessment. A total maximum mark obtainable is 100. The marks assigned for each question and parts thereof are indicated in square brackets

If you have any doubt as to the interpretation of the wordings of a question, make your own decision, but clearly state it on the script

Assume reasonable values for any data not given in or provided with the question paper, clearly make such assumptions made in the script

All examinations are conducted under the rules and regulations of the KDU

Question 1

(a) Define the term **"sampling distribution"**.

[4 marks]

(b) Let $\bar{X}$ be the mean of a random sample of size n from a normal distribution $N(\mu,9)$. Find n such that $P(\bar{X} - 1 < \mu < \bar{X} + 1) = 0.90$.

[7 marks]

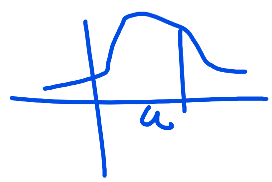
(c) The life in hours of a 75-watt light bulb is known to be normally distributed with $\sigma=25$ hours. A random sample of 20 bulbs has a mean life of $\bar{X}$ =1014 hours. .

(i) Construct a 95% two-sided confidence interval for the mean life of light bulb.

[7 marks]

(ii) Suppose the width of the two-sided confidence interval for mean life to be six hours at 95% confidence. What sample size should be used?

[7 marks]



Question 2

(a) Two machines are used for filling plastic bottles with a net volume of 16.0 ounces. The fill volume can be assumed normally distributed, with standard deviation σ_1 = 0.020 and σ_2 = 0.025 ounces. A member of the quality engineering staff suspects that both machines fill to the same mean net volume, whether or not this volume is 16.0 ounces. A random sample of 10 bottles is taken from the output of each machine.

n=10

Machine 1		Machine 2	
16.03	16.01	16.02	16.03
16.04	15.96	15.97	16.04
16.05	15.98	15.96	16.02
16.05	16.02	16.01	16.01
16.02	15.99	15.99	16.00

(i) Write the appropriate null and alternative hypothesis based on engineer's claim.
[3 marks]

(ii) Select the appropriate test statistic and calculate the test value.
[3 marks]

(iii) Test the hypothesis for 0.05 significance level.
[3 marks]

(iv) Make the conclusion.
[3 marks]

(b) Two chemical companies can supply a raw material. The concentration of a particular element in this material is important. The mean concentration for both suppliers is the same, but we suspect that the variability in concentration may differ between the two companies. The standard deviation of concentration in a random sample of $n_1 = 10$ batches produced by company 1 is $s_1 = 4.7$ grams per liter, while for company 2, a random sample of $n_2 = 16$ batches yields $s_2 = 5.8$ grams per liter. Is there sufficient evidence to conclude that the two population variances differ? Use 0.05 significance level.

[13 marks]

Question 3

(a) Consider the following distribution of battery lives (in months). Does it possible to approximate battery lives by normal distribution? Use $\alpha = 0.05$.

mp(x) = 1.7 2.2 2.7 3.2 3.7 4.2 4.7

Class boundaries	1.45- 1.95	1.95- 2.45	2.45- 2.95	2.95- 3.45	3.45- 3.95	3.95- 4.45	4.45- 4.95
Frequency	2	1	4	15	10	5	3

[10 marks]

$\bar{x} = 3.4125$

$\sigma = 0.658$

$Z = \frac{X - \mu}{\ }$

(b) A company operates four machines three shifts each day. From production records, the following data on the number of breakdowns are collected:

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Shift	Machines			
	A	B	C	D
1	41	20	12	16
2	31	11	9	14
3	15	17	16	10

Test the hypothesis (using $\alpha = 0.05$) that breakdowns are independent of the shift.

[15 marks]

Question 4

$H_0 = \mu_1 = \mu_2 = \ldots \mu_k$

(a) The tensile strength of a synthetic fiber is of interest to the particular manufacturer. It is suspected that strength is related to the percentage of cotton in the fiber. Five levels of cotton percentage are used, and five replicates are run in random order, resulting in the data below.

$H_1 = \boxed{\mu_1 \neq \mu_2 \ldots \mu_k}$

$k = 5$

Cotton Percentage	Observations					
	1	2	3	4	5	
15	7	7	15	11	9	T_1 ~~22~~ 49
20	12	17	12	18	18	T_2 ~~88~~ 77
25	14	18	18	19	19	T_3 88
30	19	25	22	19	23	T_4 108
35	7	10	11	15	11	T_5 54

$T = 376$

(i) Fill the missing values of following **ANOVA** table for **strength** .

Source of variation	Degree of freedom **DF**	Sum of square **SS**	Mean square **MS**	**F-ratio**
Cotton		475.76		
Sampling error		161.20		N/A
Total		636.96	N/A	N/A

[6 marks]

(ii) Perform an analysis of variance. Use $\alpha = 0.05$.

[6 marks]

(b) The pull strength of a wire-bonded lead for an integrated circuit monitored. The following table provides data for 20 samples which each of size three.

Sample number	x_1	x_2	x_3
1	15.4	15.6	15.3
2	15.4	17.1	15.2
3	16.1	16.1	13.5
4	13.5	12.5	10.2
5	18.3	16.1	17.0
6	19.2	17.2	19.4
7	14.1	12.4	11.7
8	15.6	13.3	13.6
9	13.9	14.9	15.5

10	18.7	21.2	20.1
11	15.3	13.1	13.7
12	16.6	18.0	18.0
13	17.0	15.2	18.1
14	16.3	16.5	17.7
15	8.4	7.7	8.4
16	11.1	13.8	11.9
17	16.5	17.1	18.5
18	18.0	14.1	15.9
19	17.8	17.3	12.0
20	11.5	10.8	11.2

(i) Determine the **central line** and **control limits** (UCL and UCL) for $\bar{X}$ and R charts.

[6 marks]

(ii) Plot $\bar{X}$ and R charts.

[4 marks]

(iii) Identify out of control points from from each charts in (ii) separately.

[3 marks]

---------------------End of the question paper------------------------