(13)

**Program:** B. Sc. in IPE (6th Semester)

**Date:** 20th May, 2024
**Time:** 10:00 AM– 1:00 PM

# ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

## DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

**Semester Final Examination**
**Course Number:** IPE 4605
**Course Title:** Quality Control and Management

**Summer Semester:** 2022 - 2023
**Full Marks:** 150
**Time:** 3 Hours

There are **6 (Six)** questions. Answer **all** of them. The symbols have their usual meanings. Marks of each question and corresponding CO and PO are written in brackets. Assume reasonable value for any missing data.

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**1. a.** Which chart is preferable between $\bar{X}$ - R and $\bar{X}$ - S chart? List and explain at least three advantages of control charts. **(2+3=5) (CO2) (PO2)**

**b.** A furniture manufacturer and its customer have decided to adopt the double sampling plan as a quality control measure for their products. Their sampling plan consists of the following: **(15) (CO2) (PO2)**

Lot size, N = 4000

First Sample size, $n_1 = 50$ First trial acceptance number, $c_1 = 3$

Second Sample size, $n_2 = 90$ Second trial acceptance number, $c_2 = 5$

Find the total probability of acceptance in the combined first and second sample for. fraction non-conforming value, p = 0.05 and 0.1.

**c.** A toy buyer agrees with the manufacturer to follow a Sequential sampling plan having the following parameters (having usual meanings). **(10) (CO2) (PO2)**

$\alpha = 0.06$, $\beta = 0.12$

$p_1 = 0.02$, $p_2 = 0.1$

i. Compute and write the Acceptance limit line equation and Rejection limit line equation.

ii. If the 10th and 30th unit drawn are non-conforming, should the lot be accepted or rejected? Show using a rough plot.

**2. a.** A toy manufacturer produces tennis balls with a target diameter of 20 mm. From the past records it has been found that the standard deviation of diameter of the balls is 0.2 mm. As a part of statistical quality control, samples of size 8 are taken everyday. The mean diameter was obtained as 20.2 mm. Probability of type I error (or level of significance $\alpha$) is specified as 0.06. **(10) (CO2) (PO2)**

i. Use Hypothesis testing to determine if the process mean really shifted?

ii. Calculate the value of type II error, $\beta$.

**b.** In a discrete parts manufacturing company, data was collected from a lathe machine, regarding diameter of a cylindrical component. The first ten samples were collected in 10 days, after which the machine was set up again after lubrication. Then another ten samples were collected in the next ten days. The measured diameters of twenty samples are recorded in the Table below. **(20) (CO2) (PO2)**

Given that the target mean value was **11 mm** and the standard deviation was **1mm**:

i. Copy and complete the table.
ii. Construct a **$\bar{X}$ chart** followed by a **CUSUM chart** and differentiate the performance between them.

***Table: Data collected from Lathe Machine***

| Sample i | $X_i$ | Sample deviation | Cumulative Sample deviation | Sample i | $X_i$ | Sample deviation | Cumulative Sample deviation |
|---|---|---|---|---|---|---|---|
| 1 | 11.2 | | | 11 | 11.71 | | |
| 2 | 10.77 | | | 12 | 11 69 | | |
| 3 | 10.27 | | | 13 | 12.13 | | |
| 4 | 11.29 | | | 14 | 11.11 | | |
| 5 | 10.29 | | | 15 | 10.51 | | |
| 6 | 11.27 | | | 16 | 11.8 | | |
| 7 | 12.31 | | | 17 | 9.72 | | |
| 8 | 11.19 | | | 18 | 12.23 | | |
| 9 | 10.28 | | | 19 | 11.92 | | |
| 10 | 11.13 | | | 20 | 11.02 | | |

**3. a.** Suppose you are a production manager at a manufacturing plant that produces automotive components. Your plant is facing challenges with equipment downtime, quality issues, and inefficiencies in production processes. To address these challenges, you've been focusing on implementing Total Productive Maintenance (TPM) principles to improve equipment effectiveness and overall production efficiency. Discuss the eight Pillars of TPM and provide examples of how each pillar can be applied in your automotive component manufacturing plant? **(15) (CO4) (PO3)**

**b.** In a chair manufacturing company, the production specification for a week is as follows: **(5) (CO4) (PO3)**

- Scheduled operation = 12 hours/day for 6 days/week
- Manufacturing downtime due to meetings, material outages, training, breaks, and so forth = 510 minutes/week
- Maintenance downtime scheduled and equipment breakdown = 238 minutes/week
- Standard cycle time = 0.45 minutes/unit
- Total Production for the week = 6600 units
- Defective parts made = 23 units

Calculate the **Overall Equipment Effectiveness** for the week.

**4. a.** Luffy is a quality assurance manager at a food processing company that specializes in producing canned goods, such as fruits and vegetables. Recently, there have been concerns raised by customers about the consistency of product quality, particularly regarding the taste and texture of the canned fruits. Some customers have reported variations in taste and texture between batches, leading to dissatisfaction and a decline in sales. As a result, the company's reputation and market share are at risk. To address these concerns about product quality consistency and improve overall product quality, Luffy decided to implement Total Quality Management (TQM) principles. Describe any two distinguishing characteristics of TQM and briefly discuss how Luffy applied them in his company to improve overall product quality and customer satisfaction. **(5) (CO3) (PO3)**

b. It is argued that ISO 9000 is not an alternative to TQM, rather complementary. What are the eight TQM principles behind ISO 9000 QMS to justify this? **(9) (CO3) (PO3)**

c. You are a production manager at a textile manufacturing plant that produces garments for a global fashion retailer. The company is facing challenges with long changeover times between production runs, high inventory levels, and inefficiencies in the production process. To address these challenges, you have decided to implement several manufacturing improvement methodologies. Discuss how the following could be implemented in your textile manufacturing plant: **(2×3 =6) (CO3) (PO3)**

i. SMED
ii. Lean manufacturing
iii. ZQC

5\. a. Soyota, an automotive parts manufacturer has been experiencing a rise in defects in one of its critical production processes. This surge in defects has led to increased scrap rates, rework costs, and customer complaints. To address this issue, the company decided to implement the DMAIC methodology. Develop a DMAIC model for Soyota which will enable the company to reduce the number of defects. **(10) (CO4) (PO3)**

b. Discuss the three kinds of losses mentioned by Taguchi. For a garment's product, identify two quality characteristics and state which type of quality loss is suitable for those 2 quality characteristics. **(3+2=5) (CO4) (PO3)**

c. A company uses Taguchi Loss Function. They manufacture water pumps, with a target output rotational speed value of 240 rpm. The record shows that the population standard deviation of rotational speed is 2 rpm. In case of any deviation from the target output rpm value, recalibration is required with certain costs associated. It is estimated that when the deviation is 10 rpm the average cost of recalibration is \$500. Several measurements of rpm values for multiple pumps were recorded. It was found that average or mean output speed is 220 rpm. For multiple units, what is the loss for nominal-the-best situation? **(5) (CO4) (PO3)**

6\. a. According to the Juran model, 100% good quality level may not be of interest to the company in terms of cost. If this is true, then zero defect concept is not economically beneficial. Do you agree? Justify with schematic diagrams. **(7) (CO1) (PO1)**

b. The manager of a chocolate manufacturing company assembled a PDCA cycle team to address declining product quality and customer complaints. The team sets a goal of achieving a 20% improvement in product quality and customer satisfaction within 60 days. After identifying inadequate training for production staff and material sourcing as a significant issue, the team suggests the following changes: **(13) (CO1) (PO1)**

- Implementing a comprehensive chocolate-making training program for production staff.
- Introducing a buddy system for new hires, pairing them with experienced chocolatiers.
- Enhancing quality control through regular taste-testing sessions.
- Upgrading production equipment for improved efficiency.
- Sourcing premium-quality ingredients to enhance the taste and quality of chocolates.

Using the above information, develop a brief hypothetical PDCA cycle. The cycle can be a successful one or the opposite depending on your choice.

c. A senior manager at a manufacturing company that produces electronic components observes that the company has been experiencing declining productivity, increasing defects, and a decrease in customer satisfaction. To address these challenges, he decided to implement improvements in management practices. As part of this initiative, he decided to study and apply Edward Deming's 14 points for management. State and explain any 10 points from Edward Deming's prescribed points for management. (10) (CO1) (PO1)

**_____The End_____**

## Formula and data sheets

**Constants for Control Limits**

| Sample Size, n | $A_2$ | $A_3$ | $B_3$ | $B_4$ | $d_2$ | $D_3$ | $D_4$ |
|---|---|---|---|---|---|---|---|
| 2 | 1.88 | 2.659 | 0 | 3.267 | 1.128 | 0 | 3.267 |
| 3 | 1.023 | 1.954 | 0 | 2.568 | 1.693 | 0 | 2.574 |
| 4 | 0.729 | 1.628 | 0 | 2.266 | 2.059 | 0 | 2.282 |
| 5 | 0.577 | 1.427 | 0 | 2.089 | 2.326 | 0 | 2.114 |
| 6 | 0.483 | 1.287 | 0.030 | 1.97 | 2.534 | 0 | 2.004 |
| 7 | 0.419 | 1.182 | 0.118 | 1.882 | 2.704 | 0.076 | 1.924 |
| 8 | 0.373 | 1.099 | 0.185 | 1.815 | 2.847 | 0.136 | 1.864 |

$$UCL = \bar{\bar{x}} + A_2\bar{R}$$
$$CL = \bar{\bar{x}}$$
$$LCL = \bar{\bar{x}} - A_2\bar{R}$$

$$UCL = D_4\bar{R}$$
$$CL = \bar{R}$$
$$LCL = D_3\bar{R}$$

$$UCL = \bar{\bar{x}} + A_3\bar{S}$$
$$CL = \bar{\bar{x}}$$
$$LCL = \bar{\bar{x}} - A_3\bar{S}$$

$$UCL = B_4\bar{S}$$
$$CL = \bar{S}$$
$$LCL = B_3\bar{S}$$

$$S = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

$$P_a = \sum_{i=0}^{c}\binom{n}{i}p^i(1-p)^{n-i}$$

$$a_1 = \frac{ln\left[\frac{1-\alpha}{\beta}\right]}{k}$$

$$a_2 = \frac{ln\left[\frac{1-\beta}{\alpha}\right]}{k}$$

$$b = \frac{ln\left[\frac{1-p_1}{1-p_2}\right]}{k}$$

$$k = ln\left[\frac{p_2(1-p_1)}{p_1(1-p_2)}\right]$$

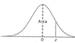


Table A.3 Areas under the Normal Curve

| $z$ | .00 | .01 | .02 | .03 | .04 | .05 | .06 | .07 | .08 | .09 |
|---|---|---|---|---|---|---|---|---|---|---|
| −3.4 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0002 |
| −3.3 | 0.0005 | 0.0005 | 0.0005 | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0003 |
| −3.2 | 0.0007 | 0.0007 | 0.0006 | 0.0006 | 0.0006 | 0.0006 | 0.0006 | 0.0005 | 0.0005 | 0.0005 |
| −3.1 | 0.0010 | 0.0009 | 0.0009 | 0.0009 | 0.0008 | 0.0008 | 0.0008 | 0.0008 | 0.0007 | 0.0007 |
| −3.0 | 0.0013 | 0.0013 | 0.0013 | 0.0012 | 0.0012 | 0.0011 | 0.0011 | 0.0011 | 0.0010 | 0.0010 |
| −2.9 | 0.0019 | 0.0018 | 0.0018 | 0.0017 | 0.0016 | 0.0016 | 0.0015 | 0.0015 | 0.0014 | 0.0014 |
| −2.8 | 0.0026 | 0.0025 | 0.0024 | 0.0023 | 0.0023 | 0.0022 | 0.0021 | 0.0021 | 0.0020 | 0.0019 |
| −2.7 | 0.0035 | 0.0034 | 0.0033 | 0.0032 | 0.0031 | 0.0030 | 0.0029 | 0.0028 | 0.0027 | 0.0026 |
| −2.6 | 0.0047 | 0.0045 | 0.0044 | 0.0043 | 0.0041 | 0.0040 | 0.0039 | 0.0038 | 0.0037 | 0.0036 |
| −2.5 | 0.0062 | 0.0060 | 0.0059 | 0.0057 | 0.0055 | 0.0054 | 0.0052 | 0.0051 | 0.0049 | 0.0048 |
| −2.4 | 0.0082 | 0.0080 | 0.0078 | 0.0075 | 0.0073 | 0.0071 | 0.0069 | 0.0068 | 0.0066 | 0.0064 |
| −2.3 | 0.0107 | 0.0104 | 0.0102 | 0.0099 | 0.0096 | 0.0094 | 0.0091 | 0.0089 | 0.0087 | 0.0084 |
| −2.2 | 0.0139 | 0.0136 | 0.0132 | 0.0129 | 0.0125 | 0.0122 | 0.0119 | 0.0116 | 0.0113 | 0.0110 |
| −2.1 | 0.0179 | 0.0174 | 0.0170 | 0.0166 | 0.0162 | 0.0158 | 0.0154 | 0.0150 | 0.0146 | 0.0143 |
| −2.0 | 0.0228 | 0.0222 | 0.0217 | 0.0212 | 0.0207 | 0.0202 | 0.0197 | 0.0192 | 0.0188 | 0.0183 |
| −1.9 | 0.0287 | 0.0281 | 0.0274 | 0.0268 | 0.0262 | 0.0256 | 0.0250 | 0.0244 | 0.0239 | 0.0233 |
| −1.8 | 0.0359 | 0.0351 | 0.0344 | 0.0336 | 0.0329 | 0.0322 | 0.0314 | 0.0307 | 0.0301 | 0.0294 |
| −1.7 | 0.0446 | 0.0436 | 0.0427 | 0.0418 | 0.0409 | 0.0401 | 0.0392 | 0.0384 | 0.0375 | 0.0367 |
| −1.6 | 0.0548 | 0.0537 | 0.0526 | 0.0516 | 0.0505 | 0.0495 | 0.0485 | 0.0475 | 0.0465 | 0.0455 |
| −1.5 | 0.0668 | 0.0655 | 0.0643 | 0.0630 | 0.0618 | 0.0606 | 0.0594 | 0.0582 | 0.0571 | 0.0559 |
| −1.4 | 0.0808 | 0.0793 | 0.0778 | 0.0764 | 0.0749 | 0.0735 | 0.0721 | 0.0708 | 0.0694 | 0.0681 |
| −1.3 | 0.0968 | 0.0951 | 0.0934 | 0.0918 | 0.0901 | 0.0885 | 0.0869 | 0.0853 | 0.0838 | 0.0823 |
| −1.2 | 0.1151 | 0.1131 | 0.1112 | 0.1093 | 0.1075 | 0.1056 | 0.1038 | 0.1020 | 0.1003 | 0.0985 |
| −1.1 | 0.1357 | 0.1335 | 0.1314 | 0.1292 | 0.1271 | 0.1251 | 0.1230 | 0.1210 | 0.1190 | 0.1170 |
| −1.0 | 0.1587 | 0.1562 | 0.1539 | 0.1515 | 0.1492 | 0.1469 | 0.1446 | 0.1423 | 0.1401 | 0.1379 |
| −0.9 | 0.1841 | 0.1814 | 0.1788 | 0.1762 | 0.1736 | 0.1711 | 0.1685 | 0.1660 | 0.1635 | 0.1611 |
| −0.8 | 0.2119 | 0.2090 | 0.2061 | 0.2033 | 0.2005 | 0.1977 | 0.1949 | 0.1922 | 0.1894 | 0.1867 |
| −0.7 | 0.2420 | 0.2389 | 0.2358 | 0.2327 | 0.2296 | 0.2266 | 0.2236 | 0.2206 | 0.2177 | 0.2148 |
| −0.6 | 0.2743 | 0.2709 | 0.2676 | 0.2643 | 0.2611 | 0.2578 | 0.2546 | 0.2514 | 0.2483 | 0.2451 |
| −0.5 | 0.3085 | 0.3050 | 0.3015 | 0.2981 | 0.2946 | 0.2912 | 0.2877 | 0.2843 | 0.2810 | 0.2776 |
| −0.4 | 0.3446 | 0.3409 | 0.3372 | 0.3336 | 0.3300 | 0.3264 | 0.3228 | 0.3192 | 0.3156 | 0.3121 |
| −0.3 | 0.3821 | 0.3783 | 0.3745 | 0.3707 | 0.3669 | 0.3632 | 0.3594 | 0.3557 | 0.3520 | 0.3483 |
| −0.2 | 0.4207 | 0.4168 | 0.4129 | 0.4090 | 0.4052 | 0.4013 | 0.3974 | 0.3936 | 0.3897 | 0.3859 |
| −0.1 | 0.4602 | 0.4562 | 0.4522 | 0.4483 | 0.4443 | 0.4404 | 0.4364 | 0.4325 | 0.4286 | 0.4247 |
| −0.0 | 0.5000 | 0.4960 | 0.4920 | 0.4880 | 0.4840 | 0.4801 | 0.4761 | 0.4721 | 0.4681 | 0.4641 |

Table A.3 (continued) Areas under the Normal Curve

| $z$ | .00 | .01 | .02 | .03 | .04 | .05 | .06 | .07 | .08 | .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 |