0342

The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mathematics and Philosophy of Engineering

Study Programme	:	Bachelor of Industrial Studies Honours
Name of the Examination	:	Final Examination
Course Code and Title	:	**MHZ3576 Statistics for Industrial Studies**
Academic Year	:	2024/25
Date	:	27th January 2026
Time	:	0930-1230h
Duration	:	3 hours

General instructions

REGISTRATION NO:

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- ***Part A is Compulsory***
  - *Provide short answers in the given space.*
  - *Do not need to show any workings.*
- *Answer **five (05)** questions only out of seven (07) questions from **Part B**.*
  - *Provide answers in separate sheets (answer booklet) which will be provided in the examination.*
  - *Show all your workings.*
- *The number of pages in the paper is **Eight (08)**.*
- *All the symbols are in standard notation unless they are defined.*
- *All the relevant statistical tables and equations are provided.*
- *You are allowed to use a non-programmable calculator during the examination.*
- ***Attach Part A to the Answer script of Part B.***
- *Answer for each question should commence from a new page.*
- *This is a Closed Book Test (CBT).*

Part A

Provide short answers in the given space. Do not need to show any workings or work. Please attach this part to your answer script.

1. In a textile factory, there are 4 fabric quality inspectors and 3 dye technicians. Two workers are randomly selected, one after the other, without replacement. Write down the sample space for the selection.

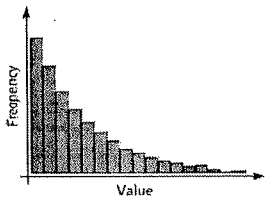
   Answer: .....

2. Let E and F be two independent events such that $P(E) = 0.4$ and $P(E \cup F) = 0.7$. Find $P(F)$.

   Answer: .....

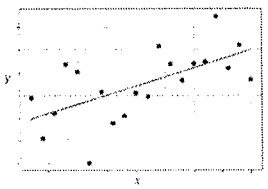
3. State the shape of the distribution represented by the following histogram.

   Answer: .....



4. Based on the given scatter plot, describe the nature of the relationship between the variables x and y.

   Answer:.....



5. A textile inspector aims to determine the tear strength of fabric bundles. He categories fabric rolls into silk, cotton, and polyester, then randomly selects rolls from each category for tear strength testing. State the sampling method employed in this context.

   Answer: .....

6. If the probability of selecting a stained fabric is 0.2, the probability of selecting a non-stained fabric is,

   Answer: .....

7. In an experimental design of the effect of a new dye on fabric color, the batch of fabric that receives the new dye treatment is called the,

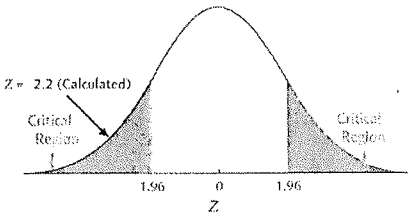
   Answer: .....

8. A quality inspector at a garment factory inspects fabric rolls for defects. If the number of rolls he needs to inspect before finding a defective one follows a geometric distribution with parameter p. Obtain the mean of the distribution.

   Answer: .....

9. State the decision that can be made according to the position of calculated and critical Z values as displayed in the graph when doing hypothesis testing.

   Answer: .....



10. In hypothesis testing, the probability of failing to reject H_0 when it is false is called,

    Answer: .....

Part B

Q1.

(a) Consider the following extract from quality inspection log maintained at Trendy Accessories (Pvt) Ltd.

Quality inspection log-Trendy Accessories

Item No	*Accessory Type*	*Color*	*Number of Defects*	*Defect severity*
A100	Scarf	Red	2	Minor
A101	Belt	Black	1	Minor
A102	Hat	Blue	5	Major
A103	Gloves	White	0	None
A104	Handbag	Brown	3	Moderate

(i) Determine the type of data and scale of the measurement associated with each of the following variables in the above quality inspection log.

(12 marks)

	Type of data	*Scale of measurement*
Accessory Type	.....	.....
Color	.....	.....
Number of Defects	.....	.....

(ii) Suppose you are the quality control officer at Trendy Accessories. Based on the defect severity levels recorded, propose a simple coding scheme to quantify defect severity for further statistical analysis.

(05 marks)

Defect Severity	*Suggested Code*
None	.....
Minor	.....
Moderate	.....
Major	.....

(iii) Then identify the scale of measurement associated with the coded variable in part (ii) and suggest the best statistical summary for central tendency to use on this variable.

(08 marks)

(b) A garment manufacturing company aims to analyses the thread waste generated in three sewing units (Unit A, Unit B, and Unit C) during the course of one production week. The factory utilizes two distinct varieties of thread:

Cotton Thread (Environmentally Friendly)

Polyester Thread (Synthetic Fiber)

At the end of the week, supervisors record kilograms of thread waste from each unit.

Thread waste

Unit	Cotton Thread Waste (Kg)	Polyester Thread Waste (Kg)
A	12	24
B	15	18
C	10	30

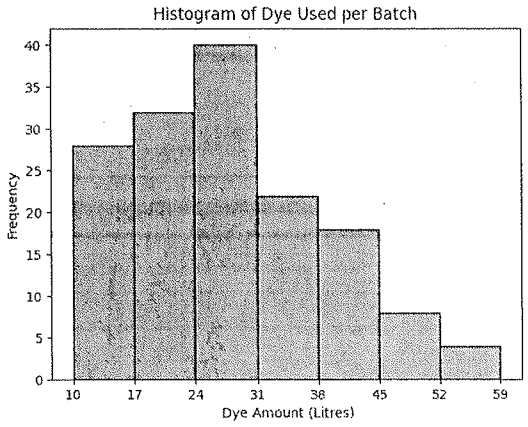
Company aims to reduce polyester waste by 25% as part of its commitment to reduce microplastic pollution.

(i) Draw a suitable graph to compare waste across units. **(15 marks)**

(ii) Explain the differences in waste production among each unit. **(10 marks)**

(iii) Identify which Unit must reduce the most polyester waste and by how many kilograms. **(15 marks)**

(c) A fabric printing plant monitored the amount of dye consumed per batch for one week. A sample of 152 printed fabric batches was recorded and summarized in the histogram below.



(i) Comment about the shape of the distribution of the data. **(10 marks)**

(ii) Draw the frequency polygon corresponding to the histogram. **(15 marks)**

(iii) Determine the total number of batches that were used between 24 and 45 liters of dye. **(10 marks)**

Q2.

The following stem-and-leaf diagram shows the defect counts per 100 meters of fabric inspected from 21 different fabric rolls at Royal Waves Company. Each number represents the number of defects per roll, where the stem is the tens digit and the leaf is the units digit.

Stem	*Leaf*
0	1 1 2 2 3 4
1	0 1 1 1 2 5 5
2	3 3 4
3	5 6
4	8
5	9
6	9

(a) Find the Central Tendency measures (Mean, Median, Mode) of the given data. **(25 marks)**

(b) The company is interested in determining the defect levels that divide the distribution into four equal groups, so they can focus on the best performing and worst performing sections. Find the defects counts at these dividing points. **(30 marks)**

(c) Obtain the inter quartile range of the defect counts by using the results obtained in part (b). **(10 marks)**

(d) Construct a box and whisker plot to represent the given data, clearly indicating the presence of any outliers. **(25 marks)**

(e) State, giving a reason for which measure of central tendency, you would recommend summarizing this data. **(10 marks)**

Q3.

(a) At Pure Style Fashions, a quality control (QC) inspector inspects a batch lot of 150 denim jackets before shipment. According to the company's statistics, the probability of a jacket having loose threads is 0.05, while the probability of a jacket having button defects is 0.03. Assuming loose threads and button defects occur independently,

(i) Obtain the probability that a jacket has both defects. **(15 marks)**

(ii) Calculate the probability that a jacket has at least one defect. **(15 marks)**

(iii) Determine the expected number of jackets (out of 150) that will have at least one defect. **(10 marks)**

(b) At Silver Thread Garments, the screen-printing department applies patterns to T-shirts. During printing, ink smudges may occur on garments. Past records show that the average number of ink smudges is ***3 per 6 – hour shift.*** If smudges are assumed to occur randomly and independently,

(i) Determine the rate (λ) of smudges per hour. **(10 marks)**

(ii) Compute the probability of no smudges during a one-hour period. **(25 marks)**

(iii) State the probability distribution which you used to find the probability in part (ii). **(15 marks)**

(iv) Calculate the probability of exactly 2 smudges in a 6-hour shift. **(10 marks)**

Q4.

(a) Runway Footway manufactures sneaker soles from molded rubber. The soles are supposed to weigh $255g$, but actual weights range is due to variations in rubber injection. According to the production data, sole weights follow a normal distribution with a mean of $255g$ and a standard deviation of $10g$

(i) If the acceptable range is $245g$ to $255g$, what proportion of sneaker soles will meet this requirement. **(30 marks)**

(ii) If the acceptable range is to $240g$, what proportion of sneaker soles will meet this requirement. **(30 marks)**

(b) The following data represents the average stich length (in *mm*) and the range obtained from five samples, each of size 6 taken from a circular knitting machine.

Sample No	***1***	***2***	***3***	***4***	***5***
Average stitch length(mm)	2.85	2.92	2.88	2.90	2.97
Range(mm)	0.12	0.18	0.14	0.16	0.20

(i) Construct the mean control chart for stitch length by calculating ***Central Line, Upper Control Limit, Lower Control Limit.*** **(20 marks)**

(ii) State the conclusion about the knitting process stability based on the control charts. **(20 marks)**

Q5.

(a) Comfort Fabrics Ltd manufactures cotton blouses. Following the initial wash, the fabric's percentage shrinkage is assessed to verify quality. A random sample of ten blouses is examined, and the corresponding shrinkage percentages are documented.

Shrinkage (%) readings	2.1	1.8	2.4	2.0	1.9	2.3	2.2	1.7	2.0	2.1

(i) Determine the best estimate for the population mean shrinkage.

(25 marks)

(ii) Obtain the best estimate for population variance. **(25 marks)**

(b) A factory evaluates the tensile strength (measured in N) of polyester thread spools. One hundred twenty thread spools were chosen at random for testing and findings revealed that the average breaking load was $85N$ and standard deviation was $4N$.

(i) Find the standard error of the estimation of population mean breaking load.

(15 marks)

(ii) Obtain the interval estimate for the population mean breaking load at 5% significant level. **(30 marks)**

(iii) Interpret your result. **(05 marks)**

Q6.

A Luxury Weave Ltd manufactures premium wool coats. Historically, the average fabric used per coat is $1220g$, with a known population standard deviation of $30g$. The production team is introducing a new cutting machine, claiming it will reduce the average fabric weight per coat to improve efficiency without compromising quality. To test this claim, a random sample of 150 coats produced by the new machine is measured, and the average fabric weight is found to be $1185g$.

(i) State the null hypotheses and alternative hypotheses for testing the claim.

(20 marks)

(ii) Find the test statistics associated with this hypothesis testing.

(30 marks)

(iii) At the **1% significance level**, determine whether the claim that the new cutting machine reduces fabric weight is supported. **(30 marks)**

(iv) State your conclusion regarding the hypothesis and comment on the claim. **(20 marks)**

Q7.

(a) Define the term correlation coefficient. **(10 marks)**

(b) A garment factory wants to assess whether machine breakdown time is affecting their production output. The data below shows the total hours of machine downtime, and the number of garments produced over 5 consecutive weeks.

Number of advertising campaigns	5	8	6	9	7	10	4	11
Sales increase (in rupees)	5000	15000	6000	18000	8000	20000	3000	22000

(i) Identify the independent variable and the dependent variable. **(10 marks)**

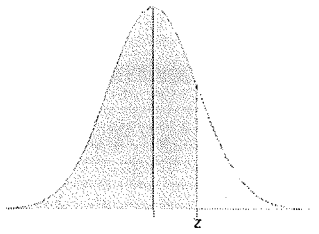
(ii) Calculate the correlation coefficient for the above data and interpret it. **(30 marks)**

(iii) Find the coefficient of determination. **(20 marks)**

(iv) Draw the scatter plot for the dependent variable against the independent variable. **(20 marks)**

(v) What conclusion can you draw from the plot? **(10 marks)**

Standard Normal Cumulative Probability Table



Cumulative probabilities for POSITIVE z-values are shown in the following table:

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998

Important formulas:

- $\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$
- $s^2 = \frac{\sum_{i=1}^{n} x_i{}^2 - \left(\sum_{i=1}^{n} x_i\right)^2 / n}{n-1}$
- Binomial Distribution

$$P[X = x] = \frac{n!}{x!(n-x)!} p^x q^{n-x}; for\ x = 0,1,2, \dots, n$$

- Poisson Distribution

$$P[X = x) = \frac{e^{-\lambda}\lambda^x}{x!}; for\ x = 0,1,2, \dots$$

- Geometric Distribution

$$P[X = x] = (1-p)^{x-1}p; for\ x = 1,2,3, \dots$$

- If a random variable X follows a normal distribution, $X \sim N(\mu, \sigma^2)$ then $\frac{X-\mu}{\sigma}$ follows a standard normal distribution where $Z \sim N(0, 1^2)$.
- $UCL = \bar{x} + A\bar{R} and\ LCL = \bar{x} - A\bar{R}\ or$
- $UCL = \bar{x} + 3\sigma\sqrt{n}\ and\ LCL = \bar{x} - \bar{x} + 3\sigma\sqrt{n}$
- $r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$

Factors useful in the construction of a control chart

Number of items in the sample	*Chart for averages*	*Chart for ranges*		
n	*Factors for control limit*	*Factors for central line*	*Factors for control limit*	
	A	d_2	D_3	D_4
2	1.880	1.128	0	3.266
3	1.023	1.693	0	2.574
4	0.729	2.059	0	2.281
5	0.577	2.326	0	2.114