NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCES

DEPARTMENT OF STATISTICS AND OPERATIONS RESEARCH

SORS4208: STATISTICAL QUALITY CONTROL AND RELIABILITY

BSc. OPERATIONS RESEARCH and STATISTICS: Part IV

MARCH 2025 EXAMINATION

Time: 3 Hours

Candidates should attempt **ALL** questions from Section A and **ANY THREE** questions from Section B. Each question should start on a fresh page.

TOTAL MARKS: 100

SECTION A [40 marks]

A1. Write short notes on the following terms:

(a) Quality,
(b) Statistical Process Control,
(c) Process capability,
(d) Reliability function. [10]

A2. In a certain bottling industry, the quality control inspector recorded the weight of each of the 5 bottles selected at random during each hour of four hours in the morning. Recorded information is shown in Table 1.

Table 1: Weights of bottles in ml

Time	Weights in ml				
0800	43	41	42	43	41
0900	40	39	40	39	44
1000	42	42	43	38	40
1100	39	43	40	39	42

Construct the appropriate control chart for quality control inspector and determine whether the process is in control. [10]

A3. State the difference between reliability and quality. [5]

A4. The time to wear for a cutting tool is distributed normally with a mean of 2.8hour and standard deviation of 0.6 hour. Find:

    (a)   the probability that the tool will wear out in 1.5 hours,   [5]

    (b)   find out the reliability for 1.5 hours, and   [5]

    (c)   how often the cutting edge of the tool must be replaced in order to keep the failure less than 10 percent?   [5]

SECTION B

Attempt any **THREE** questions from this section [60 marks]

B5.   A control chart for the number nonconforming is to established, based on samples of size 400. To start the control chart, 30 samples were selected and the number nonconforming in each sample determined, yielding:

$$\sum_{i=1}^{30} D_i = 1200.$$

    (a)   What are the parameters of the *np* chart?   [5]

    (b)   Suppose the process average fraction nonconforming shifted to 0.15. What is the probability that the shift would be detected on the first subsequent sample?   [5]

    (c)   Find the average run length (ARL) to detect a shift to a fraction nonconforming of 0.15.   [10]

B6.   A time to failure distribution is given by a uniform distribution:

$$f(t) = \begin{cases} \dfrac{1}{\beta - \alpha}, & \alpha \leq t \leq \beta. \\ 0, & otherwise. \end{cases}$$

    (a) Determine the reliability function.   [10]

    (b) Determine the hazard function.   [5]

    (c) Show that:

$$R(t) = e^{-\int H(t)dt}, \quad where \quad H(t) = \frac{f(t)}{R(t)}.$$
         [5]

B7.   Samples of *n=4* items are taken from a manufacturing process at regular intervals. A normally distributed quality characteristic is measured and $\overline{X}$ and S values are calculated for each sample. After 50 subgroups have been analysed, we have:

$$\sum_{i=1}^{50} \overline{X_i} = 1000 \text{ and } \sum_{i=1}^{50} S_i = 72 .$$

(a) Compute the control limits for the $\overline{X}$ and S control charts.   [5]
(b) Assume that all points on both charts plot within the control limits. What were the natural tolerance limits of the process?   [10]
(c) If the specifications limits are 19 ± 4.0, what are your conclusions regarding the ability of the process to produce items conforming to specifications?   [5]

B8. a) With an aid of an example, explain *memorylessness property* of a component as applied in reliability.   [5]

   b) Explain the term mean time to failure (MTTF)   [5]

   c) Find out the reliability of the following system in Figure 1 with 1,2,3,4,5 and 6 as 0.85,0.90, 0.95,0.90,0.80 and 0.85, respectively.   [10]
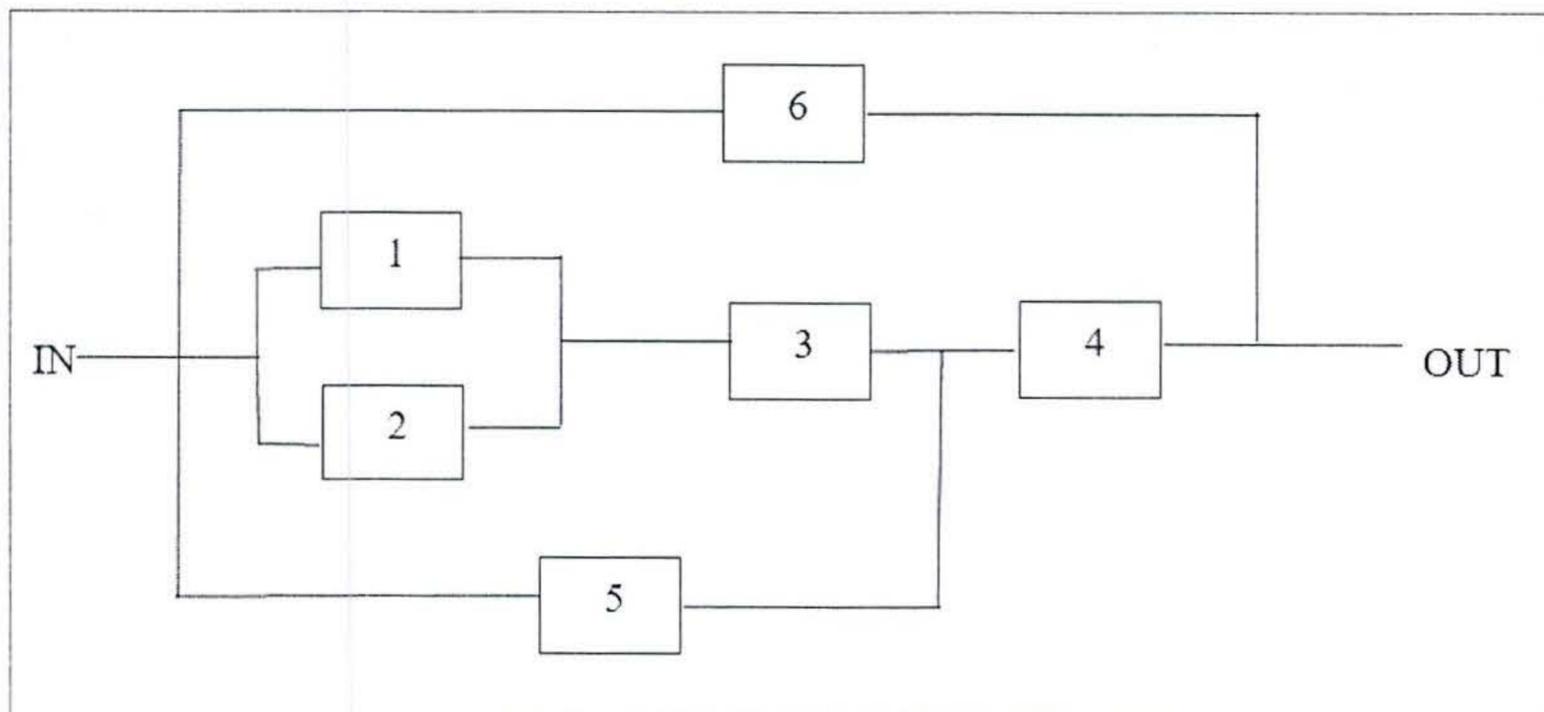

Figure 1: Arrangement of components

END OF QUESTION PAPER