MSc Eng/PhD (MPE) 22 December 2023

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Semester-Final Examination — Summer Semester, A.Y. 2022-2023
Course No. MCE 6221 — Time : 3 hours
Course Title: Quality Assurance and Management — Full Marks : 150

There are **6 (Six)** Questions. Answer any **5 (Five)** of them.
Use the graph paper wherever necessary. Marks in the Margin indicate the full marks.

1

a) The applied definitions of quality are quite a few. You see definitions that imply the maximization of benefits and see the definitions that imply minimization of losses. Will both approaches lead to the same basic results/outcomes in quality assurance? Should some processes or products be approached from maximization and others from minimization? Explain the matter in depth. **10**

b) A manufacturer wishes to increase quality and productivity concurrently. Enumerate the critical observations about their connection and suitability. **5**

c) System view is vital in quality assurance and management. By a figure state Checkland's general systems thinking model. **10**

d) What is documentation? What are required to be documented in a quality system? **5**

2

a) You have been called upon by your manager to present an analysis on quality assurance of the department in your organization and you have been asked to present it to the top management. One of the members of the board who happens to be a novice asked you to explain to him what was meant by "no two products are ever absolutely identical". Explain it in your own words from physical as well as statistical points of view (may use the necessary diagrams). **8**

b) Describe an experience you have had with a product or service based on customer satisfaction and perceived value. State the various aspects. **7**

c) Suppose you joined a company after completing this course (MCE 6221). The company is yet to implement any organized quality system and facing difficulties in creating new products, increasing market share, halting employees' high turnover, and so on. What would you consider in constructing a quality management (say TQM) framework to overcome these and other potential problems. Show your answer by figure/s along with the key statements/explanations. **15**

3

a) Suppose you are a manager of a small manufacturing plant producing three brands of piston rod. Are you going to use any quality assurance and management tools and techniques? Give reasons in favor of your answer with sufficient examples. **6**

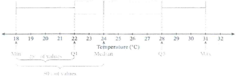
b) The following is the data from a production process on a certain quality characteristic. 42, 14, 22, 16, 2, 15, 8, 27, 6, 15, 19, 48, 4, 31, 26, 20, 28, 13, 10, 18, 13, 15, 48, 16, 15, 5, 18, 16, 28, 11, 0, 27, 28, 5, 40, 21, 18, 7, 12, 6, 40, 12, 2, 20, 35, 3, 16, 13, 8, 15, 7, 65, 65, 25, 15, 21, 12, 12, 35, 30, 14, 35, 20, 35, 7, 35 **8**

Draw a tabular stem-and-leaf diagram like below in the lower half of the above graph paper.

Stem	Leaf	Frequency	Overall comment on data

c) Ahmad presents the following data on the wire break strength for a supplier. Prepare a box plot in a graph paper like the one below. Comment on distribution of data. **8**

475	435	418	605	455
553	395	478	520	315
520	420	389	365	550



d) By means of a scatter diagram, determine if any relationship exists between product temperature in degree Celsius and percent foam for a soft drink. Use a graph paper. **8**

Day	1	2	3	4	5	6	7	8	9	10
Temperature	36	38	37	44	46	39	41	47	39	40
Foam %	15	19	21	30	36	20	25	36	22	23
Day	11	12	13	14	15	16	17	18	19	20
Temperature	44	42	38	41	45	49	50	48	46	41
Foam %	32	33	20	27	35	38	40	42	40	30

4

a) Explain how it is possible to have a stable process that is incapable. How should process capability indexes be interpreted? **7**

b) Criticism has been leveled at both the C_p and C_{pk} capability indices. Alternative indices such as C_{pm} and C_{pmk} have been proposed. What criticism, and advantages and disadvantages do these indices offer? Explain. **7**

c) A medium company is required to show the statistical evidence that its process capability ratio C_p exceeds de facto value. The company has taken a sample of 20 parts that results in $\bar{x} = 97.50$ and $s = 1.75$. Assume that the quality characteristic follows a normal distribution with the product specifications 95 ± 5. **12**

i. Compute the point estimate of C_p. Can the company demonstrate that C_p exceeds the desired value at the 95% level of confidence?

ii. Compute the point estimate of C_{pk}. Find the 95% confidence interval on C_{pk} and comment on it.

d) How and why would you choose a set of control charts (in case of variable data)? **4**

5

a) What is the necessity of applying design of experiments in quality assurance? Explain the general model of a system where we need to consider signal and noise factors. What do you understand by signal to noise ratio? **10**

b) A pharmaceutical manufacturer wants to investigate the bioactivity of a new drug. A completely randomized single-factor experiment was conducted with three dosage levels, and the following results (Tabled) were obtained. **20**

Dosage	Observations			
20 g	24	28	37	30
30 g	37	44	31	35
40 g	42	47	52	38

Use the design of experiment concept and,

i. Write down the relevant hypotheses.

i. Is there any evidence to indicate that dosage level affects bioactivity at $\alpha = 0.05$?

6

a) In what contexts is acceptance sampling an appropriate tool in modern quality assurance? **5**

b) What is the role of acceptance sampling in a TQM environment? Explain the procedure of making a double sampling plan. **10**

c) There is an agreement between a producer and a customer that at most double-sampling plan will be administered. They have decided to construct the operating characteristic (OC) curves for a range of lot fraction defective of 0 to 0.12. Show some sample calculations on probability of acceptance of the first and combined samples using the relevant formulas (not the table) for $n_1 = 50, c_1 = 1, n_2 = 100, c_2 = 3$. No need to draw the OC curves. **15**

-End of the question paper-

All notations carry their usual meanings.

Design of experiments/ANOVA

$$\sum_{i=1}^{a} \tau_i \quad y_{i.} = \sum_{j=1}^{n} y_{ij} \qquad \bar{y}_{i.} = y_{i.} / n$$

Grand total and grand mean of all observations are respectively

$$y_{..} = \sum_{i=1}^{a} \sum_{j=1}^{n} y_{ij} \quad \text{and} \quad \bar{y}_{..} = y_{..} / N$$, where $N = an$ (total no. of observations).

Hypotheses are

H_0: $\tau_1 = \tau_2 = \ldots = \tau_a$ and H_1: $\tau_i \neq 0$ for at least one *i*.

$$SST = \sum_{i=1}^{a} \sum_{j=1}^{n} y^2{}_{ij} - \frac{y^2{}_{..}}{N} \qquad SS_{treatments} = \sum_{i=1}^{a} \frac{y^2{}_{i.}}{n} - \frac{y^2{}_{..}}{N}$$

$$SSE = SST - SS_{treatments}$$

$$MS_{treatments} = \frac{SS_{treatments}}{a-1}$$

Then the *test statistic* or observed *F* value is

$$F_0 = \frac{\dfrac{SS_{treatments}}{a-1}}{\dfrac{SSE}{a(n-1)}} = \frac{MS_{treatments}}{MSE}$$

Acceptance Sampling

$$P_a(p) = \sum_{x=0}^{c} \frac{{}^{Np}C_x \, {}^{N(1-p)}C_{n-x}}{{}^{N}C_n} \qquad P_a(p) = \sum_{x=0}^{c} {}^{n}C_x p^x (1-p)^{n-x}$$

$$P_a(\lambda) = \sum_{x=0}^{c} {}^{N\lambda}C_x \left(\frac{k}{N}\right)^x \left(1 - \frac{k}{N}\right)^{N\lambda - x} \qquad P_a(p) = \sum_{x=0}^{c} \frac{(\exp)^{(-k\lambda)} (k\lambda)^x}{x}$$

$$1 - \alpha = P(AQL) = \sum_{x=0}^{c} \frac{\angle n}{\angle x \angle (n-x)} AQL^x (1 - AQL)^{n-x} \qquad \beta = P(RQL) = \sum_{x=0}^{c} \frac{\angle n}{\angle x \angle (n-x)} RQL^x (1 - RQL)^{n-x}$$

$$ATI(p) = nP_a(p) + N(1 - P_a(p)) = n + (N-n)(1 - P_a(p))$$

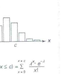
$$AOQ(p) = \sum_{x=0}^{c} \frac{Np - x}{N} \frac{{}^{Np}C_x \, {}^{N(1-p)}C_{n-x}}{{}^{N}C_n} \qquad AOQ(p) = 0(1 - P_a(p)) + \frac{(N-n)p}{N} P_a(p) = \left(1 - \frac{n}{N}\right) p P_a(p)$$

$$AOQ(p) = \sum_{x=0}^{c} \frac{(Np - x)}{N - x} \frac{{}^{Np}C_x \, {}^{N(1-p)}C_{n-x}}{{}^{N}C_n} \qquad AOQ(p) = \sum_{x=0}^{c} \frac{(N-n)p}{N-x} {}^{n}C_x p^x (1-p)^{(n-x)}$$

F-table of Critical Values of α = 0.05 for F(df1, df2)

	DF1=1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	∞
DF2=1	161.45	199.50	215.71	224.58	230.16	233.99	236.77	238.88	240.54	241.88	243.91	245.95	248.01	249.05	250.10	251.14	252.20	253.25	254.31
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38	19.40	19.41	19.43	19.45	19.45	19.46	19.47	19.48	19.49	19.50
3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.74	8.70	8.66	8.64	8.62	8.59	8.57	8.55	8.53
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.91	5.86	5.80	5.77	5.75	5.72	5.69	5.66	5.63
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.68	4.62	4.56	4.53	4.50	4.46	4.43	4.40	4.37
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.00	3.94	3.87	3.84	3.81	3.77	3.74	3.70	3.67
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.57	3.51	3.44	3.41	3.38	3.34	3.30	3.27	3.23
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.28	3.22	3.15	3.12	3.08	3.04	3.01	2.97	2.93
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.07	3.01	2.94	2.90	2.86	2.83	2.79	2.75	2.71
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.91	2.85	2.77	2.74	2.70	2.66	2.62	2.58	2.54
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85	2.79	2.72	2.65	2.61	2.57	2.53	2.49	2.45	2.40
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	2.69	2.62	2.54	2.51	2.47	2.43	2.38	2.34	2.30
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.60	2.53	2.46	2.42	2.38	2.34	2.30	2.25	2.21
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.53	2.46	2.39	2.35	2.31	2.27	2.22	2.18	2.13
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.48	2.40	2.33	2.29	2.25	2.20	2.16	2.11	2.07
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.42	2.35	2.28	2.24	2.19	2.15	2.11	2.06	2.01
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45	2.38	2.31	2.23	2.19	2.15	2.10	2.06	2.01	1.96
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41	2.34	2.27	2.19	2.15	2.11	2.06	2.02	1.97	1.92
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38	2.31	2.23	2.16	2.11	2.07	2.03	1.98	1.93	1.88
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.28	2.20	2.12	2.08	2.04	1.99	1.95	1.90	1.84
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32	2.25	2.18	2.10	2.05	2.01	1.96	1.92	1.87	1.81
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30	2.23	2.15	2.07	2.03	1.98	1.94	1.89	1.84	1.78
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32	2.27	2.20	2.13	2.05	2.01	1.96	1.91	1.86	1.81	1.76
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25	2.18	2.11	2.03	1.98	1.94	1.89	1.84	1.79	1.73
25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28	2.24	2.16	2.09	2.01	1.96	1.92	1.87	1.82	1.77	1.71
26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27	2.22	2.15	2.07	1.99	1.95	1.90	1.85	1.80	1.75	1.69
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25	2.20	2.13	2.06	1.97	1.93	1.88	1.84	1.79	1.73	1.67
28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24	2.19	2.12	2.04	1.96	1.91	1.87	1.82	1.77	1.71	1.65
29	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22	2.18	2.10	2.03	1.94	1.90	1.85	1.81	1.75	1.70	1.64
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.09	2.01	1.93	1.89	1.84	1.79	1.74	1.68	1.62
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08	2.00	1.92	1.84	1.79	1.74	1.69	1.64	1.58	1.51
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99	1.92	1.84	1.75	1.70	1.65	1.59	1.53	1.47	1.39
120	3.92	3.07	2.68	2.45	2.29	2.18	2.09	2.02	1.96	1.91	1.83	1.75	1.66	1.61	1.55	1.50	1.43	1.35	1.25
∞	3.84	3.00	2.60	2.37	2.21	2.10	2.01	1.94	1.88	1.83	1.75	1.67	1.57	1.52	1.46	1.39	1.32	1.22	1.00

Cumulative Poisson Probabilities



$$P(x \le c) = \sum_{x=0}^{x=c} \frac{\lambda^{x} \cdot e^{-\lambda}}{x!}$$

np	c = 0	1	2	3	4	5	6	7	8	9	10	11	12	13
.05	.951	.999	1.000											
.10	.905	.995	1.000											
.15	.861	.990	.999	1.000										
.20	.819	.982	.999	1.000										
.25	.779	.974	.998	1.000										
.30	.741	.963	.996	1.000										
.35	.705	.951	.994	1.000										
.40	.670	.938	.992	.999	1.000									
.45	.638	.925	.989	.999	1.000									
.50	.607	.910	.986	.998	1.000									
.55	.577	.894	.982	.998	1.000									
.60	.549	.878	.977	.997	1.000									
.65	.522	.861	.972	.996	.999	1.000								
.70	.497	.844	.966	.994	.999	1.000								
.75	.472	.827	.959	.993	.999	1.000								
.80	.449	.809	.953	.991	.999	1.000								
.85	.427	.791	.945	.989	.998	1.000								
.90	.407	.772	.937	.987	.998	1.000								
.95	.387	.754	.929	.984	.997	1.000								
1.0	.368	.736	.920	.981	.996	.999	1.000							
1.1	.333	.699	.900	.974	.995	.999	1.000							
1.2	.301	.663	.879	.966	.992	.998	1.000							
1.3	.273	.627	.857	.957	.989	.998	1.000							
1.4	.247	.592	.833	.946	.986	.997	.999	1.000						
1.5	.223	.558	.809	.934	.981	.996	.999	1.000						
1.6	.202	.525	.783	.921	.976	.994	.999	1.000						
1.7	.183	.493	.757	.907	.970	.992	.998	1.000						
1.8	.165	.463	.731	.891	.964	.990	.997	.999	1.000					
1.9	.150	.434	.704	.875	.956	.987	.997	.999	1.000					
2.0	.135	.406	.677	.857	.947	.983	.995	.999	1.000					
2.2	.111	.355	.623	.819	.928	.975	.993	.998	1.000					
2.4	.091	.308	.570	.779	.904	.964	.988	.997	.999	1.000				
2.6	.074	.267	.518	.736	.877	.951	.983	.995	.999	1.000				
2.8	.061	.231	.469	.692	.848	.935	.976	.992	.998	.999	1.000			
3.0	.050	.199	.423	.647	.815	.916	.966	.988	.996	.999	1.000			
3.2	.041	.171	.380	.603	.781	.895	.955	.983	.994	.998	1.000			
3.4	.033	.147	.340	.558	.744	.871	.942	.977	.992	.997	.999	1.000		
3.6	.027	.126	.303	.515	.706	.844	.927	.969	.988	.996	.999	1.000		
3.8	.022	.107	.269	.473	.668	.816	.909	.960	.984	.994	.998	.999	1.000	
4.0	.018	.092	.238	.433	.629	.785	.889	.949	.979	.992	.997	.999	1.000	
4.2	.015	.078	.210	.395	.590	.753	.867	.936	.972	.989	.996	.999	1.000	
4.4	.012	.066	.185	.359	.551	.720	.844	.921	.964	.985	.994	.998	.999	1.000
4.6	.010	.056	.163	.326	.513	.686	.818	.905	.955	.980	.992	.997	.999	1.000
4.8	.008	.048	.143	.294	.476	.651	.791	.887	.944	.975	.990	.996	.999	1.000
5.0	.007	.040	.125	.265	.440	.616	.762	.867	.932	.968	.986	.995	.998	.999
5.2	.006	.034	.109	.238	.406	.581	.732	.845	.918	.960	.982	.993	.997	.999
5.4	.005	.029	.095	.213	.373	.546	.702	.822	.903	.951	.977	.990	.996	.999
5.6	.004	.024	.082	.191	.342	.512	.670	.797	.886	.941	.972	.988	.995	.998
5.8	.003	.021	.072	.170	.313	.478	.638	.771	.867	.929	.965	.984	.993	.997
6.0	.002	.017	.062	.151	.285	.446	.606	.744	.847	.916	.957	.980	.991	.996
6.2	.002	.015	.054	.134	.259	.414	.574	.716	.826	.902	.949	.975	.989	.995
6.4	.002	.012	.046	.119	.235	.384	.542	.687	.803	.886	.939	.969	.986	.994