**BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI**
**(END SEMESTER EXAMINATION)**

**CLASS: BTECH** **SEMESTER : V**
**BRANCH: P&IE** **SESSION : MO/2023**

**SUBJECT: PE326 METROLOGY & STATISTICAL QUALITY CONTROL**

**TIME: 3 Hours** **FULL MARKS: 50**

**INSTRUCTIONS:**
**1. The question paper contains 5 questions each of 10 marks and total 50 marks.**
**2. Attempt all questions.**
**3. The missing data, if any, may be assumed suitably.**
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
**5. Tables/Data handbook/Graph paper etc. to be supplied to the candidates in the examination hall.**

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| | | | CO | BL |
|---|---|---|---|---|
| Q.1(a) | Four end bars A, B, C & D are to be calibrated using a calibrated length bar of 500mm whose actual length is 499.9999mm. The bar B is longer than bar A by 0.0005mm, bar C is longer than bar A by 0.0002mm, while bar D is shorter than bar A by 0.0001mm. The four gauges together have a combination length of 500.0002mm. Determine the corrected (actual) length of each bar. | [5] | 1 | 6 |
| Q.1(b) | A Hole and a mating Shaft are to have a nominal assembly size of 40mm.The assembly is to have a maximum clearance of 0.15mm and minimum clearance of 0.05 mm. The hole tolerance is 1.5 times the shaft tolerance. Determine the limits for both hole and shaft by using Hole basis system. | [5] | 1 | 6 |
| Q.2(a) | i) Select a specific product or service and discuss how the eight dimensions of quality impact its overall acceptance by consumers. | [3] | 2 | 1 |
| Q.2(a) | ii) The number of cardiograms performed each day for 20 days is shown at an outpatient testing centre. Construct a stem and leaf plot for the data.<br>25 31 20 32 13 14 43 02 57 23 36<br>32<br>33 32 44 32 52 44 51 45 | [2] | 2 | 4 |
| Q.2(b) | These data represent the record high temperatures for each of the 50 states. Construct a grouped frequency distribution for the data using 7 classes. Draw Histogram and ogive diagram. | [5] | 2 | 4 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 112 | 100 | 127 | 120 | 134 | 118 | 105 | 110 | 109 | 112 |
| 110 | 118 | 117 | 116 | 118 | 122 | 114 | 114 | 105 | 109 |
| 107 | 112 | 114 | 115 | 118 | 117 | 118 | 122 | 106 | 110 |
| 116 | 108 | 110 | 121 | 113 | 120 | 119 | 111 | 104 | 111 |
| 120 | 113 | 120 | 117 | 105 | 110 | 118 | 112 | 114 | 114 |

Q.3(a) A company producing kitchen worktops, specified the length of one range at 120 cm ± 0.25 cm. [5] 3 5

For n=4 the d2= 2.059, A2= 0.73, A3=1.628, B3=0, B4=2.266, D3= 0, D4=2.28

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| X1 | 120.03 | 120.01 | 120.02 | 120 | 120.01 | 120.01 | 120 | 120 | 120.03 | 120.01 |
| X2 | 120.02 | 120 | 120.01 | 120.03 | 120.02 | 119.98 | 120.01 | 120 | 120.02 | 120.01 |
| X3 | 120.01 | 120.03 | 120 | 120.04 | 120.02 | 120.01 | 120.02 | 120.02 | 119.99 | 120.01 |
| X4 | 120.01 | 119.98 | 120 | 120.01 | 119.99 | 120 | 119.99 | 120 | 120.02 | 119.99 |

i) Draw X-bar & R Control Charts.
ii) A request from the sales team for tighter limits prompted the question of whether the limits could be reduced to ± 0.1cm, as this could result in significant orders from a new customer who preferred not to shave worktops to fit. Analyse the feasibility of the same.

**PTO**

Q.3(b) i) List the Sensitizing Rules for Shewhart Control Charts [3] 3 1

ii) The data in Table gives the number of nonconforming bearing and seal assemblies in samples of size 100. Calculate the control limits for fraction nonconforming control chart for these data. [2] 3 4

| Sample no. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| No. of nonconforming assemblies | 7 | 4 | 1 | 3 | 6 | 8 | 10 | 5 | 2 | 7 |
| Sample no. | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| No. of nonconforming assemblies | 6 | 15 | 0 | 9 | 5 | 1 | 4 | 5 | 7 | 12 |

Q.4(a) Consider a single sampling plan with a lot size of 2000, a sample size of 200, and an acceptance number of 3. Construct the OC curve. If the acceptable quality level is 0.05% nonconforming and the limiting quality level is 6% nonconforming, describe the protection offered by the plan at these quality levels. [5] 4 5

Q.4(b) A sampling plan is desired to have a producer's risk of 0.05 at AQL= 1.2% nonconforming and a consumer's risk of 0.10 at LQL = 6.5% nonconforming. Find the single sampling plan that meets the producer's stipulation and comes as close as possible to meeting the consumer's stipulation. [5] 4 5

Q.5(a) Consider a double sampling plan given by the following parameters: N=2200, $n_1 = 60$, $c_1 = 0$, $r_1 — 5$, $n2 = 100$, $c2 = 6$, $r2 = 7$. *Find the probability of accepting* lots that are 3% nonconforming. [5] 4 5

Q.5(b) Define Quality circle. Explain its concept. [2] 5 1

Q.5(c) What is a six sigma process? Why it is assumed that Six Sigma process would produce about 3.4 ppm defective instead of 0.002 ppm defectives? [3] 5 2

**::::::22/11/2023::::::M**

**Table 1 : Cumulative Poisson Distribution**

| | l=np | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| X | 0.01 | 0.05 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
| 0 | 0.99 | 0.951 | 0.905 | 0.819 | 0.741 | 0.67 | 0.607 | 0.549 | 0.497 | 0.449 | 0.407 |
| 1 | 1 | 0.999 | 0.995 | 0.982 | 0.963 | 0.938 | 0.91 | 0.878 | 0.844 | 0.809 | 0.772 |
| 2 | | 1 | 1 | 0.999 | 0.996 | 0.992 | 0.986 | 0.977 | 0.966 | 0.953 | 0.937 |
| 3 | | | | 1 | 1 | 0.999 | 0.998 | 0.997 | 0.994 | 0.991 | 0.987 |
| 4 | | | | | | 1 | 1 | 1 | 0.999 | 0.999 | 0.998 |
| | 1 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | 2 |
| 0 | 0.368 | 0.333 | 0.301 | 0.273 | 0.247 | 0.223 | 0.202 | 0.183 | 0.165 | 0.15 | 0.135 |
| 1 | 0.736 | 0.699 | 0.663 | 0.627 | 0.592 | 0.558 | 0.525 | 0.493 | 0.463 | 0.434 | 0.406 |
| 2 | 0.92 | 0.9 | 0.879 | 0.857 | 0.833 | 0.809 | 0.783 | 0.757 | 0.731 | 0.704 | 0.677 |
| 3 | 0.981 | 0.974 | 0.966 | 0.957 | 0.946 | 0.934 | 0.921 | 0.907 | 0.891 | 0.875 | 0.857 |
| 4 | 0.996 | 0.995 | 0.992 | 0.989 | 0.986 | 0.981 | 0.976 | 0.97 | 0.964 | 0.956 | 0.947 |
| | 2.2 | 2.4 | 2.6 | 2.8 | 3 | 3.5 | 4 | 4.5 | 5 | 5.5 | 6 |
| 0 | 0.111 | 0.091 | 0.074 | 0.061 | 0.05 | 0.03 | 0.018 | 0.011 | 0.007 | 0.104 | 0.002 |
| 1 | 0.355 | 0.308 | 0.267 | 0.231 | 0.199 | 0.136 | 0.092 | 0.061 | 0.04 | 0.027 | 0.017 |
| 2 | 0.623 | 0.57 | 0.518 | 0.469 | 0.423 | 0.321 | 0.238 | 0.174 | 0.125 | 0.088 | 0.062 |
| 3 | 0.819 | 0.779 | 0.736 | 0.692 | 0.647 | 0.537 | 0.433 | 0.342 | 0.265 | 0.202 | 0.151 |
| 4 | 0.928 | 0.904 | 0.877 | 0.848 | 0.815 | 0.725 | 0.629 | 0.532 | 0.44 | 0.358 | 0.285 |
| | 6.5 | 7 | 7.5 | 8 | 9 | 10 | 12 | 14 | 16 | 18 | 20 |
| 0 | 0.002 | 0.001 | 0.001 | 0 | 0 | | | | | | |
| 1 | 0.011 | 0.007 | 0.005 | 0.003 | 0.001 | 0 | 0 | | | | |
| 2 | 0.043 | 0.03 | 0.02 | 0.014 | 0.006 | 0.003 | 0.001 | | | | |
| 3 | 0.112 | 0.082 | 0.059 | 0.042 | 0.021 | 0.01 | 0.002 | 0 | | | |
| 4 | 0.224 | 0.173 | 0.132 | 0.1 | 0.055 | 0.029 | 0.008 | 0.002 | 0 | | |

**Table 2: Value of np for a producers Risk of 0.05 and a consumers Risk of 0.10 (Grubbs table)**

| Acceptance number, c | Pa= 0.95, np1 | Pa= 0.1, np2 | Np2/np1 |
|---|---|---|---|
| 0 | 0.051 | 2.303 | 44.84 |
| 1 | 0.355 | 3.890 | 10.96 |
| 2 | 0.818 | 5.322 | 6.51 |
| 3 | 1.366 | 6.681 | 4.89 |
| 4 | 1.970 | 7.994 | 4.06 |