§ Quality Management

ONE SHOT + PYQ SOLUTION

UNIT-1 – [Quality Concepts]

Topics :

1. Quality & its characteristic
2. Evolution of Quality Control
3. TQM
4. Quality concept in design & Review of design
5. Evolution of Prototype
6. Procurement
7. Quality in Sales & Service, Guarantee, analysis of claims
8. Inspection

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⇒ Quality :-

⇒ Quality is refers to the degree of excellence of something, often a high degree of it.

⇒ A definition of quality is "your focus on the satisfying your customer's needs

⇒ Quality characteristics :-

⇒ Quality characteristics are the properties of a product or a service that are required to satisfy the customers.

⇒ Quality of products depends upon various elements shape, size, physical or chemical properties.

⇒ Evaluation of Quality Control (QC)

⇒ Evaluation of Quality Control is a detailed and systematic process used to ensure that products, services, or processes meet specific quality standards and consistently deliver the desired outcomes

1. Establishment of Quality Standards

→ Define clear and measurable quality standards or benchmarks that products or processes must meet.

2. Data Collection
⇒ Gather data related to the quality of products, servies or processes

3. Monitoring and Measurement
⇒ Use tools and techniques to monitor quality in real time at specific stages of production

4. Analysis of Results
⇒ Analyze the collected data to identify trends, deviations or area of non-conformance

5. Corrective Actions
⇒ If quality issues are identified, implement corrective actions to address the root causes

6. Continuous Improvement
⇒ Use the insight gained from the evaluation to improve quality control process

7. Documentation and Reporting
⇒ Document all finding, actions taken, and outcomes of the evaluation process.

8. Audit and Review
⇒ Conduct regular audits or reviews of the quality control system to ensure it remains effective and aligned with organizational goals

⇒ TQM

⇒ TQM stands for total quality Management

⇒ TQM is the combination of three words

- Total → Made up of the whole
- Quality → Degree of excellence a product or services provides
- Management → Act, art, or manner of handling, controlling, directing, etc.

⇒ Total Quality Management is a way of running a business where everyone in the company works together to make sure everything they do is of the best quality.

1. **Focus on Customers** : Understand what customers want and make sure you delievers it.

2. **Involve Everyone** : Every employee, from top management to workers, plays a part in improving quality

3. **Improve Processes** : Continuously look for ways to make processes better, faster and more efficient.

4. **Make decisions based on facts** : Use data and feedback to solve problems and make improvements

5. **Build a Quality Culture** : Create an environment where everyones cares about quality and works together to achive it.

Q Describe the Quality concept in design. Explain the process of the "review of design".

Sol Quality in design means creating something that works well, meets user needs, and is reliable, safe and efficient.

=> Focus Area:
- Functionality, Usability, Safety, Durability, Asthetics.

=> Review of Design Process :-

1. Preparation :-
- Gather all design documents, plans and requirements
- Assemble a team of experts (designers, engineers, users, etc)

2. Check the Design :-
- Review the design against the goals and requirements.
- Look for errors, missing parts, or potential problems.

3. Discuss and Suggest Improvements :-
- Team members share feedback on what works and what doesn't.
- Suggest changes to improve the design

4. Make changes :-
- The design team implements the suggested improvements
- Fix errors or refine weak areas.

5. Final Approval :-
- Re-check the updated design to ensure all issue are resolved
- Approve the design if it meets all requirement

Q. Explain the dimensions of the quality?

Sol Dimensions of quality are following :-

1] Performance
2] Features
3] Durability
4] Reliability
5] Serviceability
6] Consistency
7] Safety
8] Time
9] Customer Service

Q Explain the process of evolution of the prototype

Sol The process of evolving a prototype is a step by step journey where an initial idea is turned into working model, tested, improved, and refined until it become the final product.

- **Define the Problem and Goals :-**
→ Understand what problem the product will solve and what is need to achieve.

- **Create the Initial Concept :-**
→ Sketch or describe the basic idea of the product

- **Build the First Prototype :-**
Create a simple, basic version of the product using inexpensive materials (like cardboard, clay or 3D printing)

- **Test the prototype :-**
Use the prototype to see how well it works and identify any problems

- **Gather Feedback**
Ask users or experts to try the prototype and share their opinions

- **Analyze and Improve**

. Build an Improved prototype

. Test Again

. Repeat the process

. Finalize the Design

Q Enumerate the various methods of procurement of products.

⇒ Procurement is the process of buying or obtaining goods and services for a business or organization

Steps in Procurements :

1] Identify Needs : Determine what product/service are required

2] Research Supplier : Find vendors who provide what's needed.

3] Compare options : Evaluate quality, price and delivery terms.

4] Negotiate & choose : Pick the best supplier and Finalize the deal

5] Place Order : officially request the product/service

6] Receive & Inspect : check if the delivery matches the order.

7] Make Payment : Pay the supplier as agreed

8] Record & Store : Update records and store items properly

⇒ Various methods of procurement :-

1. Direct Purchase
   - Buying directly from a supplier or manufacturer.

2. Competitive Bidding
   - Suppliers compete by offering the best price or terms

3. Request for Quotation (RFQ)
   - Asking suppliers to provide price quotes for specific products

4. Request for Proposal (RFP)
   - Asking suppliers to propose solutions for a specific need.

5. Framework Agreement
   - A long-term agreement with a supplier for repeated purchase

6. E-Procurement
   - Buying products online through digital platforms

7. Spot Buying
   - Purchasing products immediately at the current market price

8. Global Sourcing
. Buying products from international suppliers

9. Outsourcing
. Hiring an external company to provide products or services.

10. Leasing / Renting
. Renting products instead of buying them outright

11. Reverse Auction
. Suppliers bid to offer the lowest price of a product.

12. Consignment
. Paying for products only after they are sold or used.

Q Discuss the following terms
1] Quality in sales and Service
2] Gurantee
3] Analysis of claims

Sol Quality in Sales and Services :-
-> Delivering products or service that meet or exceed customer expectations
-> In Sales : Providing the right product, at the right price, and on time

- In Services: Ensuring the service is efficient, helpful, and meets customer needs

Guarantee :-

- A promise made by the seller to fix or replace a product if it has problem within a specific time.
- Builds trust and confidence in the product.

Analysis of claims

- Investigating customer complaints or issues to under-stand what went wrong and how to fix it.

Steps :-

- Listen to the customer's complaint.
- Check if the claim is valid
- Find the root cause of the problem
- Take action to resolve the issue

Q Differentiate between the term warranty and guarantee. How the claims are being analyzed?

Aspect	Warranty	Guarantee
Meaning	A written promise to repair or replace a product if it has issues within a specific period	A promise (written or verbal) to fix, replace, or refund a product if it doesn't meet expectations
Duration	Usually longer (e.g 1 years, 5 years)	Usually shorter (e.g 30 days, 6 months
Focus	Focuses on product quality and performance.	Focuses on customer satisfaction and trust
Legality	Legally binding and often comes with terms and conditions	May or may not be legally binding
Example	A car - comes with a 3-year warranty for engine repairs	A short guarantees a full refund if the customer is unhappy with a product

How claims are analyzed (simple steps) :-

1. Listen to the customer :
→ Understand the complaint or issue they are facing.

2. Check validity :
→ Verify if the claim is valid.

3. Investigate the problem :-
→ Find out what went wrong (e.g product defect, misuse, or normal wear and tear).

4. Take action :
→ Resolve the issue based on the warranty / guarantee terms.

5. Learn and Improve :
→ Use the claim data to improve the product or service.

⇒ **Inspection** :-

⇒ After manufacturing, the product is required to perform certains functions.

⇒ The process of checking whether the product does so or not is called Inspection.

⇒ Objectives of inspection

1. Ensure Quality
   - Check if products or services meet the desired quality standards

2. Prevent Defects
   - Identify and fix problems early to avoid defective product.

3. Comply with Standards
   - Make sure product or processes follow industry rules and regulations

4. Reduce costs
   - Catch issues early to avoid expensive repairs or recall later.

5. Ensure Safety
   - check if products or processes are safe for workers and customers.

6. Build Customer Trust
   - Deliver high-quality products that meet customer expectations.

7. Improve Processes
   - Identify areas for improvement in production or service delivery

8. Meet Legal Requirements
- Ensure compliance with laws and regulations

9. Maintain Consistency
- Ensure all products or services are of the same high standard.

10. Support Decision - Making
- Provide data and insights to help managers make better decisions.

Types of Inspection methods :-

1] Revolving process, patrolling or floor inspection.
-> The revolving inspections helps to find error during the process and before the final product is ready.

-> It is more effective and not need to move the product to another department for checking.

2] Fixed Inspection :-
-> Find defects after the job has been completed.
-> When equipment and tools can not be brought on the workplace.

3] Key - point inspection :-
A key- point is a stage of production beyond which it requires an expensive operation or it may not rework.

Separates → Reject them from going to further processing

↓

Thus avoid unnecessary futher expenditure on those poor and substandard product

→ It reduces the cost of production

4. Final Inspection :-

destructive and non-destructive testing → Tensile testing, Impact testing, Fatigue testing, etc.

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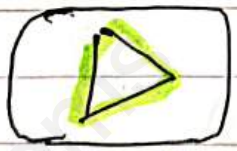

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UNIT-2 [Quality Management]

Topics:

1. Organization structure and design
2. Quality function
3. Economics of quality value and contribution
4. Quality cost
5. Optimizing Quality cost
6. Human factors in quality Attitude of top management
7. Apparatus error

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Q What is Quality Management ? Diswss its various functions in detail ?

Sol Quality Management is a systematic approach to ensuring that products, services and processes meet or exceed customer expectations and industry standards

- It involves planning, controlling, and continuously improving quality to achieve efficiency, consistency and customer satisfaction

Function of Quality Management :-

1. Quality Planning

→ This is the first step where a company decides what quality standard are needed
→ It involves setting clear goals
→ Companies define how to achieve these goals by choosing the right materials, process and trainning

2. Quality Control

→ QC involves inspecting and testing products to find and fix defects before they reach customers.
→ Workers check sample from production lines to ensures they meet quality standards.
→ If a problem is found, production is stopped, and corrections are made

3. Quality Assurance (QA)

→ QA focuses on preventing mistakes by improving processes rather than just fixing defects.

→ It ensures that systems and procedures are followed correctly to maintain consistency

4. Quality Improvement

→ This is an ongoing process of finding ways to make products, service, or processes better.

→ Companies use customer feedback, data analysis and new technologies to improve quality over time.

Organisation Structure

⇒ Organisation structure is the systematic arrangement of human resources in an organization so as to achieve common business objectives.

⇒ Quality Management requires a well-defined organizational structure to ensure product / servies meet standards

⇒ The organizational structure also determines how information flows between levels within the company

⇒ Design of an Organisation

1) **Define Quality objectives**

- Quality objectives are specific, measurable goals set by an organization to ensure its products, services, and processes meet desired standard.
- Eg Zero defects

2) **Choose the organizational Structure**

Common Quality Management Structure

A) **Functional** Structure
- Department (Production, QA, HR) work separately but follow central QM policies
- Best for: Small to medium businesses

B) **Divisional** Structure
- Each product line/ branch has its own QM team
- Best for: Large companies with diverse products

C) **Matrix** Structure
- Employees report to both department heads and QM leaders
- Best for: Complex projects needing cross-department coordination

D) **Process - Based** Structure
- Teams are organized around key processes (e.g "order Fulfillment", "Customer Support").

. Best for : Companies focused on workflow efficiency

3) Assign Role and Responsibilities

Role	Responsibility
Top Management	Sets QM vision, approves budget
Quality Manager	Oversees QC/QA, trains employ
QC Inspector	Test products, report defects
QA Team	Audit processes, ensure compliance
Employees	Follows QM guidelines in daily work

4) Implement Communication channels

-> Regular meetings between departments
-> Digital tools (e.g ERP, QMS software) for real-time updates.

5) Continuous Improvement

-> Collect feedback from employees & customers.
-> use data (e.g defect reports) to refine processes

-> Q Write a note on the organization structure and design of quality Management ?

⇒ Types of Organizational Structure

1. Functional Structure :

→ Employees are grouped by their skills (e.g, marketing, Finance, Sales)
→ Each department has an expert leader.
→ Decision making is centralized.
→ Poor communication between departments.

Best for : Companies needing efficiency and specialization

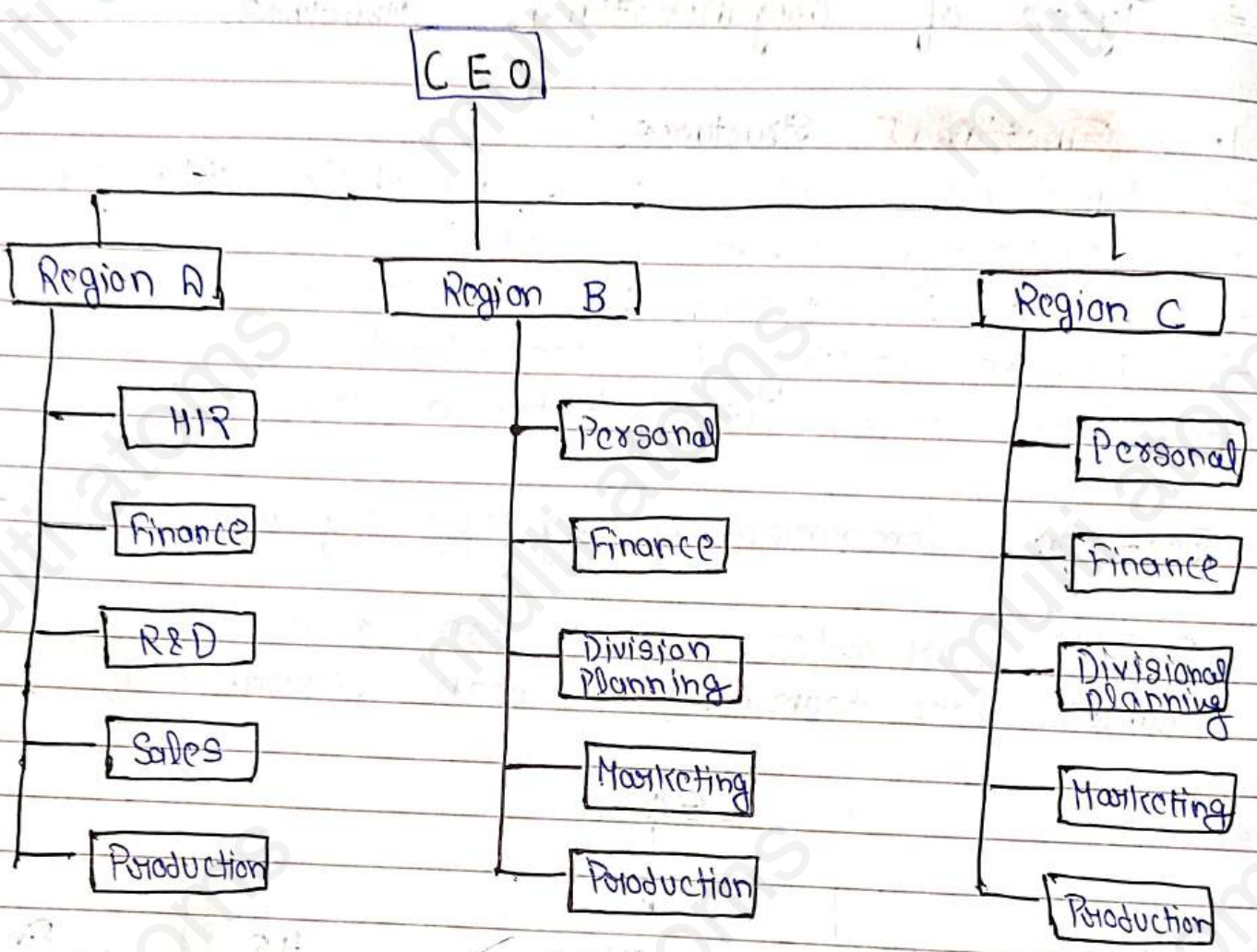
Pros : Clear roles, specialization, efficiency.
Cons : Poor teamwork between department.

2. Divisional Structure :

→ Company is divided into separate units based on product, region, or market
→ Each unit has its own teams (marketing, Sales, etc)
→ Each division operates somewhat independently

Best for : Large companies with multiple products.

Pros : Better market focus, flexible, faster decision-making
Cons : Duplicated work, poor communication



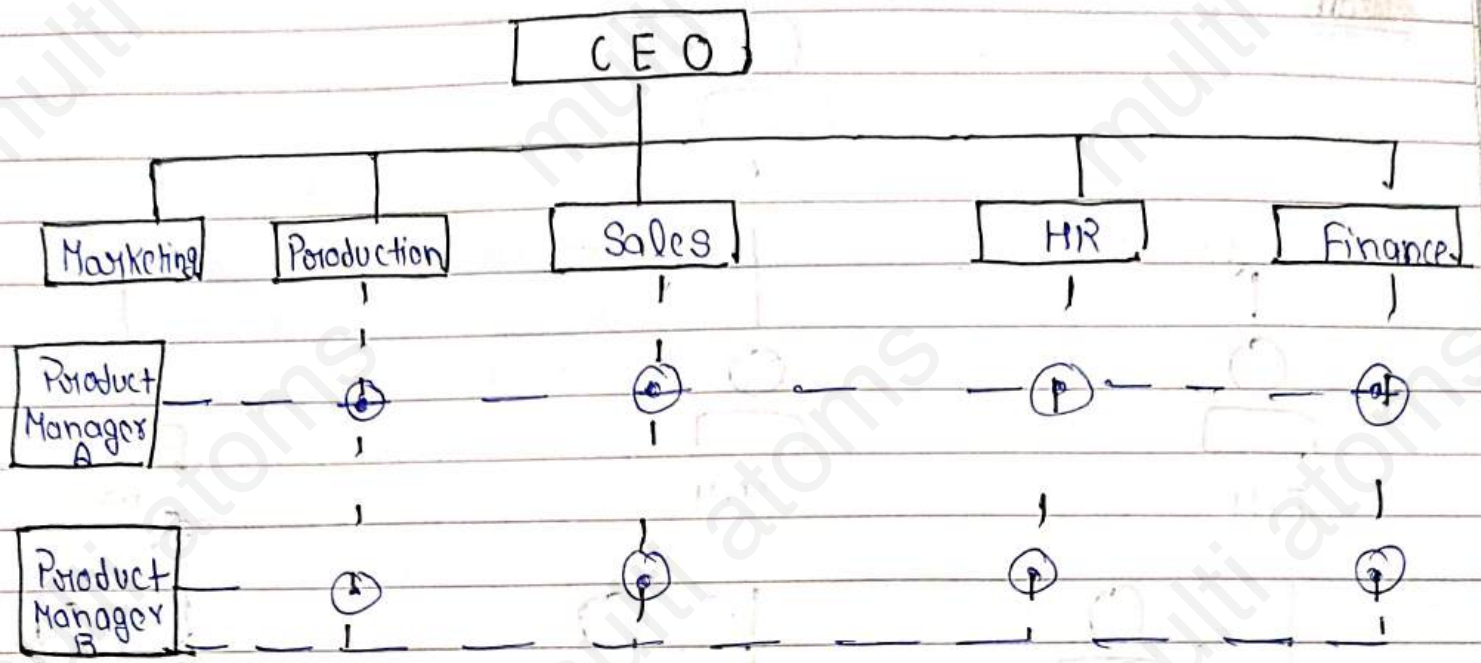
3. Matrix Structure:

- Employees report to multiple managers
- Encourage teamwork across department
- Can cause confusion on authority

Best for: Companies needing both specialization and teamwork

Pros: Flexible, faster project completion.

Cons: Confusion in leadership, conflicts, frequent changes



4. Team-Based Structure

- Employees work in small teams with shared goals.
- Teams make decisions without outside approval.
- Works well in fast-changing industries

Best for: Startups, tech companies, creative industries

Pros: Fast decisions, innovation, collaboration.

Cons: No clear boss, unclear career growth.

5. Network Structure

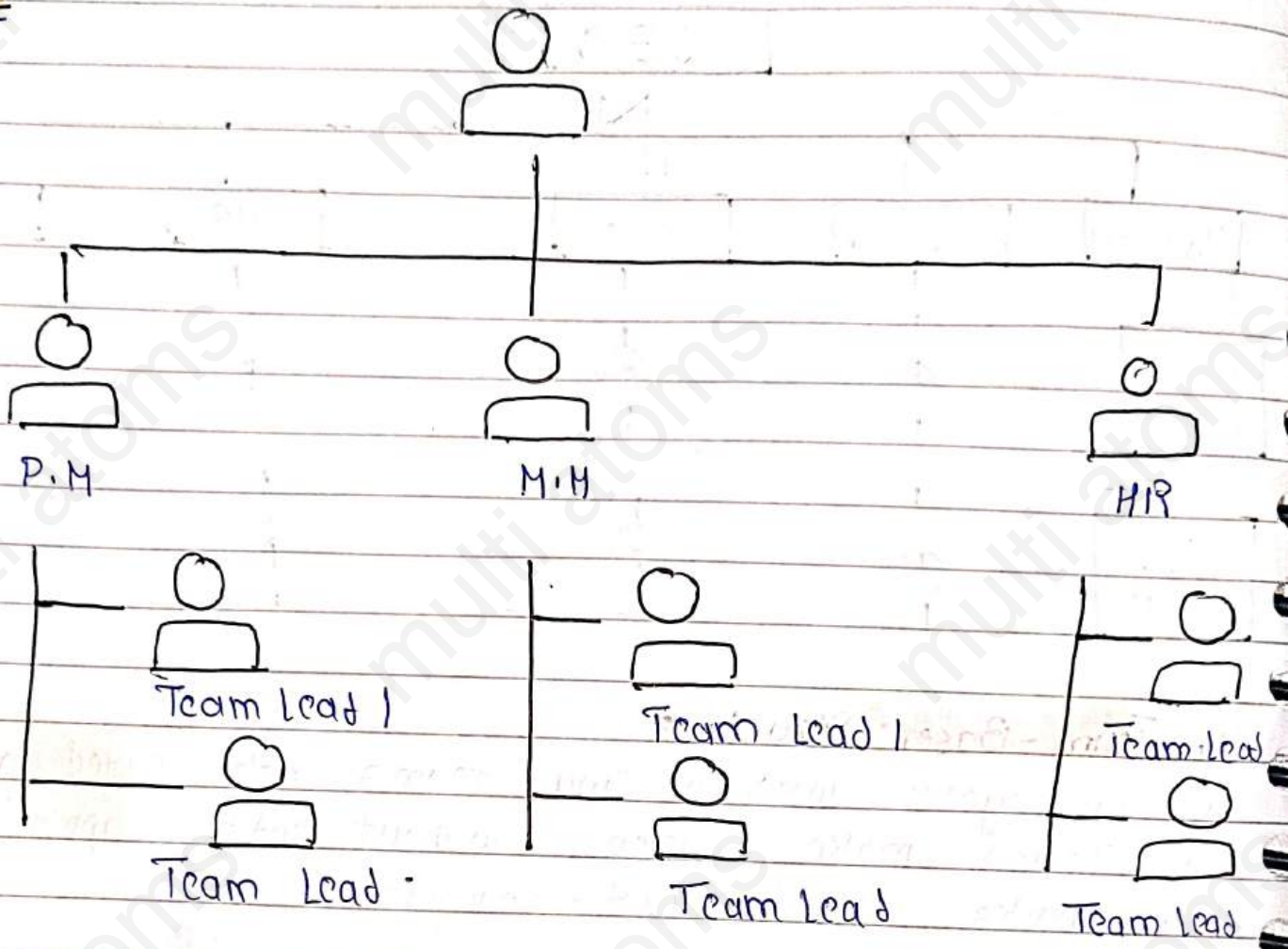
- Uses both in-house employees and external partners.
- Focuses on outsourcing work to specialists
- Flexible but hard to change.

Best for: Companies relying on outsourcing.

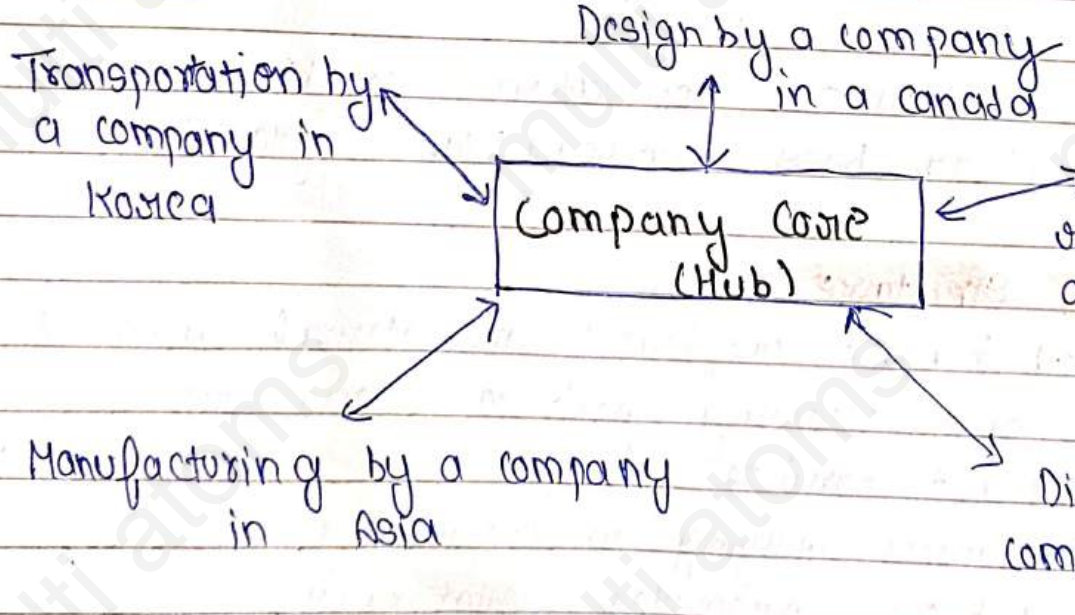
Pros: Adaptables, promotes collaboration

Cons: Complex, unclear authority, high turnover

Team



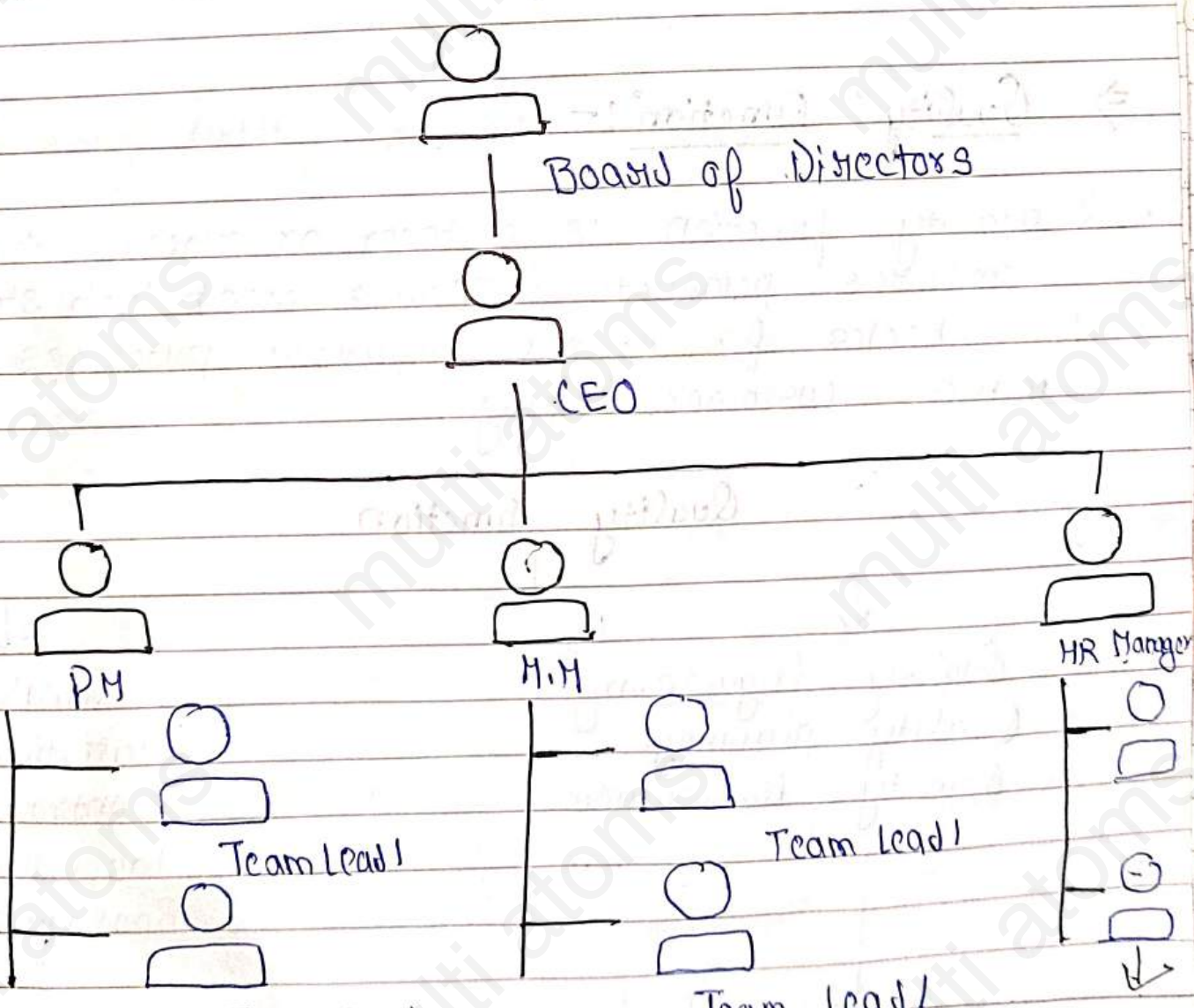
Networks



6. Hierarchical Structure

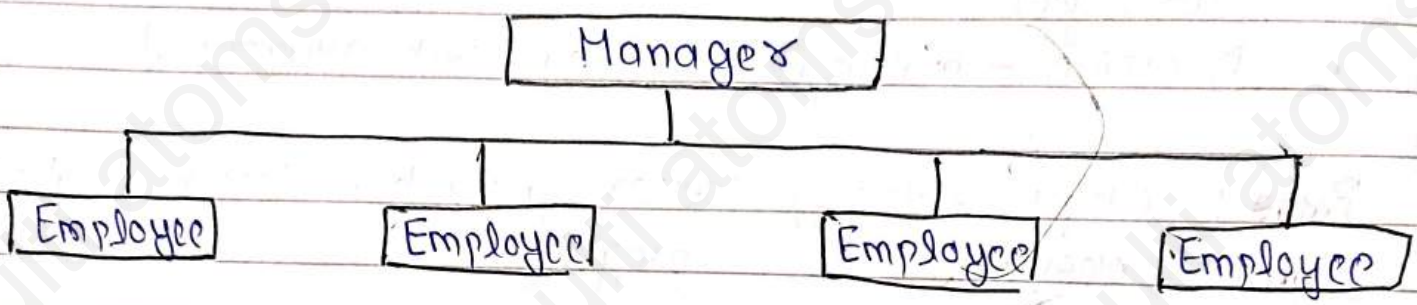
- Traditional pyramid-shaped structure with clear authority.
- CEO at the top, followed by managers, then employees
- Decision-making is slow but organized.

Pros: Clear roles, career growth, strong leadership
Cons: resistant to change



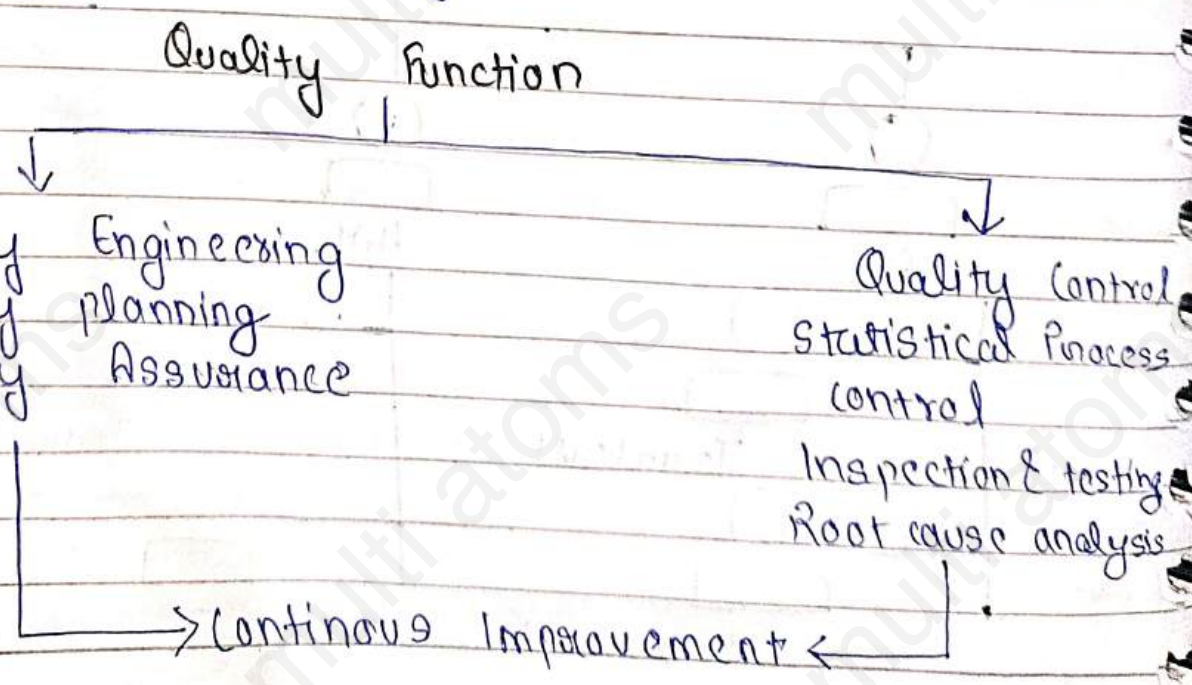
7. Flat Structure :

- Few or no middle ; employees work closely with top leaders
- Encourages open communication and fast- decision making
- Hard to scale as the company grows



⇒ Quality Function :-

- A quality function is a team or process that ensures products / service meet high standards
- It checks for errors, improve processes, and makes customer happy



Q Explain Quality Function and the process of deployment of quality function in an organization.

Sol Steps to deploy Quality function in an organization

1. Understanding customer needs
   - Collect feedback from customer
   - Identify what they expect in term of quality, price and service

2. Setting Quality Standards
   - Define clear rules for quality
   - Set benchmarks that product or services must meet

3. Planning for quality improvement
   - Identify weak areas in production or service
   - plan ways to improve quality at every stage

4. Trainning Employees
   - Educate employees on quality standards.
   - Teach them how to maintain and improve quality

5. Implementing Quality Control Measures
   - Use tool like QFD to check quality
   - Regularly test product and processes

6. Monitoring and Continuous Improvement
- Keep checking for quality issues
- Improve process based on feedbacks and analysis

7. Customer satisfaction checks
- Ask customer if they are happy with the quality
- Make change if needed to keep them satisfied

=> Decentralized Quality :-
- Instead of one central quality team, each department handles its own quality check.

Example :- Production team checks their own work, not just a separate QA team

Q Explain the economics of quality of conformance.

Sol. It means ensuring that a product or service meet design specification without defects
- The goal is to produce items exactly as planned, reducing error and rework

=> Cost of Conformance :
This include the costs incurred to ensure products or services meet quality standards

- Prevention costs : Money spent on avoiding defects

Ex trainning, better materials

- **Appraisal costs**: Money spent on checking quality
  Ex testing, inspection

→ Investing in these areas reduces defect and save money in the long run

⇒ Cost of Non-Conformance:
This refers to the costs associated with products or service failing to meet specification

- **Internal failure costs**: Losses from defects before reaching customer (e.g rework, scrap)

- **External failure costs**: losses when defects reach customer (e.g returns, complaints, legal issues)

- Poor quality leads to higher costs, bad reputation and loss of customers

⇒ **Economics of Quality value**:-

- Quality value refers to the balance between cost and quality that provides the best benefits to customers and business

- It ensures that a products or service is worth its price and meets customer expectations efficiently

⇒ Economic Impact of Quality value
→ Higher quality Increases value
→ Low Quality reduces value

Q Explain the following with example

(i) Quality value and Contribution
(ii) Quality cost and its optimization

Quality Value

- Quality value refers to the benefits a company gains by delivering high-quality products/services.

It includes:

- customer satisfaction → Happy buyers return and recommend
- Brand reputation → Trust leads to more sales
- Competitive edge → Stand out from rivals.

Quality Contribution

- Quality Contribution highlights how the quality positively impacts the organization's performance and success.

Such as

Higher Sales → fewer returns, more repeat purchas
lower cost → Less waste, fewer repairs
long-term growth → strong brand loyalty

=> **Quality Cost** :-

. The total money spent to ensure good quality.

. It encompass all expenses associated with achieving and maintaining quality, including costs related to preventing poor quality, assesing quality, and addressing failures

. It includes :-

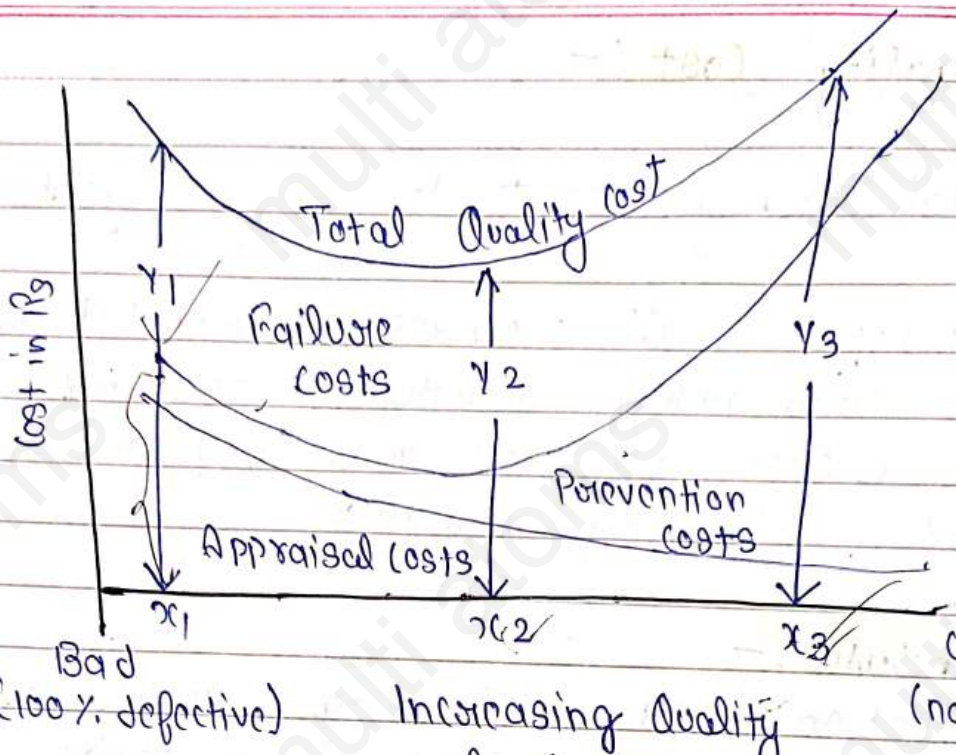
-> Prevention costs - Trainning, quality planning, material
-> Appraisal costs - Testing, inspection, audits
-> Internal failure costs - Rework, scrap, fixing defects
-> External failure costs - warranty claims, return, lost reputation

=> **Quality cost optimization** :-

⊙ The goal is to reduce failure costs by investing more in prevention and appraisal.
⊙ Balancing cost and quality leads to long-term saving and better customer satisfaction

Steps

. Focus on Prevention
. Improve Appraisal processes
. Reduce internal failure
. Proactively address external failure
. Data analysis and continuous Improvement



Q Enumerate the various steps to be taken in the planning of cost reduction programs

Sol Steps for planning a cost Reduction Program

1] Analyze current costs
- Identify all major expenses in production, operations and administration
- separate necessary costs from avoidable costs

2] Set cost Reduction Goals
- Define clear objectives
- Ensure goals align with business strategy.

3] Identify Cost-Saving Areas
- Look for inefficiencies in materials, labor, energy and processes.
- Find alternative suppliers, automation, or process improvements

4] Use value analysis
- Evaluate whether each cost adds real value to the product/service.
- Eliminate unnecessary expenses without affecting quality.

5] Improve Operational Efficiency
- Streamline workflow, reduce waste and optimize resource utilization.
- Implement lean manufacturing or automation where possible.

6] Employee Involvement & Training
- Encourage employees to suggest cost-saving ideas
- Train staff on efficient practices and waste reduction

7] Monitor & measure Performance
- Track progress using key performance indicators.
- Compare actual savings with planned targets

8] Review & Continuous Improvement.

Q Contrast the statement "Quality is free". If some organization is investing capital to achieve quality standards then how quality is free in long run.

Sol The famous statement "Quality is Free" comes from Philip B. Crosby, meaning that preventing defects costs less than fixing them later.

⇒ While investing in quality standards initially requires capital, the long-term benefits of "quality is free" stem from reduced cost associated with rework, scrap, and customer returns, ultimately leading to increased efficiency, customer satisfaction and a stronger brand reputation

Q Contrast the role of human factor in quality Attitude of top management. Also explain how the leadership attitude of top management affects quality

Contrasting the role of human factor in Quality vs Attitude of Top Management.

Aspect	Human factor in Quality	Attitude of Top Mant
Definition	The behavior, skills, and mind set of employees in maint aining quality	The commitment, vision, and priorities set by leadership towards quality
Focus	Day-to day execution of quality practices by workers	Strategic direction, resource allocation and culture-setting for quality
Impact	Directly affects product/ service quality at the operational level	Shapes the entire organizational approach to quality
Example	A factory workers double checking product dimension	The CEO mandating "zero Defects" as a company policy

How Leadership Attitude Affects Quality

1. Sets the Tone for Quality culture
   - If top management prioritizes quality, employees take it seriously
   - Negative Example: If leaders focus only on cost-cutting

workers may skip quality checks to meet targets

2. Drives Resource Allocation
- leaders decide budgets for trainning, tools and inspection
- Good leadership :- Invest in automation to reduce human errors.
- Bad leadership :- Buy cheap materials, increasing defect risks

3. Influence Employee Motivation
- when leaders reward quality efforts, employees strive for excellence.

4. Determines Long-term strategy
- Leaders decide whether to compete on price or quality

5. Ensures Accountability
- strong leadership tracks quality metrics and holds teams responsible.

Q What do you mean by house of quality? Explain it with the help of figures

Sol The House of quality is a core tool in Quality Function Deployment (QFD) that translate customer needs into technical requirements.

=> Many managers and engineers consider the house of quality to be the primary chart in quality planning.

⊡ The parts of the house of quality are :-

a. The exterior walls of the house are the customer requirements.

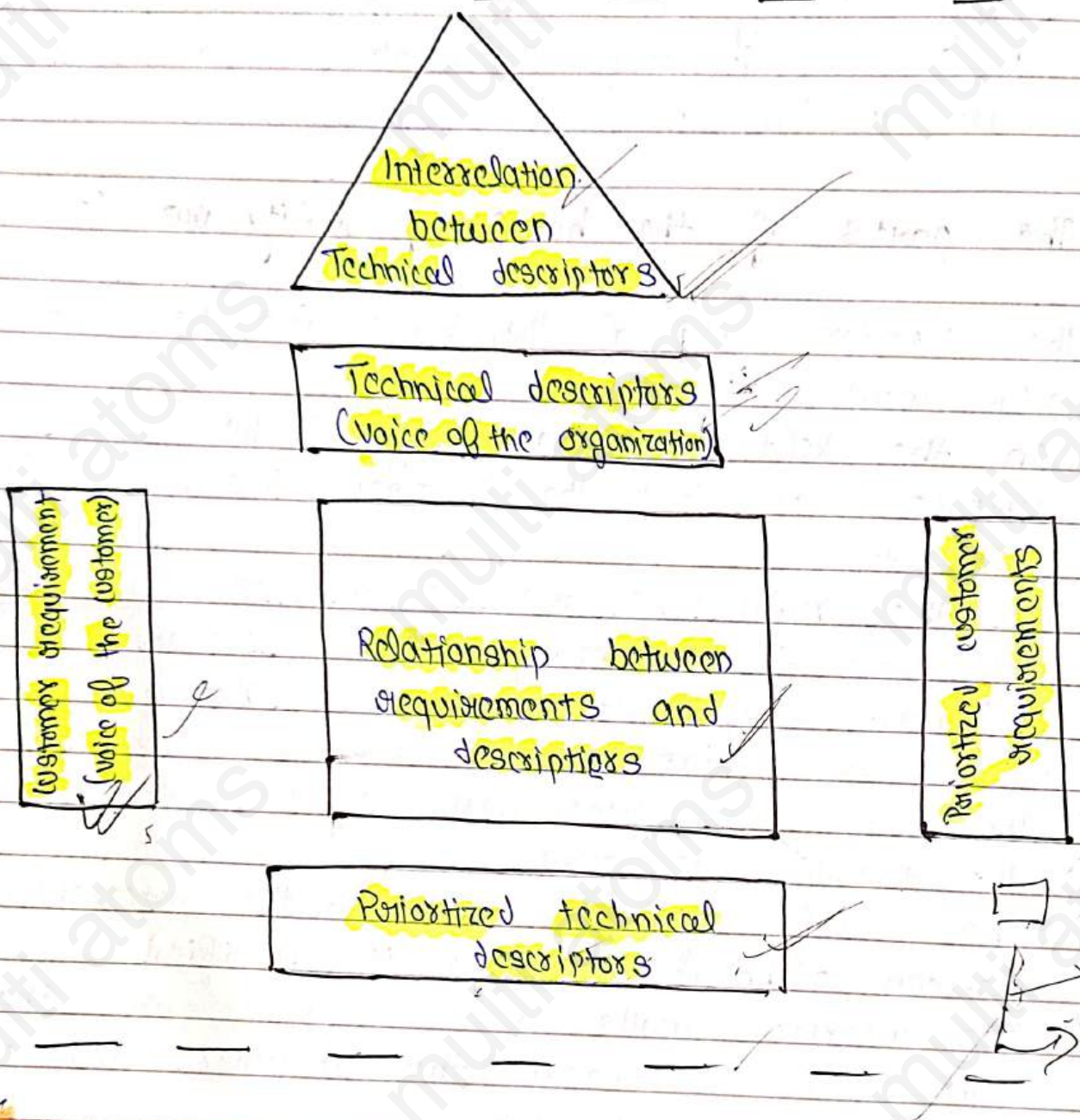
b. On the left side is a listing of the voice of the computer, or what the customer expects in the product.

c. On the right side are the prioritized customer requirements, or planning matrix. such as, benchmarking, customer importance rating, target-value and sales point.

d. The ceiling or second floor, of the house contains the technical descriptors.

e. The roof of the house is the interrelationship between technical descriptors is identified

f. The interiors walls of the house are the relationship between the customer requirement and technical descriptors



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⇒ Apparatus Error and its Corrective Methods

Apparatus error occur due to faults in measuring instruments, leading to inaccurate results.

Cause of Error	Corrective Method
Calibration issues	Regular recalibration with standards
Wear and tear	Replace worn parts; preventive maintenan
Environmental factors	Control lab conditions; use shields
Human handling errors	Trainning : automated tools
Electrical faults	Stabilize power ; check batteries
Design limitations	Upgrade to higher-precision instrument
Contamination	clean and store properly
Softwasre errors	Update firmwasre ; verify data

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UNIT-3 [Control charts]

Topics:

1. Histogram
2. Pareto Diagram
3. Control charts
4. Shewhart Control charts
5. R-chart
6. X bar chart
7. Process capability Study
8. Acceptance Sampling by Attribute Vs Variable
9. P-chart
10. C-chart

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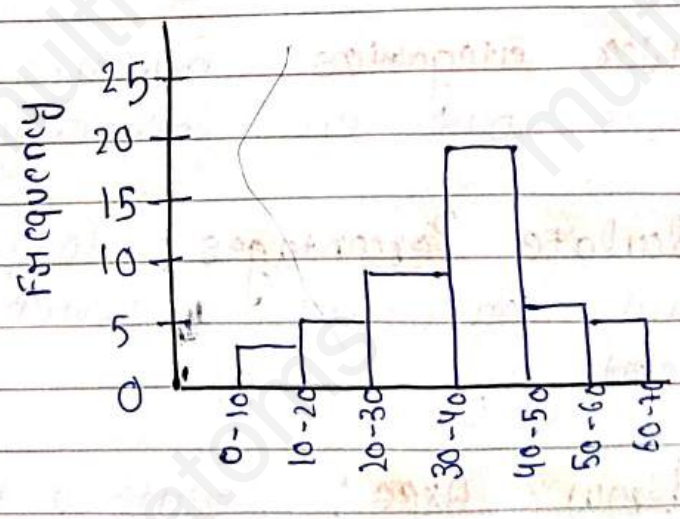
Histogram :-

- A histogram is a type of graph that shows the distribution of data.
- It consist of bars that touch each other to show continuous data.
- The X-axis represent data ranges (intervals)
- The Y-axis represent frequency (count of values in each range)
- Height of bars show many values fall into that range
- Bars are touching because data flows continuously
- Used to analyze large data set and pattern easily
- Commonly used in statistics, research and exams

Eg

Class Marks	Frequency
10-20	3
20-30	5
30-40	9
40-50	19
50-60	6
60-70	5



Q Explain Pareto diagram and how it is constructed.

Sol A pareto Diagram (or Pareto chart) is a special type of bar graph that help identify the most important problems or cause in a process.

-> It follows the 80/20 rule (Pareto principle)
-> 80% of problems come from 20% of cause.

=> Steps to Construct a Pareto Diagram :-

1] Identify Categories : Determine the categories (e.g defect types).

2] Collect Data : Gather frequency or impact data for each category.

3] Order Categories : Arrange categories in descending order based on frequency or impact.

4] Calculate Percentages : Compute the percentage and commulative percentage for each category.

5] Draw Axes : Create a horizontal axis for categories and a vertical axis for frequency or impact

Include a right vertical axis for cumulative percentage.

6] **Draw Bars**: Plot bars for each category based on frequency or impact

7] **Plot Cumulative line**: Plot and connect points for the cumulative percentage.

8] **Label the chart**: Add titles and labels to the axes, bars, and cumulative line.

Eg Collect Data

Ex: A pizza shop tracks customer complaints for a week

-> late delivery — 40 times
wrong order — 25 times
cold pizza — 15 times
Burnt crust — 10 times
Missing toppings — 5 times

2] Sort Data from Highest to lowest

1 Late delivery = 40
2 Wrong order = 25
3 Cold pizza = 15
4 Burnt Crust = 10
5 Missing toppings = 5

3) Calculate Cummulative Percentage

. Total complaints = 40 + 25 + 15 + 10 + 5 = 95

. calculate Cumulative Percentage = Next step

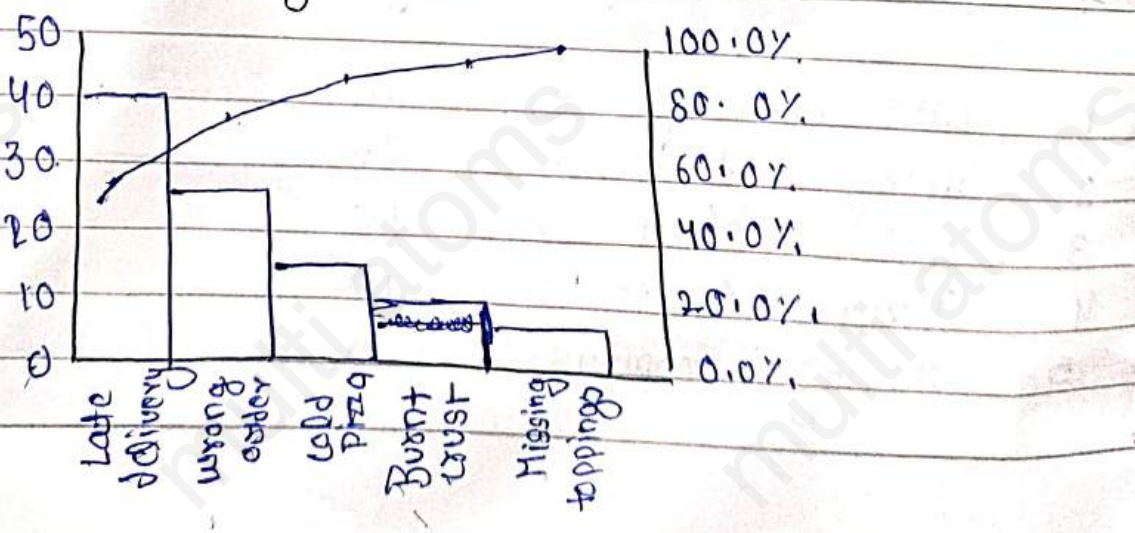
Taculate % for each problem

→ Late delivery = (40/95) x 100 = 42.1%
Wrong order = (25/95) x 100 = 26.3%
Cold pizza = (15/95) x 100 = 15.8%
Burnt crust = (10/95) x 100 = 10.5%
Missing toppings = (5/95) x 100 = 5.3%

4) Cummulative % [Add up as you go]:

→ Late delivery = 42.1%
Wrong order = 42.1 + 26.3 = 68.4%
Cold pizza = 68.4 + 15.8 = 84.2%
Burnt crust = 84.2 + 10.5 = 94.7%
Missing toppings = 94.7 + 5.3 = 100%

5) Draw the Pareto diagram



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Process Capability Study :-

- A process capability study checks how well a process can make products within set limits.
- It tells us wheather a process is good enough to produce quality products consistently

How does it work ?

1. Set Limits (specifications)
   - Every product has a lower limit (LCL) and an Upper Limit (UCL)
2. Measure the process Output
   - Take samples of the product and measure their actual size
3. Compare with Limits
   - If most products fall within the limits, the process is capable
   - If many products are outside the limits, the process needs improvement

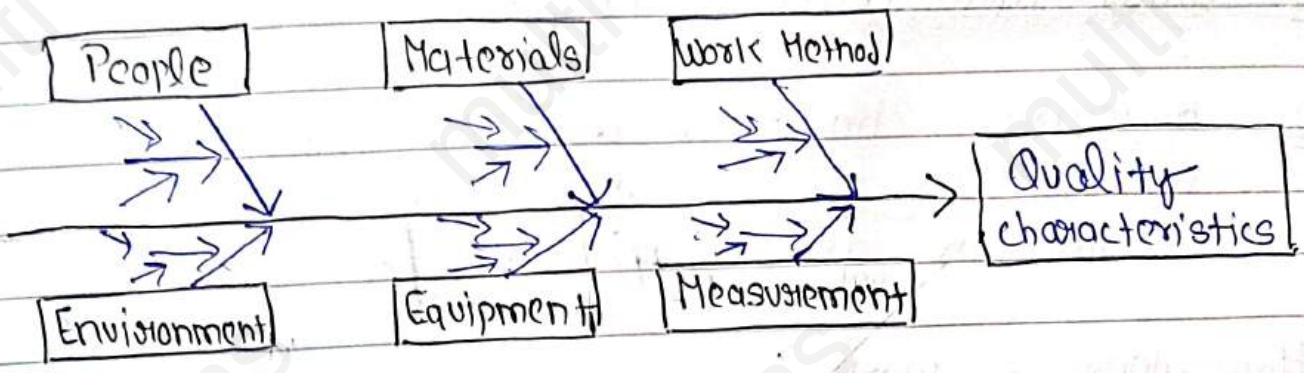
⇒ **Check sheets:**

- The main purpose of check sheets is to ensure that the data is collected carefully and accurately by operating personnel.
- Data should be collected in such a manner that it can be quickly and easily used and analyzed

	check sheet	
Product: Bicycle 32, Defect type	Number inspected: 2217 check	
Blister	𝍸 𝍸 I	11
light Spray	𝍸 III	8
Drips	𝍸 𝍸 𝍸 III	18
OverSpray	II	2

⇒ **Cause and Effect**

① A cause and Effect Diagram (also called fishbone Diagram or Ishikawa Diagram) is a tool that helps you find all possible reasons behind a problem



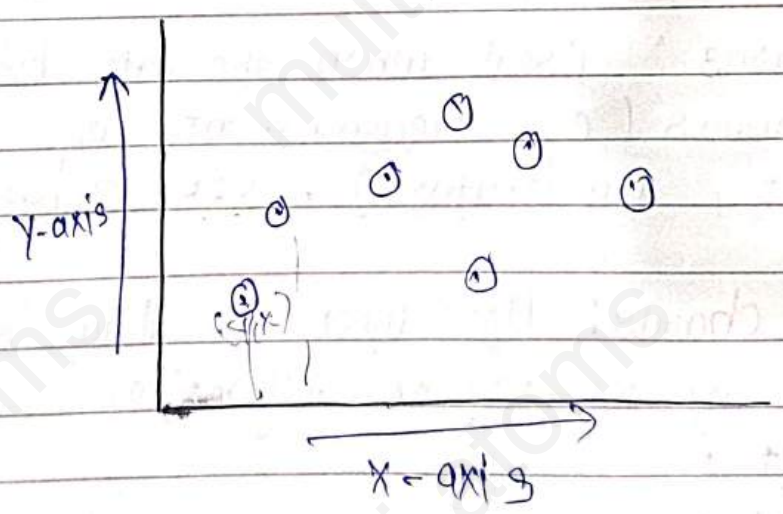
⇒ Scatter Diagram

- A scatter diagram is a graph that displays values for two variables using cartesian coordinates.
- Each point represent a single data observation

Purpose:

- Identify relationship between two variables.
- Visualize data trends and patterns
- Detect correlations (+ve, -ve or none)

⇒



MULTI ATOMS

Q What are control charts? Discuss

Sol A control chart is a graph that helps you monitor a process over time to check if it's stable or going out of control.

How does it work?

step-1 Collect Data over time

step-2 plot the data

step-3 Draw key lines
1 Center Line (CL)
2 Upper control Limit
3 Lower control Limit

Types

- Variable charts: Used when the data being monitored is continuous (e.g measurements of length, weight, temperature). X-R Chart;
- Attribute charts: Used when the data is discrete (e.g count of defects or defective).
  -> P-Chart.
  -> C-Chart.

⇒ Shewhart Control Charts :-

- A shewhart control chart is a special type of graph used in industries to monitor a process and check if it is stable or has problem.
- It helps detect errors or variations in a process before they cause major defects

Key Components

1 Center line (CL) : Average value of the process
2 Upper Control Limit : Maximum acceptable limit
3 Lower Control Limit : Minimum acceptable limit

Types of Shewhart Control charts :-

- X-bar chart : Monitors the mean of samples
- R chart : Monitors the range of samples
- S chart : Monitors the standard deviation
- P chart : Monitors the proportion of defectives
- C chart : Monitors the count of defect per unit

Q Explain the construction of R charts. Discuss with some example

Q Explain the construction of Xbar and R control charts. where are they used?

Sol "R" stands for "Range". The range is simply the difference between the biggest and smallest values in a group of measurements

- An R chart tracks these ranges over time
- It helps us see if the amount of variation in our process is stable

construction:

Step 1: Sample numbers are taken along X-axis and range along Y-axis

Step 2: Find the average range for all the samples

$$\bar{R} = \frac{\Sigma R}{n}$$

where, n = Number of samples

Step 3: Find the control limits

Upper control limit = $D_4 \bar{R}$

Lower control limit = $D_3 \bar{R}$

Step 4: Draw the $\bar{R}$ and control limit on the graph

Step 5: Plot the points to represent the range values

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⇒ X Chart

- It shows changes in process average and is effected by changes in process variability
- It is the most commonly used variable chart.
- It is also known as mean chart

Construction

Step 1 : Samples $X_1, X_2 \ldots$ are drawn from the process

Step 2 : Find out the mean of each sample

$$\bar{X} = \frac{\Sigma X}{n}$$

Step 3 : Find the mean of sample means

$$\bar{\bar{X}} = \frac{\Sigma \bar{X}}{\text{No. of samples}}$$

Step 4 : Find the standard error of mean

Step 5 : The limits are

$$UCL = \bar{\bar{X}} + 3\sigma_{\bar{X}} = A_2\bar{R} + \bar{\bar{X}}$$

$$LCL = \bar{\bar{X}} - 3\sigma_{\bar{X}} = \bar{\bar{X}} - A_2\bar{R}$$

Step 6 - Sample number are taken along X-axis and mean value along Y-axis

Step 7 - Draw the control limits and plot the points to represent the mean values

Q. if a sample contains 5 items, whose diameter are d_1, d_2, d_3, d_4, d_5.

Sample No (Sample size - 5)	$\bar{X}$	R
1	7.0	2
2	7.5	3
3	8.0	2
4	10.0	2
5	9.5	3
	$\Sigma\bar{X} = 42.0$	$\Sigma R = 12$

Sample average

$$\bar{X} = \frac{d_1 + d_2 + d_3 + d_4 + d_5}{5}$$

R = Maximum diameter - minimum diameter

$$\bar{\bar{X}} = \frac{\Sigma\bar{X}}{\text{no. of samples}} = \frac{42}{5} = 8.5$$

$$\bar{R} = \frac{\Sigma R}{\text{no. of samples}} = \frac{12}{5} = 2.4$$

For $\bar{\bar{X}}$ chart

Upper control limit

$$UCL = \bar{\bar{X}} + A_2\bar{R}$$

Lower control

$$LCL = \bar{\bar{X}} - A_2\bar{R}$$

For R chart

Upper control limit (UCL) $= D_4\bar{R}$

Lower control limit (LCL) $= D_3\bar{R}$

The value of various factors (like A_2, D_4, D_3) based on normal distribution can be found from the following table.

Sample Size (No. of item in a sample)	A_2 Limit Avg	D_3 Range lower Limit	D_4 Range upper Limit
2	1.88	0	3.27
3	1.02	0	2.57
4	0.73	0	2.28
5	0.58	0	2.11
6	0.48	0	2.00
8	0.37	0.14	1.86
10	0.31	0.22	1.78
12	0.27	0.28	1.72

∴ Sample size is 5

So $A_2 = 0.58$

$D_3 = 0$

$D_4 = 2.11$

So For $\bar{X}$ chart

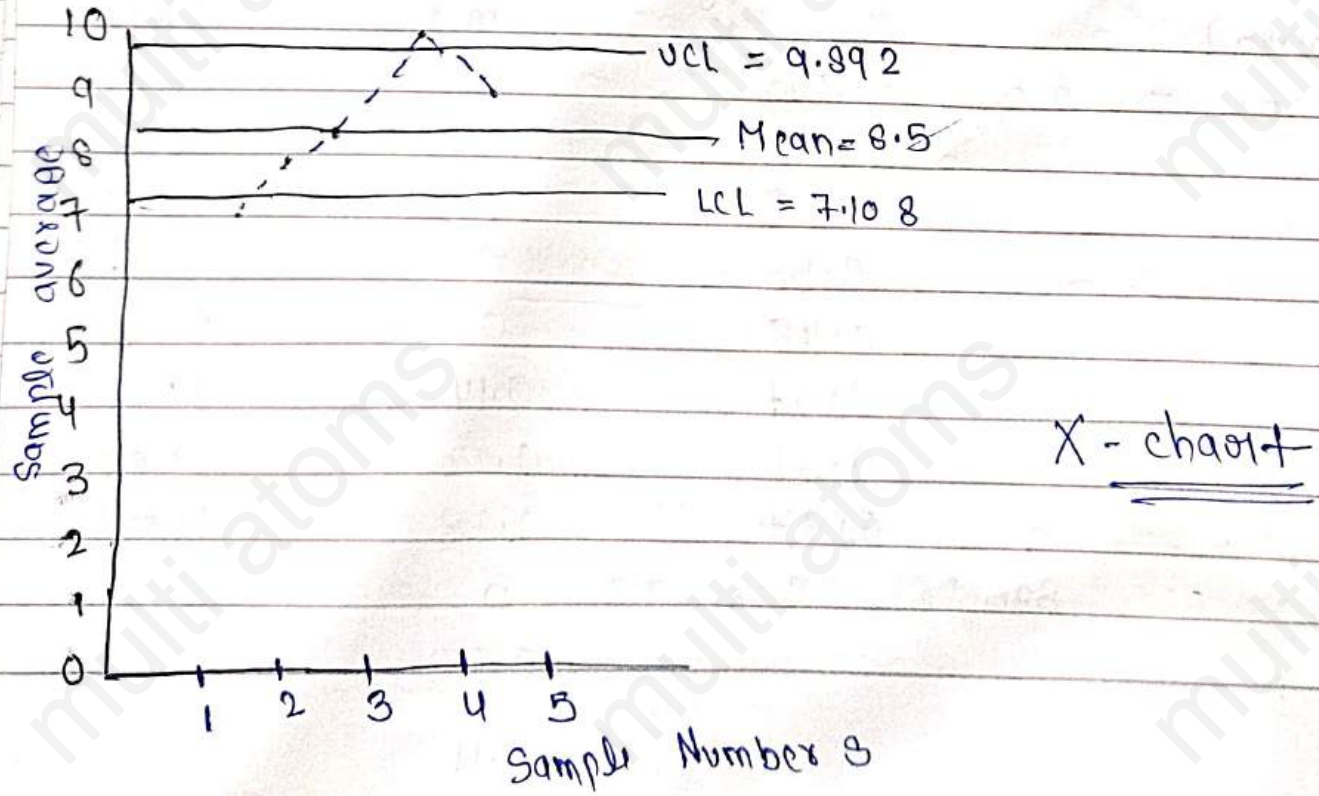
$$UCL = \bar{\bar{X}} + A_2\bar{R}$$
$$= 8.5 + (0.58 \times 2.4)$$
$$= 9.892$$

$$LCL = \bar{\bar{X}} - A_2\bar{R}$$
$$= 8.5 - (0.58 \times 2.4)$$
$$= 7.108$$

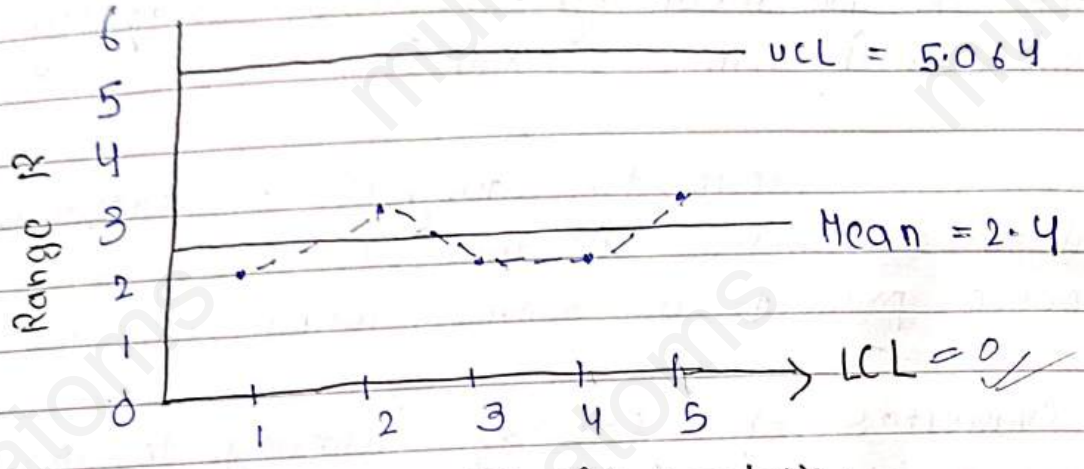
So For R chart

$$UCL = D_4\bar{R}$$
$$= 2.11 \times 2.4 = 5.064$$

$$LCL = D_3\bar{R}$$
$$= 0 \times 2.4 = 0$$



X - chart



R-chart

=> X-bar and R-charts are essential tools for monitoring process stability and variability across industries

- **Manufacturing**: Ensure product consistency by tracking dimensions, machine settings and quality
- **Healthcare**: Monitor wait times, infection rate, and procedural consistency
- **Service**: Control response times, order accuracy, and call durations.
- **Finance**: Track transition durations and financial reporting accuracy
- **Chemical Processing**: Maintain mixture consistency and reaction temperature.

Q What do you mean by process capability study? Diswss with some example.

- A process capability study is a statistical analysis used to determine whether a process can consistently produce products or services within specified limits.

- It evaluates the process's ability to meet customer requirements by measuring its natural variability and comparing it to pre-defined specifications

Key Terms

1. Specification Limits (Customer Needs):
- USL (Upper Spec Limit): Maximum allowed value
- LSL (lower spec limit): Minimum allowed value

2. Process Variation (Natural Spread)
- Measured by standard deviation (σ)
how much output vary (because of machine variability, material differences and human error).

3. Capability Indices (C_p, C_{pk}):- These are statistical measures that compare process variation to specification limits

- C_p (Process capability Index)- Measures the potential capability assuming the process is centered within the limits

$$C_p = \frac{USL - LSL}{6\sigma}$$

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- if $C_p \geq 1$, the process has low variability and is capable
- if $C_p < 1$, the process variation exceeds tolerance limits

- C_{pk} (process Performance Index) – Account for process centering and shift.

$$C_{pk} = \min\left(\frac{USL - \mu}{3\sigma}, \frac{\mu - LSL}{3\sigma}\right)$$

- if $C_{pk} \geq 1$, the process is well-centered and within limits
- if $C_{pk} < 1$, the process is off-target or has high variability.

Example Bottle Filling Process

Scenario: A juice factory fill bottles to 500ml ± 10ml

$$\begin{bmatrix} LSL = 490\,ml \\ USL = 510\,ml \end{bmatrix}$$

Step 1: Collect Data

Measure 100 bottles:

→ Average (μ) = 505ml

→ Standard Deviation (σ) = 3ml

Step 2:- Calculate C_p & C_{pk}

1. C_p (Process Potential):

$$C_p = \frac{USL - LSL}{6\sigma} = \frac{510 - 490}{6 \times 3} = 1.11 \text{ (Good)}$$

2. C_{pk} (Actual Performance):

$$C_{pk} = \min\left(\frac{USL - \mu}{3\sigma}, \frac{\mu - LSL}{3\sigma}\right) = \min\left(\frac{510 - 505}{9}, \frac{505 - 490}{9}\right)$$

$\Rightarrow$ 0.56 (Bad)

Step 3: Fix the process

- Problem: Average fill (505 ml) is too close to USL (510ml)
- Solution: Adjust machine to center at 500 ml.

Q How does the acceptance sampling by variables differ from that by attributes? Explain

Sol Acceptance Sampling is a statistical quality control technique used to determine whether to accept or reject a batch (or lot) of products based on the inspection of a sample.

1. Acceptance Sampling by Attributes:

1. Data Type: Attribute data is qualitative data that can be counted.
   - It focuses on whether a product or service conforms
2. Evaluation: Each item in the sample is classified as either "good" or "defective". Count, defective item

2. Acceptance Sampling by Variables:

1. Data Type: It focuses on the degree to which a product or service conforms to specifications.
2. Evaluation: Specific quality characteristics are measured for each item in the sample

Feature	Acceptance Sampling by Attribute	Acceptance Sampling by Variables
Feature :-		
Data Type	Qualitative (conform / does not conform)	Quantiative (measured on a continuous scale)
Evaluation	Counting the number of defective items	Measuring quality characteristics and using sample statistics
Sample Size	Generally larger	Generally smaller
Complexity	Simple	More complex
Information	Less informative	More informative
Cost / item	lower	higher
Assumptions	- Distribution - free	Assumes a specific distribution
Precision	Less precise	More precise

⇒ **P-chart** :-

P-chart is designed to control the proportion percentage or defectives per sample

⇒ Fraction defective (p) = $\frac{\text{Number of defective article}}{\text{Size of the sample}}$

Construction of p-chart :-

Step 1: Calculate the average fraction defective $\bar{p}$

Step 2: Compute σ, the standard error of $\bar{p}$

$$\sigma = \sqrt{\frac{\bar{p}\bar{q}}{n}} = \sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

Step 3: Calculate the upper control limit and the lower control limit

$$UCL_p = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

$$LCL_p = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

Step 4: Draw the control line at $\bar{p}$ as thick horizontal line and the two control line UCL and LCL as dotted horizontal lines.

Step 5: Plot the individual points p

Q The following data are found during the inspection of the first 15 samples of size 100 each from a lot of two-wheelers manufactured by an automobile company.

Sample No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
No. of Defective	3	4	6	2	12	5	3	6	3	5	4	15	5	2	3

Draw the chart for fraction defective (p) and comment on the state of chart. if the process is out-of control, calculate the revised centre line and control limits by assuming assignable causes for any out-of control point

Sol

Sample No.	Sample Size	Number of defective	Proportion Defective (p)
1	100	3	0.03
2	100	4	0.04
3	100	6	0.06
4	100	2	0.02
5	100	12	0.12
6	100	5	0.05
7	100	3	0.03
8	100	6	0.06
9	100	3	0.03
10	100	5	0.05
11	100	4	0.04
12	100	15	0.15
13	100	5	0.05
14	100	2	0.02
15	100	3	0.03
Total		78	

We have

$$\bar{p} = \frac{1}{nk} \Sigma d$$

$$= \frac{1}{15 \times 100} \times 78 = 0.052$$

∴ we can calculate the centre line and control limits

$$CL = \bar{p} = 0.052$$

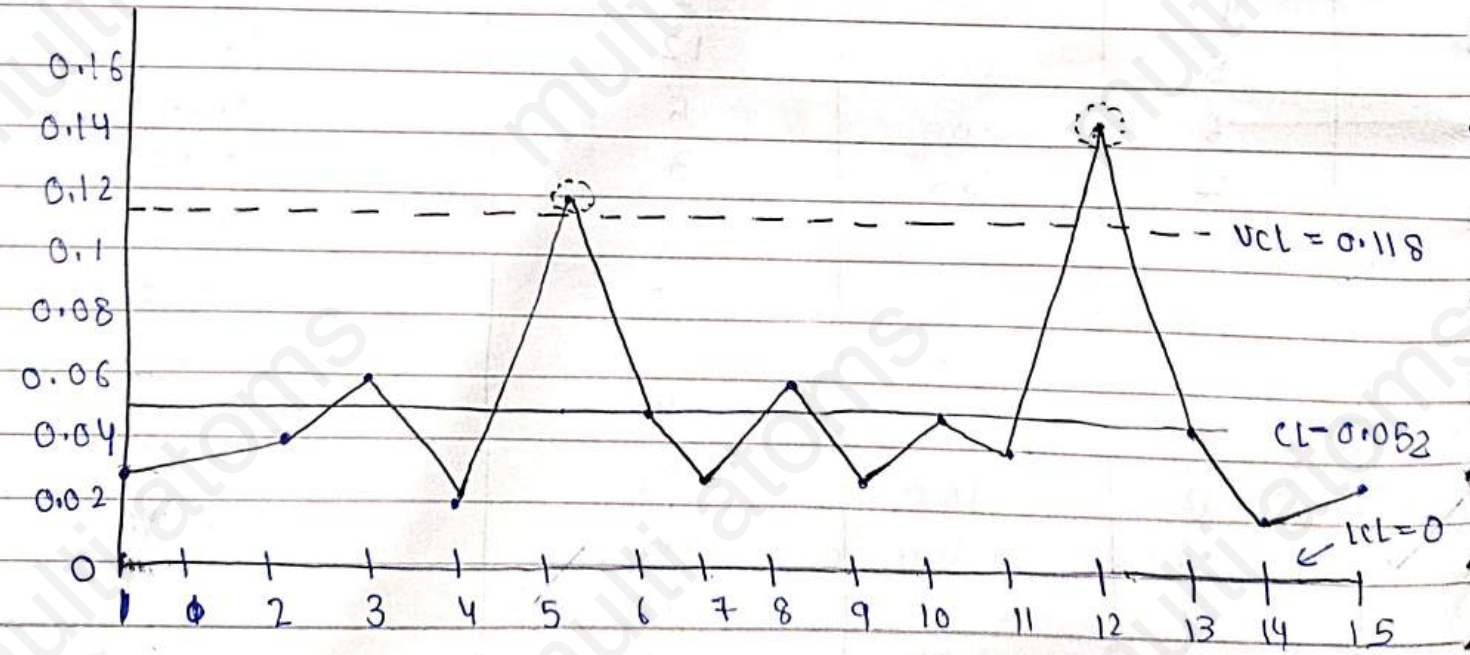
$$UCL = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} = 0.052 + 3\sqrt{\frac{0.052 \times (1-0.052)}{100}}$$

$$= 0.052 + 3 \times 0.022 = 0.118$$

$$LCL = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} = 0.052 - 3\sqrt{\frac{0.052 \times (1-0.052)}{100}}$$

$$\Rightarrow 0.052 - 3 \times 0.022$$

$$\Rightarrow -0.014 = 0$$



P-chart

we observe that the points corresponding to sample numbers 5 and 12 lie outside the upper control limits

∴ The process is out-of-control

∴ For calculating the revised limits for the p-chart, we first delete the out-of-control points (5 and 12) and calculate the new $\bar{p}$ using remaining sample

$\Rightarrow n = 100, \quad k = 15, \quad d = 2 \quad \sum_{j=1}^{2} d_j = 12 + 15 = 27$

$$\therefore \bar{p}_{new} = \frac{\sum_{i=1}^{k} d_i - \sum_{j=1}^{d} d_j}{n(k-d)} = \frac{78-27}{100(15-2)}$$

$$\Rightarrow \frac{51}{1300} = 0.0392$$

$\Rightarrow CL = \bar{p}_{new} = 0.0392$

$$UCL = \bar{p}_{new} + 3\sqrt{\frac{\bar{p}_{new}(1-\bar{p}_{new})}{n}}$$

$$= 0.0392 + 3\sqrt{\frac{0.0392 \times 0.9608}{100}}$$

$\Rightarrow 0.0392 + 3 \times 0.0194$

$\Rightarrow 0.0392 + 3 \times 0.0194 = 0.097$

$LCL = 0.0392 - 0.0582 = -0.019 \approx 0$

Final revised control limits

$CL = 0.0392, \quad UCL = 0.0974, \quad LCL = 0.$

⇒ C - chart

- C - charts are particularly useful where the product is a complex one such as engine or a machine tool. where some defects are almost found in the inspection after assembly

Construction of C - chart

Step 1 : Control limit line $(\bar{c})$ = $\frac{\text{Total number of defects}}{\text{Total number of samples}}$

Step 2 : Calculate

$$UCL = \bar{c} + 3\sqrt{\bar{c}}$$
$$LCL = \bar{c} - 3\sqrt{\bar{c}}$$

Step 3 : Plot all the points on the chart taking sample number on the X-axis and $\bar{c}$ on the Y-axis

THANK YOU FOR WATCHING

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{Quality Management}

ONE SHOT + PYQ SOLUTION

Unit - 4

Topics :

- Defect Diagonsis
- Identification & analysis of defects
- Correcting measure
- Reliability
- MTTF
- Maintainability
- Zero defects
- Quality Circle

JOIN TELEGRAM & FOLLOW ON INSTAGRAM

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Defects :-

⇒ A defects is a mistake or problem in a product or service that makes it not meet the expected standards

⇒ A defects is an error or problem in a product or service that affects its quality.

Q Explain the process of identification and analysis of defects in the product line.

Sol To ensure high-quality products and customer satisfaction, companies must systematically identify, analyze, and eliminate defects in their production line.

1. Defect Identification — Detecting the problem
- To find and recognize defects before products reach customers, minimizing recalls, waste and reputational damage

Method Used:
- Visual Inspection: Workers manually examine products for visible flaws (e.g scratches, misalignments, missing part)
- Automated Testing: Machines performs precision checks

- **Sampling Inspections**: Random samples from batches are tested to estimate defect rates

- **Customer & Employee Feedback**: Reports from end-users or assembly line workers highlight recurring issues

2. **Defect Recording** - Documenting the issues

→ To maintain accurate records of defects for analysis and future improvements

- **Defect logs**: A structural database (Excel, ERP, or QMS software) tracks
  → Type of defect (e.g crack, short circuit, misprint)
  → Quantity (how many defective units found)
  → Location in production
  → Time / date of detection

- **Checklists & Tags**: Physical or digital tags marks defective items for review

⇒ **Defect Analysis Process**:

1. Identifying or determining defects is the initial step performed in defect analysis.
2. Defects that are being identified are analyzed by testers

3. After analyzing, the main root cause of the defect should be determined and defined

4. Corrective Measures: Actions are taken to fix the root cause and prevent future defects

5. Validation: steps are verified to ensure they effectively prevent re-occurence of defects.

Q. Illustrate the defect management process. Explain the various steps involved the defect management process.

Sol It's a structured approach to detect, record track, and resolve defects in a software product, ensuring quality and reliability

Steps in the defect management process

1. Defect Detection:
   - Defect are identified and, during testing, user feedback, or monitoring tools.
   - Methods:- Manual testing, automated tests, code reviews, or production incidents

2. Defect Logging:
   - Defect are categorize, and are documented in a defect tracking system

Details :- title, description, priority, environments, screenshots / logs

3. Defect categorization & Prioritization
   - Defect are categorized by type (functional, UI, performance, etc)
   - Prioritized based on severity and impact on the product

4. Defect Assignment
   - The defect is assigned to the responsible developer or team for analysis and resolution

5. Defect Analysis
   - The assigned team investigates the root cause of the defect
   - Tools like the 5 whys
   → Fishbone Diagrams (Ishikawa)
   → Pareto Analysis (80/20 Rule)
   → Statistical Process Control (SPC).

6. Defect Fixing
   - Developer corrects the defect in the code or process
   - Code changes are reviewed before deployment

7. Verification & Retesting
   - QA retests the fixed defect to ensure the issue is resolved
   - Regression testing is done to check no new issue were introduced

8. Closure
- If the defect passes verification, it's marked as "closed" in the tracking system
- If not resolved properly, it may be reopened.

9. Defect Reporting & Metrics
- Generate reports to analyze trends: defect count, resolution time, defect origin, etc.
- Helps in improving process and reducing future defects.

⇒ MTTF :-

- It stands for Mean Time To Failure
- How long something works before it breaks for the first time

Used for: Items that can't be fixed (like light bulbs or batteries)

MTTF = Total hours of operation / Total assets in used

⇒ MTBF :-

- It stands for Mean time between failure
- How long something works on average between two failures.

Used for: Things that can break and be repaired

100 → problem
150 → problem

$$MTBF = \frac{\text{Total test time}}{\text{Number of failures during test}}$$

⇒ **MTTR :-**

- It stands for Mean time to repair.
- How long it takes to fix something once it breaks
- Used for: Items that can be repaired (like machines, software)

$$MTTR = \frac{\text{Total Maintenance time}}{\text{Number of maintenance action}}$$

⇒ **Maintenance Action Rate (μ):**

- This is how often maintenance actions (like repairs or checks) are performed.
- Helps measure how active the maintenance process is.

$$\mu = \frac{1}{MTTR}$$

⇒ **Availability :**

- Availability shows how often a system is working and ready to use.

Formula

$$\text{Availability} = \frac{MTBF}{MTBF + MTTR}$$

=> FMECA :-

=> FMECA stands for Failure Modes, Effects and Criticality Analysis.

=> It is a method to find
- How something can fail (Failure Modes)
- What happens if it fails (Effects)
- How serious it is.

=> Helps in prioritizing which failure need the most attention.

Types of FMECA:

i Design FMECA
ii Process FMECA
iii Equipment FMECA
iv Maintenance FMECA
v Service FMECA

=> Linear Hazards Model :-

- The linear Hazards Model is used to predict failures over time
- Because it assumes the risk of failure increases in a straight line as time goes on.
- The longer a system or component is used, the more likely it is to fail

⇒ FMES :-

- FMES Stands for failure Modes and Effects Summary.
- It gives a clear and organized overview of possible failure in a system and what happen if they occur.
- It summarizes :-
  - Failure Modes - Ways in which a part or system can fail.
  - Effects - what happens when that failures occurs
  - Detection Methods - How the failure can be found

Reliability :-

- Reliability means how well a product, system, or machine works without failing over time.
- A reliable system keeps working properly for a long time.
- It's about consistency, dependability, performance

→ Elements of Reliability :-

1. Probability : The chance that a system will works correctly for a certain time

2. Time Duration: How long the system is expected to perform without failure.

3. Performance Standards: The system must work as expected, not just be running.

4. Operating Conditions: Reliability depends on whether the system is used in its intended environment

Factor Affecting Reliability

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1. Design Quality:
   - Better design = fewer failures.
   - A poor design leads to frequent breakdowns

2. Material Quality:
   Strong and durable materials increase the system's reliability

3. Manufacturing Process:
   A well-controlled process leads to fewer defects in the final product

4. Maintenance:
   Regular maintenance keeps the system running smoothly and avoids failure

5. Usage Conditions:
   Using the product under harsh or incorrect condition can reduce reliability

6. Testing and Inspection:
More thorough testing catches problems early and improves reliability.

7. Aging and Wear_out:
Over time, parts wear out, which can reduce reliability unless replaced or serviced

Self Diagnostics:-

Self-diagnostics is a system's ability to check itself for problem and detect errors automatically.

How it Works:

1. Automated checks: The system runs tests on its own parts
2. Error Detection - Find issues
3. Alerts or Fixes - show warnings or tries to repair itself.

Fault Isolation:-

Fault isolation is the process of identifying exactly where a problem (fault) is located in a system, machine, or process.

How it Works:
1. Detect a Problem - The system notice something is wrong

2. Narrow Down the cause - Tests different parts to find the faulty one (like checking fuses when power goes out).

3. Pinpoint the issue - Confirms which specific component or step is failing

Interchangeability

Interchangeability means parts or components are made to a standard size and function, so they can swapped with identical parts without any special adjustments

Key Features:

- Same size and shape - Fits perfectly in the same place
- Same function - works just like the original part
- No custom Modifications Needed - Plug and play replacemen

Modularity

Modularity means designing a system (like a machine, software, or product) in separate, independent parts (module) that can be easily combined, replaced or upgraded.

Key features:-

1. Independent Modules
2. Standardized Connections
3. Easy upgrades & Repairs

Q. Explain "zero- defect". Explain the role of zero defect policy in achieving the highest standard of quality.

Sol Zero- defect is a quality management philosophy that aims to eliminate all defects in products or processes by preventing errors at the source rather than detecting and fixing them later

- It focuses on doing it right at the first time
- The goal is perfection, not just "acceptable" quality
- It requires continuous improvement and employee responsibility.

Role of zero- Defect Policy in Achieving Highest Quality Standards:

1. Prevents Errors Before They Happen
   - Instead of inspecting defects at the ends, team design processes to make mistakes impossible

2. Saves Time & Money
   - Fixing defects later is costly
   - Zero defects reduces scrap, warranty claims and customer complaints

3. Boosts Customer Trust
   - Delivering flawless products build brand reputation and loyalty

4. Encourages Employee Ownership:
- Workers are trained to stop production if a defect is found.
- Everyone takes responsibility for quality, not just inspectors

5. Drives Continuous improvement:
- Teams constantly analyze processes to eliminate root cause of defects

6. Support Industry Standards (ISO, TQM)
- Zero-defect aligns with ISO 9001 (Quality Management) and TQM

Q Write short note on the following
(i) MTTF
(ii) Maintainability
(iii) Quality circle

Sol (i) Maintainability

- Maintainability is the ease and speed with which a system or product can be repaired or maintained.
- A system with high maintainability has less downtime and is easier to fix.
- It depends on design, tools required, access to parts and skill level of technicians

- Good maintainability improves availability and reduces maintenance cost

Quality Circle :-

A Quality Circle is a small group of employees (usually 4-10) people from the same work area who voluntarily meet regularly to:

- Identify work-related problems (quality, productivity, safety etc)
- Analyze root causes using problem-solving tools
- propose solution to management.
- Implement improvement

- It is a participative management technique where frontline workers contribute ideas to enhance quality and efficiency.

Key features of Quality Circles

1. Voluntary Participation - Workers join willingly, not forced
2. Same Work Area - Members understand daily challenges
3. Regular Meetings - Weekly / Monthly discussions
4. Problem-solving Tools - Uses tools like Pareto charts, 5 Whys, Fishbone diagrams
5. Management Support - Supervisors review and approve solutions

⇒ How Quality cycle Works ?

→ Indentify a problem

→ Collect data

→ Analyze causes

→ Suggest solutions

→ Implement & monitor

Q Let the failure rate of a railway engine is 0.0002 failure/hr. Find MTTF of the railway engine.

Sol Failure rate $\lambda = 0.0002$ failure/hr

$$MTTF = \frac{1}{\lambda}$$

$$= \frac{1}{0.0002}$$

$$\boxed{MTTF = 5000 \text{ hr}}$$

Q The probability distribution function for time to failure in years for the drive train on the Regional Transit Authority bus is given by

$$f(t) = 0.2 - 0.02t \quad 0 \le t \le 10 \text{ years}$$

Find :

1] Reliability R(t)

$$R(t) = \int_t^{10} f(u)\,du$$

$$R(t) = \int_t^{10} (0.2 - 0.02u)\,du = \left[0.2u - 0.01u^2\right]_t^{10}$$

$$R(t) = \left(0.2(10) - 0.01(10)^2\right) - \left(0.2t - 0.01t^2\right)$$

$$R(t) = (2-1) - (0.2t - 0.01t^2)$$

$$\boxed{R(t) = 1 - 0.2t + 0.01t^2}$$

2] Hazard Rate Function h(t)

The hazard rate (failure rate) is the instantaneous failure rate at time t, given survival up to time t.

$$h(t) = \frac{f(t)}{R(t)}$$

$$f(t) = 0.2 - 0.02t$$
$$R(t) = 0.01t^2 - 0.2t + 1$$

$$h(t) = \frac{0.2 - 0.02t}{0.01t^2 - 0.2t + 1}$$

$$h(t) = \frac{0.2 - 0.02t}{0.01t^2 - 0.2t + 1}$$

3] Mean time to failure (MTTF)

$$MTTF = \int_0^\infty R(t)\,dt$$

$$\Rightarrow \int_0^{10} (0.01t^2 - 0.2t + 1)\,dt$$

$$MTTF = \left[\frac{0.01t^3}{3} - \frac{0.2t^2}{2} + t\right]_0^{10}$$

$$MTTF = \left[\frac{0.01(1000)}{3} - 0.1(100) + 10\right] - 0$$

$$MTTF = \left(\frac{10}{3} - 10 + 10\right) = \frac{10}{3} \approx 3.333 \text{ years}$$

$$MTTF = \frac{10}{3} \text{ years} \approx 3.333 \text{ years}$$

iv Mean Time Between Failures (MTBF)

$$MTBF = MTTF$$

$$MTBF = \frac{10}{3} \text{ years}$$

5] Standard Deviation of Time to Failure

$$Var(T) = E(T^2) - [E(T)]^2$$

First, compute $E(T^2)$:

$$E(T^2) = \int_0^{10} t^2 f(t)\, dt$$

$$= \int_0^{10} t^2 (0.2 - 0.02t)\, dt$$

$$E(T^2) = 0.2 \int_0^{10} t^2 dt - 0.02 \int_0^{10} t^3 dt$$

$$E(T^2) = 0.2 \left(\frac{t^3}{3}\right)_0^{10} - 0.02 \left(\frac{t^4}{4}\right)_0^{10}$$

$$E(T^2) = 0.2 \left(\frac{1000}{3}\right) - 0.02 \left(\frac{10000}{4}\right)$$

$$E(T^2) = \frac{200}{3} - 50 = \frac{200 - 150}{3} = \frac{50}{3}$$

$$\text{Var}(T) = E(T^2) - [\text{MTTF}]^2$$

$$= \frac{50}{3} - \left(\frac{10}{3}\right)^2$$

$$= \frac{50}{3} - \frac{100}{9}$$

$$= \frac{150 - 100}{9} = \frac{50}{9}$$

Standard deviation

$$\sigma = \sqrt{\text{Var}(T)}$$

$$= \sqrt{50/9}$$

$$= \frac{5\sqrt{2}}{3} \approx 2.357 \text{ years}$$

$$\sigma = \frac{5\sqrt{2}}{3} \text{ years}$$

$$\boxed{\sigma \approx 2.357 \text{ years}}$$

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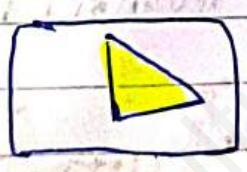


Quality Management

One Shot + PYQ Solution

Unit - 5

Topics:

- ISO - 9000 family
- ISO - 9000 series
- Taguchi method
- JIT

Q Describe ISO 9000 family. Describe the ISO 8402, 9000, 9001, 9002, 9003 and 9004 in detail

Sol The ISO 9000 family is a group of international standards created by ISO ('International Organization for standardization')

→ These standards help businesses and organizations manage quality and make sure they meet customer needs

→ It tells companies how to manage their work to make customer happy.

⇒ Key Features:-

- It gives guidelines, not certification
- It helps build quality systems
- Used by companies all over the world
- Works for any type & size of company
- It is the base for other ISO standard

ISO 8402: (Vocabulary of Quality)

- ISO 8402 was an early ISO standard about quality terms
- It define key words used in quality management
- It was removed in 2000 and merge into ISO 9000

Key Definition in ISO 8402

1. Quality = How good something is at meeting customer needs
2. Quality Policy = A company's promise to deliever good quality
3. Quality Management = planning and controlling quality
4. Quality Assurance (QA) = Making sure quality standard are met
5. Quality Control (QC) = checking product for defects
6. Quality System = All the processes a company uses to maintain quality
7. Nonconformity = when a product/service doesn't meet standard
8. Continuous improvements

-> Helped everyone use the same word
-> Make it easier to understand ISO 9000 standards

ISO 9000 - Basic Concepts and Guidelines

. This standard gives an overview of quality management systems.

=> what it explains:

- what a quality management system is
- why it's important
- The principles of quality (like customer focus, leadership, continuous improvement, etc)

- Help companies understand ISO 9001 better
- Not for certification.
- It's the base for other ISO standards

ISO 9001 — Quality Standard for Certification

- ISO 9001 is a quality standard that companies can get certified in to prove they give good-quality products and services

- It shows customers that the company is trustworthy and focused on quality

- Companies must document and follow their processes.
- focuses on customer satisfaction
- Needs regular checking (audits)
- Helps improve efficiency and reduce waste
- Pushes for continuous improvement
-

ISO 9002 & 9003 :-

ISO 9002 (Previously for Production & Installation)

- Used for companies that did not design products, but only produced or installed them
- Not for certification
- This is no longer used today - it was merged into ISO 9001

ISO 9003 (Previously for Final Inspection only)

- focused only on final checks and testing before delivering a product
- Not for certification

- It is also now included in ISO 9001.

ISO 9004 - (Guidelines for Performance Improvement)

- Helps companies go beyond just basic quality and aim for excellence
- Focuses on:
  - → long term success
  - → continuous improvement
  - → Making the whole organization better, not just meeting the minimum.
- Not for certificate
- Think of ISO 9004 as a "next-level guide" for companies that want to became leaders in quality

Q. What do you understand by documentation of quality system in ISO 9000?

Sol - In the ISO 9000 framework, documentation refers to the structured recording of policies, procedures, and processes that define how an organization maintains quality

- It ensures consistency, traceability, and compliance with ISO 9001 requirements

- Ensures everyone does things the right way every time

Key Purposes:

- Communication : Tells staff how to work.
- Consistency : Same steps = same good results
- Proof : Shows auditors you follow the rules
- Training : Teaches new hires quickly
- Improvement : Help fix mistakes and do better
- Customer trust : Proves you're reliable
- law compilance : Meets legal requirements

What's documented:

- Scope : What your quality system covers.
- Quality Policy : Company's promise
- Objectives : Goals (e.g "fewer than 2 complaints/month")
- Procedures : Main steps (e.g "How to check raw materials")
- Work Instructions : Detailed tasks (e.g "oven temperature settings")
- Records : Proof (e.g, "Daily temperature logs").

How to manage it:

- Create/Update : Only experts write/edit documents
- Control : Use latest versions; trash old ones
- Access : Easy to find (paper or computer).
- label : Clear titles/dates so no mix-ups

Q What is ISO - 9000 and its concept to quality management?

Sol ISO 9000 is a family of international standards that provide guidelines and requirements for quality management systems (QMS).

- Developed by the International Organization for Standardization (ISO),
- Ensure consistent quality in product / services
- Meet customer & regulatory requirements
- Improve processes continuously.

⇒ The most well-known standard in this family is ISO 9001, which is certifiable - meaning companies can get audited and certified to prove they follow best practices

Core concept of ISO 9000 in Quality Management

ISO 9000 is based on the idea that good quality doesn't happen by accident - it must be systematically managed.

1. Process Approach (key idea)
- A business is made up of interconnected processes (e.g design, production, delivery)
- ISO 9000 requires companies to:
  - → Map out key processes
  - → Control them properly to avoid mistakes
  - → Measure performance to ensure efficiency.

2. Customer Focus:
- The ultimate goal is customer satisfaction.
- Companies must:
  - Understand customer needs.
  - Deliver products/services that meet expectations
  - Handle complaints effectively.

3. Continuous Improvement: (Plan-Do-Check-Act (cycle)

- Plan: Set quality objectives
- Do: Implement processes
- Check: Monitor results (audits, inspections).
- Act: Fix issues and improve.

4. Risk-Based Thinking:
- Instead of just fixing problems, companies must anticipate risks
- Preventive actions reduce errors before they happen

5. Leadership & Employee Involvement:
- Top management must commit to quality policies.
- Employees should be trained and engaged in quality efforts

Q Describe Quality Audit and its types in detail.

Sol Quality Audit is a systematic examination to check if a process, product or system meets quality standards.

- It helps identify gaps, ensure compilance and improve quality

Types of Quality Audits:

1. Internal Audit (First-Party Audit)
- Conducted by the organization itself.
- checks if internal processes follow quality standards.
- Helps in continuous improvements

2. External Audit (Second-Party Audit)
- Conducted by customer or stakeholder on a supplier.
- Ensures the supplier meets contractual quality requirement

3. Third-Party Audit
- Done by an independent certification body (like ISO auditors)
- Verifies compilance with industry standards.
- Results in certification if standards are met

4. Process Audit
- Focuses on specific processes
- check if procedures are followed correctly.
- Helps in optimizing workflows

5. Product Audit
- Examines the final product for defects or deviations
- Ensures the product meet customer requirements

6. System Audit
- Review the entire Quality Management System (QMS)
- checks if policies, documentation, and controls are effective.

7. Compilance Audit
- Ensures adherence to legal or regulatory standards

8. Performance Audit
- Evaluates efficiency and effectiveness of operations.
- Focuses on achieving business goals with quality

Six Sigma - (Quality Improvement Method)

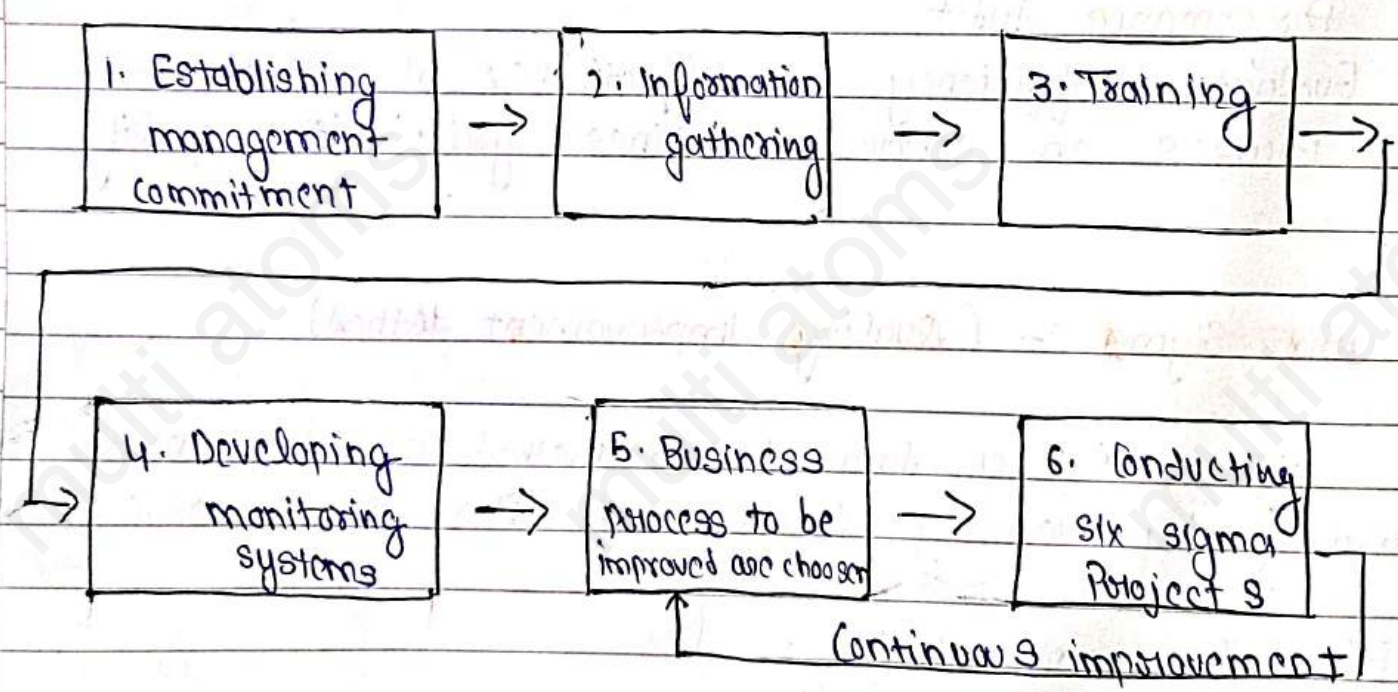
- Six sigma is a data-driven method used to improve quality by reducing defects and errors in processes.

- It helps companies:
→ Improve product quality
→ Reduce defects
→ Save time and money
→ make customer happy

Key Principles of Six Sigma:

1. **Focus on customers** - Improve what matters most to customer
2. **Data-Driven Decisions** - Use facts, not guesses, to solve problem
3. **Process Improvement** - Fix the root cause of defects, not just symptoms
4. **Team Collaboration** - Expert work together
5. **Sustainable Results** - Ensure improvements last long-term

- Most common type is the DMAIC (Define, Measure, Analyze, Improve, Control) method



Six Sigma Implementation Model

⇒ EMS (Environmental Management System) - ISO 14000

- EMS is a system that helps companies manage their impact on the environment.
- It is based on the ISO 14000 standards.

- It helps companies be eco-friendly and follow environmental rules

Key Bints :
- Helps reduce pollution and waste
- Support green (eco-friendly) thinking
- Makes sure companies follow environmental laws.
- Encourages better use of resources

Q Explain the Taguchi Method in quality engineering ?

Sol The Taguchi method, developed by Dr. Genichi Taguchi, is a statistical approach to quality management improvement that focuses on designing robust systems and processes.

The Taguchi method is a technique used to make product more reliable and high quality by designing them properly

- Uses orthogonal Arrays for testing
- Reduces variations and errors
- Make products strong and durable

Steps in the Taguchi Method :-

1. **Define the objective :**
Clearly state what quality characteristic is being optimized

2. **Identify the factors and levels :**
Select the factors that affect the process and decide on their levels

3. **Select an Orthogonal Array :**
Choose an appropriate orthogonal array to design the experiments efficiently

4. **Conduct the experiments :**
Perform the tests based on the combinations specified in the array

5. **Analyze the results :**
Use S/N ratios and analysis of variance (ANOVA) to determine the optimal factor levels.

6. **Confirm the results :**
Validate the optimal setting through additional testing

Orthogonal Array

An Orthogonal Array (OA) is a special kind of table used in experiments to test different combinations of factors in a smart and efficient way.

Q. Describe JIT approach to minimize the waste in manufacturing. Explain the need of JIT.

Sol Just-In-Time (JIT) is a production strategy where materials, parts, and products are made only when they are needed, in the right amount, and at the right time - not before and not in excess.

* It aims to reduce inventory, waste and waiting time in manufacturing.

⇒ How JIT Minimizes Waste

The JIT approach helps reduce 7 types of waste in manufacturing:

1. Over production
→ Making too much = storage problems and extra cost
JIT produces only what is needed.

2. Waiting
→ Idle workers or machines = lost time
JIT ensures smooth workflow with timely supplies

3. Inventory
→ Extra stock = money tied up and storage space used
JIT keep inventory levels very low

4. Transportation

→ Unnecessary movement of materials
JIT streamlines material flow

6. Motion

→ Wasted movement by workers
JIT encourages efficient layouts

6. Defects

→ Poor quality = rework or scrap
JIT focuses on quality at every step.

7. Overprocessing:

→ Doing more than needed
JIT simplifies steps to match actual requirements

Need for JIT

1. To reduce inventory costs
2. To improve efficiency and flow
3. To increase product quality
4. To stay competitive

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