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ANNA UNIVERSITY (UNIVERSITY DEPARTMENTS)

B.E. /B.Tech / B. Arch (Full Time) - END SEMESTER EXAMINATIONS, MAY 2025

MECHANICAL ENGINEERING

6th Semester

ME5085 QUALITY AND RELIABILITY ENGINEERING

(Regulation2019)

Time: 3hrs Max.Marks: 100

CO1	To provide an overview about quality concepts and SPC tools for continuous improvement.
CO2	To impart knowledge on the control charts and process capability studies.
CO3	To give an insight on acceptance sampling plan and its parameters.
CO4	To inculcate the fundamentals of the reliability concepts
CO5	To render exposure on improving the reliability and its optimization.

BL – Bloom's Taxonomy Levels

(L1-Remembering, L2-Understanding, L3-Applying, L4-Analysing, L5-Evaluating, L6-Creating)

PART- A(10x2=20Marks)

(Answer all Questions)

Q.No	Questions	Marks	CO	BL
1	Differentiate between Quality Control and Quality Assurance in four different aspects.	2	1	2
2	Identify the types of cost of quality.	2	1	2
3	If USL = 110, LSL = 90, σ = 5. Find Cp.	2	2	2
4	Match the Following with respect to Control Charts for Attributes. 1. p-chart — a. Number of defectives 2. np-chart — b. Nonconformities per unit 3. C-chart — c. Count of nonconformities 4. U-chart — d. Proportion of defectives	2	2	2
5	Distinguish between AQL and LTPD with respect to four different criteria.	2	3	2
6	What is the producer's risk if the probability of accepting a good lot is 0.95?	2	3	2
7	Compare failure rate and hazard rate.	2	4	2
8	If a product has MTTR = 2 hours and MTBF = 10 hours, find its system availability.	2	4	2
9	What are the various purposes of fault tree analysis (FTA) in reliability engineering?	2	5	2
10	What is the combined reliability when a standby redundant system has main unit reliability 0.8, and standby unit reliability 0.6?	2	5	2

PART- B(5x 13=65Marks)

<table>
<tr><th>Q.No</th><th>Questions</th><th>Marks</th><th>CO</th><th>BL</th></tr>
<tr><td>11 (a)</td><td>Sketch a sample Ishikawa Diagram as well as a sample Pareto Chart and evaluate the strengths and weaknesses of the Ishikawa Diagram compared to the Pareto Chart for identifying root causes of quality problems.</td><td>13</td><td>1</td><td>3</td></tr>
<tr><td colspan="5">OR</td></tr>
<tr><td>11 (b)</td><td>Analyze a case (real or imaginary) where not using the Life Cycle Approach to Quality Costs caused major losses. What corrective actions would you suggest?</td><td>13</td><td>1</td><td>3</td></tr>
<tr><td>12 (a)</td><td>A manufacturing company produces bolts in large batches. Quality inspection is carried out daily. The following data was collected over 10 days:
<table>
<tr><th>Day</th><th>Number of Units Inspected</th><th>Number of Defective Units</th><th>Number of Defects Observed</th></tr>
<tr><td>1</td><td>150</td><td>12</td><td>18</td></tr>
<tr><td>2</td><td>200</td><td>8</td><td>10</td></tr>
<tr><td>3</td><td>180</td><td>14</td><td>20</td></tr>
<tr><td>4</td><td>160</td><td>10</td><td>13</td></tr>
<tr><td>5</td><td>190</td><td>7</td><td>9</td></tr>
<tr><td>6</td><td>170</td><td>11</td><td>15</td></tr>
<tr><td>7</td><td>210</td><td>6</td><td>8</td></tr>
<tr><td>8</td><td>200</td><td>9</td><td>12</td></tr>
<tr><td>9</td><td>180</td><td>13</td><td>19</td></tr>
<tr><td>10</td><td>160</td><td>12</td><td>17</td></tr>
</table>
i) Construct a p-chart (proportion of defective units) and calculate the Centre Line (CL), Upper Control Limit (UCL), and Lower Control Limit (LCL).
ii) Construct a u-chart (average number of defects per unit) and calculate CL, UCL, and LCL.
iii) Interpret whether the process is under control based on your charts and recommend necessary quality improvement actions if any points are out of control.</td><td>13</td><td>2</td><td>4</td></tr>
<tr><td colspan="5">OR</td></tr>
<tr><td>12 (b)</td><td>A company is monitoring the diameter of a precision-machined shaft. Every hour, a sample of n = 5 shafts is measured for 10 hours, and the $\bar{X}$ (mean) and R (range) are recorded. Specification limits are: LSL = 19.85 mm, USL = 20.15 mm, and Target = 20.00 mm. The data for the 10 subgroups is:</td><td>13</td><td>2</td><td>4</td></tr>
</table>

Sub group	$\bar{X}$ (mm)	R (mm)	Sub group	$\bar{X}$ (mm)	R (mm)
1	20.01	0.12	6	20.03	0.13
2	20.02	0.14	7	19.99	0.14
3	20.00	0.13	8	20.00	0.10
4	20.04	0.11	9	20.01	0.12
5	19.98	0.10	10	19.96	0.15

i) Construct the $\bar{X}$ and R control charts and determine whether the process is in control. Analyse any patterns or shifts in the charts.
ii) Estimate the process standard deviation (σ) using the R chart.
iii) Compute the Process Capability Index (Cp) and the Process Capability Performance Index (Cpk) and evaluate whether the process is capable of consistently meeting the specification limits.

13 (a) (i)	Given a standard single sampling plan of n = 125 and c = 2, analyze how this plan conforms to a specific AQL and LTPD. Use binomial distribution to support your conclusion.	7	3	3
(ii)	**analyse** the significance of AQL and LTPD in designing a sampling plan **and explain** with an example how both affect the risks in quality decisions.	6	3	3
	OR			
13 (b) (i)	A manufacturer must ensure AOQL does not exceed 2%. **Analyse** whether a single sampling plan with n = 100, c = 1 meets this requirement. **Show** calculations and reasoning.	7	3	3
(ii)	**Compare** AOQL (Average Outgoing Quality Limit) with AQL. **Analyse** how AOQL is affected in a rectifying inspection setup.	6	3	3
14 (a) (i)	A batch of 500 LED bulbs was tested for 200 hours. During the test, 10 bulbs failed at 30 hours, 5 bulbs failed at 70 hours, 5 bulbs failed at 150 hours, The remaining 480 bulbs survived the entire 200-hour test duration.(a) Estimate the Mean Time to Failure (MTTF).(b) Assuming an exponential distribution of failures, calculate the reliability of a bulb at 100 hours.	7	4	4
(ii)	**Analyse** the significance of the bathtub curve in reliability engineering. **Discuss** its three phases with examples from real-world systems.	6	4	4
	OR			
14 (b) (i)	A system has an exponential time-to-failure distribution with a constant failure rate of λ=0.002failures/hour. (a) Compute the hazard rate, failure density function, and reliability function. (b) Determine the conditional reliability that the system will operate for another 50 hours, given that it has already operated	7	4	4

<table>
<tr><td></td><td>without failure for 100 hours.
(c) The Mean Time To Repair (MTTR) is 2 hours. Compute the Availability and Maintainability of the system at 5 hours.</td><td></td><td></td><td></td></tr>
<tr><td>(ii)</td><td>Analyse the differences between Maintainability and Reliability, and explain how both impact system performance and lifecycle cost.</td><td>6</td><td>4</td><td>4</td></tr>
<tr><td>15 (a) (i)</td><td>A system has 5 components connected as follows: Components A, B, and C are in series; Components D and E are in parallel, and the parallel unit is connected in series with the first three. Reliabilities of the components are: R_A=0.95, R_B=0.90, R_C=0.92, R_D=0.88, R_E=0.85.
(a) Determine the overall system reliability.
(b) If the reliability of component B is improved to 0.98, calculate the new system reliability. (c) Analyze the impact of this improvement.</td><td>7</td><td>4</td><td>4</td></tr>
<tr><td>(ii)</td><td>A machine fails due to 6 types of causes. The frequency of failures over a month is recorded below:
<table><tr><th>Cause</th><th>Frequency</th><th>Cause</th><th>Frequency</th></tr><tr><td>Bearing wear</td><td>28</td><td>Overheating</td><td>7</td></tr><tr><td>Motor fault</td><td>18</td><td>Gear failure</td><td>6</td></tr><tr><td>Power loss</td><td>12</td><td>Sensor fault</td><td>4</td></tr></table>(a) Construct a Pareto table and identify the vital few causes.
(b) If corrective actions improve bearing wear reliability by 50%, estimate the impact on system reliability, assuming each failure mode contributes proportionally to unreliability.</td><td>6</td><td>4</td><td>4</td></tr>
<tr><td colspan="5">OR</td></tr>
<tr><td>15 (b) (i)</td><td>A system has 3 identical components, each with a reliability of 0.85. These components are used in an active parallel redundant configuration (i.e., all operate simultaneously and any one is sufficient for success).
(a)Compute the system reliability.
(b) If you are allowed to add one more redundant unit, should you choose active or standby redundancy for maximum improvement? Justify with calculations assuming the standby unit has the same reliability and perfect switching.
(c) Analyze the trade-off between reliability gain and system complexity.</td><td>7</td><td>5</td><td>4</td></tr>
<tr><td>(ii)</td><td>A power system fails if both the main power and backup generator fail, or if both the control system and cooling unit fail.
The component reliabilities are: R_{main}=0.95; R_{backup}=0.90; $R_{control}$=0.92; $R_{cooling}$=0.93.
(a) Draw the fault tree and identify the minimal cut sets.
(b) Compute the system reliability using the inclusion-exclusion principle.
(c) analyse which failure combination contributes most to system unreliability.</td><td>6</td><td>5</td><td>4</td></tr>
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PART- C(1x 15=15Marks)

Q. No	Questions	Marks	CO	BL
16.	A company receives large lots of ball bearings from a supplier and uses Acceptance Sampling to decide whether to accept or reject each lot. The following data applies: i. Lot size: N = 2000 units ii. Inspection level: General II iii. AQL: 1.5% iv. Sampling plan: Single, Double, and Multiple sampling plans are being evaluated. **Single Sampling Plan:** Sample size = 80 ; Acceptance number = 2 ; Rejection number = 3 **Double Sampling Plan:** First sample = 50 units, acceptance number = 0, rejection number = 3 If not decided, take a second sample = 50 more units (total 100), then accept if cumulative defectives ≤ 2, reject if ≥ 3 The supplier claims that **only 1%** of items are defective. Answer the following: a) **(Single sampling)** Calculate the **probability of lot acceptance** using binomial approximation. b) **(Double sampling)** Calculate the **probability of acceptance** of the lot using double sampling. c) Analyze and compare **OC (Operating Characteristic)** performance for both plans at 1% and 4% defect levels. d) Identify and explain **Producer's Risk (α)** and **Consumer's Risk (β)** in context.	15	3	5