# LECTURE NOTES

# ON

# INDUSTRIAL ENGINEERING AND MANAGEMENT (TH-1)

SRI SAGAR KUMAR BEHERA, LECTURER

DEPARTMENT OF MECHANICALENGINEERING

GOVERNMENT POLYTECHNIC,GAJAPATI- 761201

**CONTENTS:**



## Course outcomes

At the end of the course students will be able to:

| CO | Statement |
|---|---|
| C321.1 | Identify the place for a new plant setup & systematic arrangement of machinery and shop for smooth production. |
| C321.2 | Take right decision to optimize resources utilizations by improving productivity of the lands, building, people, material, machines, methods and management effectively. |
| C321.3 | Apply stock management & maintenance principle to reduce plant ideal time. |
| C321.4 | Use the charts to record the quality of the product. |
| C321.5 | Eliminate unproductive activities under the control of the management, supervisor, worker and the design of products and processes. |

# PLANT LOCATION & LAYOUT

A plant is a place, where men, materials, money, equipment, machinery etc are brought together for manufacturing products.

The problem of plant location arises when starting a new concern or during the expansion of the existing plant.

Plant location means deciding a suitable location, area, place etc. where the plant or factory will start functioning.

Plant location involves two major activities

I. To select a proper geographic region
II. Selecting a specific site within the region

## *Plant location problem*

1. Selection of region
2. selection as a community
3. selection of a particular site
   Conditions that demand city location
   Conditions that demand sub-urban location
   Conditions demanding rural location

## *Factors affecting plant location*

1. Nearness to raw material – It will reduce the cost of transporting raw material from the vendor's end to the plant sugar, cement, jute and cotton textiles.
2. Transport facilities – A lot of money is spent both in transporting the raw material and the finished goods speedy transport facilities ensure timely supply of raw materials to the company and finished goods to the customers, There are time basic modes of physical transportation, air, road, rail, water and pipe line.
3. Nearness to market – It reduces the cost of transportation as well as the chances of the finished products getting damaged and spoiled in the way.
4. Availability of labour – Suitable labour force, of right kind, of adequate size (number), and at reasonable rates with its proper attitude towards work are a few factors which govern plant location to major extent. The purpose of the management is to face less boycotts, strikes or lockout and achieve lower labour cost per unit of production.
5. Availability of fuel and power – Steel industries are located near source of fuel (coal) to cut down fuel transportation costs. Electric power should remain available continuously in proper quantity and at reasonable rates.

6. Availability of water - Depending on the nature of the plant, water should be available in adequate quantity and should be of proper quality water is essential for paper and chemical industries.
7. Climatic condition – Climate greatly influence human efficiency and behavior. Textile mills require humidity with the developments in the field of heating, ventilating and air conditioning, climate of the region doesn't present much problem of course control of climate needs money.
8. Financial and other aids – Certain states give aids as loans, feed money, machinery, built up sheds etc. to attract industrialist.
9. Land – Topography, area, the shape of the site, cost, drainage and other facilities, the probability of floods, earthquakes etc. influence the selection of plant location.
10. Community attitude – Community attitude towards their work and towards the prospective industries cab make or mar the industry. Success of an industry depends on the attitude of the local people whether they want work or not.
11. Supporting industries – All industries will not make all the components and parts by itself and it subcontracts the work to vendors
12. Social Infrastructures – Availability of community facilities like
    A. Housing facilities
    B. Recreational facilities
    C. Educational facilities
    D. Medical facilities

    are to be considered.
13. Law and taxation – the policies of the state gent and local bodies concerning labour laws, building codes, safely its are the factors that demand attention.

## *Plant layout:*

Plant layout means the disposition of the various facilities (equipments, material, manpower etc) and services of the plant within the area of the site selected previously.

It begins with the design of the factory building and goes up to the location and movement of a work table. All the facilities like equipments, raw materials, machinery, tools, fixtures, workers etc are given a proper place.

Plant layout is a plan of an optimum arrangement of facilities including personnel, operating equipment, storage space, material handling equipment and all other supporting services along with the design of best structure to contain all these facilities.

## *Plant layout problem (Need for the plant layout):*

1. Changes in the product design.
2. Changes in the volume of demand for the company's product
3. Increasing frequency of accidents because of existing layout.
4. Plant and machinery becomes outdated and is to be replaced by new one

5. Poor working environment affecting worker efficiency and productivity.
6. Change in the location or markets.
7. Minimizing the cost through effective facilities location.

## *Objectives of plant layout:*

1. Material handling and transportation is minimized and efficiently controlled.
2. Bottle necks and points of congestions are eliminated so that the raw material and semi finished goods move fast from one work station to another.
3. Workstations are designed suitably and properly.
4. Suitable places are allocated to production centers and service centers.
5. Movements made by the workers are minimized.
6. Waiting time of semifinished products is minimized.
7. Working conditions are safer, better and improved.
8. Increased flexibility of changes in product design and for future expansion.
9. Utilization of cubic space (length, width and height).
10. These are improved work methods and reduced production cycle times.
11. Plant maintenance is simpler.
12. Increased productivity and better product quality with reduced capital cost.
13. A good layout permits materials to move through the plant at the desired speed with the lowest cost.

## *Principle of plant layout:*

1. Principle of integration:

   A good layout is one that integrates men, materials, machines and supporting services and other in order to get the optimum utilization of resources and maximum effectiveness.

2. Principle of minimum movements and material handling:

   The facilities should be arranged such that the total distances travelled by the men and materials should be minimum and as far as possible straight line movement is preferred. It is better to transport materials in bulk rather than in small amounts.

3. Principle of smooth and continuous flow :

   A good layout makes the materials to move in forward direction towards the completion stage. Bottle necks, congestion points and back tracking should be removed by proper line balancing techniques.

4. Principle of cubic space utilization :

   The good layout utilizes both horizontal and vertical space. Besides using the floor space of a room the ceiling height is also utilized. Boxes and bags containing raw material or goods cab be stacked are above the other to store more items in the same room.

5. Principle of safety and security and satisfaction :

   Working places safe-well ventilated and force from dust, noise, fumes, odours, and other hazardous conditions increase the operating efficiency of the workers and improve their morale.

6. Principle of maximum flexibility :

   The good layout is one that can be altered without much cost and time. The machinery is arranged in such a way that the changes of the production process can be achieved at the least cost or disturbance.

*Advantage of plant layout:*

1. Advantages to the worker
2. Advantages to the management
3. Advantages to manufacturing
4. Advantages to production control

Factors influencing plant layout

1. Type of production- Engg. Industry, process industry
2. Production system- Job shop, batch, mass production
3. Scale of production
4. Availability of total area
5. Arrangement of material handling system
6. Type of building- single storey, multi storey
7. Future expansion plan
8. Type of production facilities- Dedicated or general papers

Types of manufacturing system

1. Job type production:

   Manufacturing of one or few quantities of products designed and produced as per specifications high variety and low volume.

2. Batch production:

   Manufacture of limited no. of products produced at regular intervals and stocked at warehouse.

   Ex: Chemical, pharmaceutical, assembly stops.

3. Repetitive or mass production:

   Manufactures several standard products produced and stacked in the warehouses.

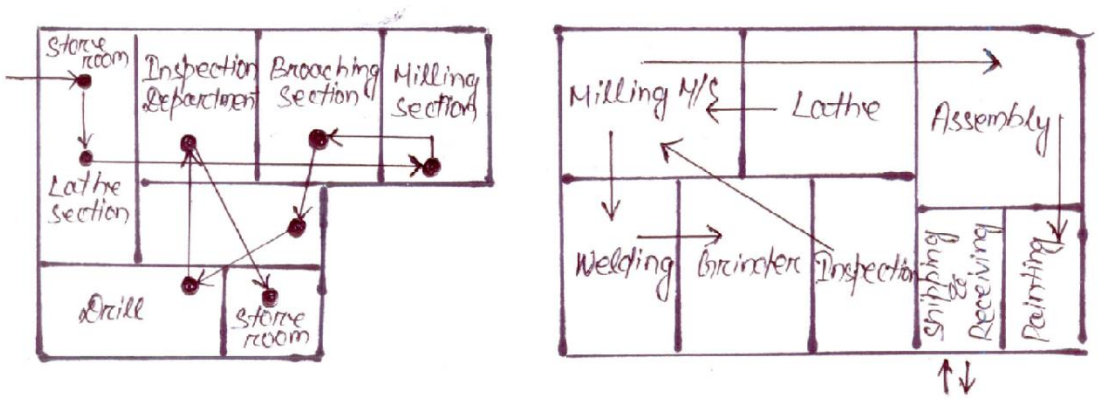
   High volume and low variety

   Ex: plastic goods, manufacture & assembly stages of automobiles

*Types of layout:*

1. Process layout (Functional layout):

The layout is recommended for batch production. All machines performing similar type of operations are grouped at one location in the process layout.
Ex – all lathes, milling machine kept at one place
The arrangements of facilities are grouped together according to their functions.




Advantages:

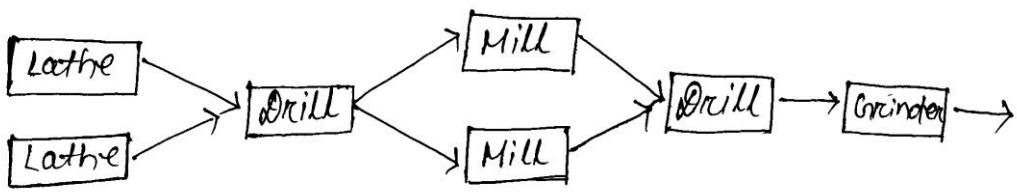
I. Wide flexibility exists during allotment of work to equipment and workers.
II. Better utilization of equipments
III. Lower investments on account of comparatively less no. of machine are used.
IV. Better product quality because to attend one type of machine.
V. Varieties of jobs coming as different job orders make the work more challenging and interesting.
VI. Workers in one section are one affected by the nature of another section.

Disadvantages:

I. For the same amount of production, more space is required.
II. Automatic material handling is difficult.
III. More materials in process remain in queue for further operation.
IV. Completion of same product takes more time.
V. Work-in-process inventory is large.
VI. Production planning and control is difficult.
VII. Raw materials have to travel larger distances for being processed to finished goods. Thus increases cost.
VIII. It means more inspections and efficient co-ordination.

2. Product layout (line layout):

The various operations on raw material are performed in a sequence and the machines are arranged in the sequence in which the raw material will be operated upon.




Advantage:

I. Less space requirements for the same volume of production.
II. Automatic material handling, less movements, so cost is reduced.
III. Less in process inventory.
IV. Product completes in lesser time.
V. Simplified production, planning and control
VI. Smooth and continuous work flow
VII. Less skilled workers can learn and serve the purpose

Disadvantage:

I. Lack of flexibility
II. Excessive idle time due to slowest machine
III. More machines to be purchased and kept which require high capital investment
IV. One inspector has to attend a no. of machine in a production line.
V. It is difficult to increase production beyond the capacities of the production lines.

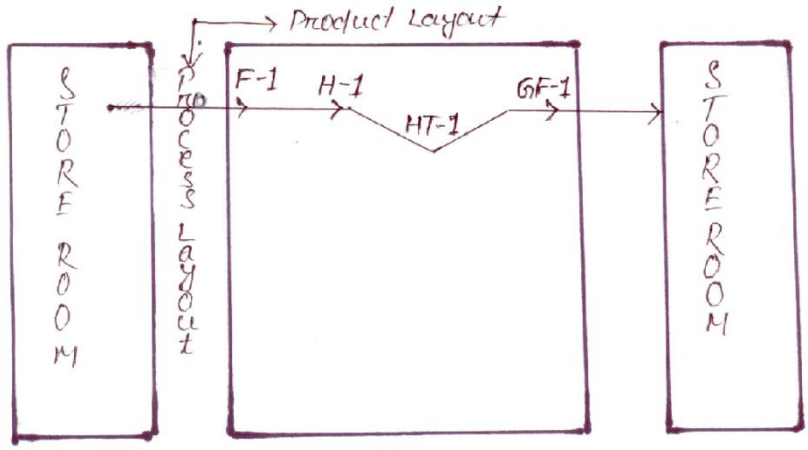
## 3. Combination layout:

This is called the mixed type of layout usually a process layout is combined with the product layout.

Ex – refrigerator manufacturing uses a combination layout.

Manufacturing various components → process layout

For assembly of component → product layout




Ex – files, hacksaw, circular metal saws, wood saws.

4. Fixed position layout:

   This is also called the project type of layout. The materials or major components remain in a fixed location and tools, machinery, men and other materials are brought to this location.

   Ex – ship building, aircraft manufacturer

Advantage:

I. One or more skilled workers are engaged to one project
II. Least movement of materials
III. Maximum flexibility
IV. Different projects can be taken with the same layout.

Disadvantages:

I. Low content of work-in-progress
II. Low utilization of labour and equipment
III. High equipment handling cost

*Plant layout procedure:*

1. Accumulate basic data:

   Such as

   - Volume and rate of production
   - Product specification and bill of material
   - Process sheets indicating tools, equipments, the method and the product which will be manufactured
   - Flow process charts
   - Standard time to complete each operation

2. Analyze and co-ordinate basic data:

In order to

- The workforce size and type
- No. of workstation required
- Type of equipment required
- Storage and other space requirements
- Assembly chart and operation process chart help coordinating basic data

3. Decide equipment and machinery required:

   Can be calculated by

   - No. of articles to be produced
   - Capacity of each equipment
   - Time in which the order is to be completed

4. Select the material handling system:

   Which depends upon

   - Material or product to be moved
   - Container in which it will be moved
   - Length of movement
   - Frequency of movement
   - Speed of movement

5. Sketch plan of the plot:

   To mark building outline, roads, storage and service etc

   - The plan orientation should utilize maximum, the natural heat, light and other weather conditions.

6. Determine a general flow pattern:

   - The flow pattern of materials should be such that the distance involved is least between the store and the shipping department through the production centers.
   - There should be minimum back tracking
   - Based upon the process or product requirement process, product or combination layout.
   - Plant layout should be flexible to accommodate changes

7. Design individual workstations:

   To get optimum

   - Performance of operation
   - Material and space utilization
   - Safely and comfort of employees

8. Assemble the individual workstation layout: into total layout
9. Calculate the storage spaced required:

   By knowing

   - Volume of each store item

- No. of items to be kept at stores
- Time of keeping the item

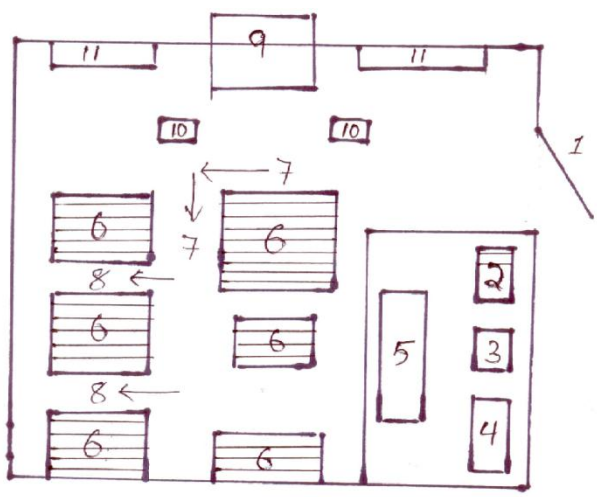
10. Make flow diagrams for workstations:
    And allocate them to areas on plot plan.
11. Plan and locate services areas such as offices, toilets, wash rooms, dispensary, cafeteria.
12. Make master layout by templates and models.
13. Check final layout:
    - Safe and economical material handling
    - Product design
    - Service area
    - Employee safety and comfort
14. Get official approval of the final layout about product drawings, BOM, man power requirements, estimated expenditure.
15. Install the approved layout.

*Storage space requirements:*

- Incoming new materials
- Checking and sorting the raw material
- Inspection of raw material
- Temporary storing the new material before it is placed at the proper location
- In process inventory
- Tools and other supplies
- Finished products

Space provided for above factors depends upon

1. Size and weight of raw material, in process goods and finished goods
2. Their quantity
3. Frequency of use



1. Incoming material receiving gate
2. Place for dumping raw material
3. Place for sorting and checking of raw material
4. Place for raw material inspection
5. Place for temporarily shorting the materials before putting them of racks.
6. Proper place for shorting each type of material
7. Main aisles
8. Side aisles
9. Service window
10. Boxes containing materials to be issued
11. Counters for keeping materials to be issued which have been brought from 6 and will be placed in 10

# PLANT MAINTENANCE

## Plant-

A plant is a place, where men, materials, money, equipment, machinery, etc are brought together for manufacturing products.

## Maintenance-

Maintenance of facilities and equipment in good working condition is essential to achieve specified level of quality and reliability and efficient working. It helps in maintaining and increasing the operational efficiency of plant facilities and contributes to revenue by reducing operating of production.

## Objectives of plant maintenance-

- To achieve minimum breakdown and to keep the plant in good working condition at the lowest possible cost.
- To keep the m/c in such a condition that permit to use without any interrupter
- To increase functional reliability of production facilities
- To maximize the useful life of the equipment
- To minimize the frequency of interruption to production by reducing breakdown
- To enhance the safety of manpower

## IMP of maintenance-

- Equipment breakdown leads to an inevitable loss of production
- An improperly maintained or neglected plant will sooner or later require expensive and frequent repairs, because with the passage of time all machines or other facilities, building, etc wear out and need to be maintained to function properly.
- Plant maintenance plays a prominent in production management because plant breakdown creates problem such as- loss of production time
    - ✓ Rescheduling of production
    - ✓ Spoilt materials (because sudden stoppage of process damages in-process materials)
    - ✓ Failure to recover overheads (because loss in production hours)
    - ✓ Need for overtime
    - ✓ Need for subcontracting work
    - ✓ Temporary work shortage- workers require alteration work

## Duties, functions and responsibilities of pant maintenance department-

### a) Inspection-

- Inspection is concerned with the routine schedule checks of the plant facilities to examine their condition and to check for needed repairs
- Inspection ensures the safe and efficient operation of equipment and machinery
- Frequency of inspections depends upon the intensity of the use of the equipment
- Items removed during maintenance and overhaul operation are inspected to determine flexibility of repairs
- Maintenance items received from vendors are inspected for their fitness

### b) Engineering-

- Engineering involves alterations and improvements in existing equipments and building to minimize breakdowns
- Maintenance department also undertakes engineering and supervision of constructional projects that will eventually become part of the plant.
- Engineering and consulting services to production supervision are also the responsibility of maintenance department.

### c) Maintenance –

- Maintenance of existing plant equipment.
- Maintenance of existing plant buildings and other service facilities such as yards, central stress, roadways.
- Minor installation of equipments, building and replacements
- Prevent breakdown by well-conceived plans of inspection, lubrication, adjustments, repair and overhaul.

### d) Repair-

- Maintenance department carries corrective repairs to avoid unsatisfactory conditions found during preventive maintenance inspection.
- Such a repair work is of an emergency nature and is necessary to correct breakdowns.

e) Overhaul-

- Overhaul is a planned, schedule reconditioning of plant facilities such as machinery etc.
- It involves replacement, reconditioning, reassembly etc.

f) Construction-

- In some organizations, maintenance department is provided with equipment and personnel and it takes up construction job also.
- It handles construction of wood, brick and steel structures, electrical installation etc.

g) Salvage-

- It may also handle disposition of scrap or surplus materials.
- This involves segregation and disposition of production scrap.

h) Clerical jobs-

- Maintenance department keeps records of cost, of time progress on jobs, electrical installations, water, steams, air and oil lines, transport facilities.

i) Generation and distribution of power.
j) Providing plant protection
k) Establishing and maintaining a suitable store of maintenance materials
l) House keeping
m) Pollution and noise control

## *Types of maintenance:*

Maintenance may be classified as

a) Corrective or breakdown maintenance
b) Scheduled maintenance
c) Preventive maintenance
d) Predictive maintenance

a) Corrective or breakdown maintenance:

- Corrective or breakdown maintenance implies that repairs are made after the equipment is out of order and it cannot perform its normal function any longer. Ex – electric motor will not start, a belt is broken.
- Under such conditions, production department calls on the maintenance department to rectify the defect. The maintenance department checks into the difficulty and makes the necessity repairs.
- After removing the fault, maintenance engineers do not attend the equipment again until another failure or breakdown occurs.
- Breakdown maintenance is economical for those equipment whose down time and repair costs are less.
- Breakdown type maintenance involves little administrative work, few records and comparative small staff.

Causes of equipment breakdown:

- Lack of lubrication
- Neglected cooling system
- Failure to replace worn out parts
- External factors (too higher or too voltage)

Disadvantages of breakdown maintenance:

- Breakdowns occur at inopportunity times, which lead to poor, hurried maintenance and excessive delays in production.
- Reduction of output
- More spoilt material
- Increased chances of accidents and less safety to both workers and machines
- Direct loss of profit.
- Breakdown maintenance cannot be employed to cranes, lifts, hoists and pressure vessels.

b) Scheduled maintenance:

- Scheduled maintenance is a stick-in-time procedure aimed at availing breakdowns
- Scheduled maintenance do inspection, lubrication, repair and overhaul of certain equipments are done in predetermined schedule.
- Schedule maintenance practice is generally followed for overhauling of machines, cleaning of water and other tanks, white washing of building etc.

c) Preventive maintenance:

- A system of scheduled, planned or preventive maintenance tries to minimize the problems of breakdown maintenance.
- It is a stich-in-time procedure.
- It locates weak spots (such as bearing surfaces, parts under excessive vibrations etc) in all equipments, proceeds them regular inspection and minor repairs reducing the danger of unanticipated breakdown.
- Preventive maintenance involves.
- Periodic inspection of equipment and machinery to prevent production breakdown an harmful depreciation.
- Upkeep of plant equipment to correct fault.

Objective of FM:

- To minimize the possibility of unanticipated production interruption and major breakdown by locationg the fault.
- To make plant equipment and machinery ready to use
- To maintain the optimum productive efficiency
- To maintain the operational accuracy
- To achieve maximum production and minimum repair cost
- To ensure safety of life and limbs of the workers

Advantages:

- Reduces breakdown and down-time
- Lesser odd-time repairs
- Greater safety for workers
- Low maintenance and repair cost
- Increased equipment life.
- Better product quality.

d) Predictive maintenance:

- It is a newer maintenance technique.
- It uses human senses or other sensitive instruments such as audio gauges, vibration analysers, amplitude meters, pressure, temperature and resistance strain gauges to predict troubles before the equipment fails.
- Unusual sound coming out of a rotating equipment predict an trouble, an electric cable excessively hot at one point predicts an trouble.
- In predictive maintenance, equipment conditions are measured periodically or on a continuous basis enables maintenance men to take timely action such as equipment adjustments, repair and overhaul.

# OPERATION RESEARCH

## *Optimization techniques:*

The word optimization is form optimum which implies a point at which the conditions are best and most favorable.

An optimum point may represent a maximum position or minimum position.

## Method for optimizing:

a) Search
b) Differential calculus
c) Statistical methods
d) Linear programming
    i. Graphical method
    ii. Transportation method
    iii. Simplex method
e) Queuing theory
f) Dynamic programming

Application:

Load allocation problems, component selection, load sharing.

## *Operation research:*

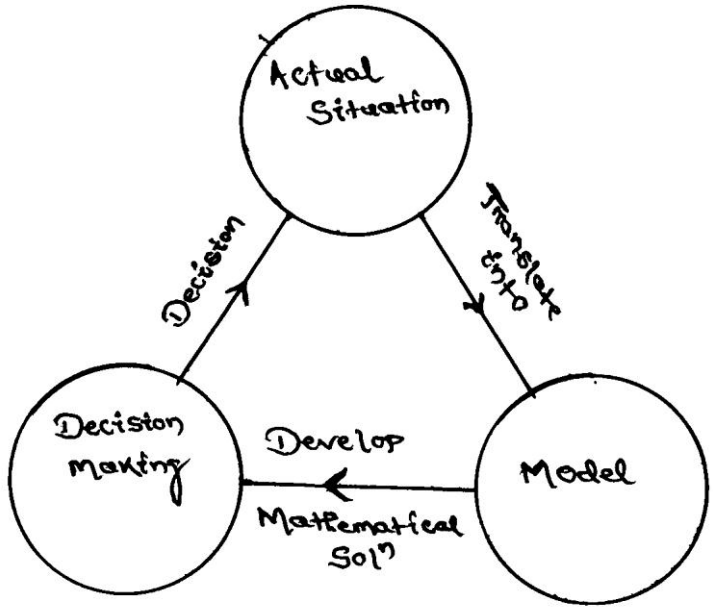
Operation research signifies research on operations. It is the organized application of modern science, mathematics and computer techniques to complex military, government, business or industrial problems arising in the direction and management of large systems of men, materials, money and machines

Methodology

1. Understand the actual real situation, capture the same and define the problem
2. Formulate a mathematical model
3. Develop a mathematical solution
4. Interpret the solution and prepare the information in such a form that it is meaningful, intelligible and quantitative. Translate it in to a decision.
5. Implement the decision to the real situation
6. Verify the results

Methods of operation research

1. Linear programming
    a) Graphical linear programming
    b) Transportation method
    c) Simplex method
2. Wait line queuing theory
3. Game theory
4. Dynamic programming




Linear programming

Linear programming is powerful mathematical technique for finding the best use of limited resources of a concern. It may be defined as a technique which allocates scarce

available resources under conditions of certainty in an optimum manner to achieve the company objectives which may be maximum overall profit or minimum overall cost.

LP can be applied effectively only if

a) The objectives can be stated mathematically
b) Resources can be measured as quantities (no. weight etc)
c) There are too many alternate solutions to be evaluated conveniently
d) The variables of the problem bear a linear relationship i.e. Doubling the units of resources will double the profit.

## Problem solving is based upon the system of linear equation:

### Standard form of linear programming problem:

Let $x_1, x_2, x_3$ ……..$x_n$ are the decision variables.

Optimize (maximum or minimize)

$Z = c_1x_1 + c_2x_2 + \ldots\ldots\ldots\ldots + c_nx_n$ (objective function)

Subject to constraints

$a_{11}x_1 + a_{12}x_2 + \ldots\ldots\ldots\ldots + a_{1n}x_n \leq b_1$

$a_{21}x_1 + a_{22}x_2 + \ldots\ldots\ldots\ldots + a_{2n}x_n \leq b_2$

. . . .
. . . .
. . . .

$a_{m1}x_1 + a_{m2}x_2 + \ldots\ldots\ldots\ldots + a_{mn}x_n \leq b_n$

$x_1, x_2, x_3$ ……..$x_n \geq 0$ (non-negative restriction)

where $c_1, c_2, c_3, \ldots\ldots\ldots\ldots c_n$ are cost or profit coefficients.

$a_{ij}$ (i = 1, 2, 3,……n)
(j = 1, 2, 3,……..n)

$b_1, b_2, \ldots\ldots\ldots\ldots\ldots b_n$ are called requirement or availability.

LPP can solved by two methods.

1. Graphical method: when two decision variables are involved. This is simple.
2. Simplex method: useful for any no. of decision variable in the problem and no. of constraints.

## Formulation of LP problem:

1. From the given problem, identify the key decisions to be made.
2. Identify the decision variables, whose values give the solution to the problem.

3. Write the objective in the quantitative terms and express it as a function of linear variables.
4. Study the constraints and express them as a linear equation.

## Graphical method:

Simple two dimensional linear programming problems can be easily and rapidly solved by this technique. This method can be easily be applied upto 3 variables.

Example 1: A furniture manufacturer makes two products $X_1$ & $X_2$ namely chair and tables. Each chair contributes a profit of Rs 20 and each table that of Rs 40. Chairs and tables from raw material to finished product, are processed in 3 sections $S_1$, $S_2$, $S_3$. In section $S_1$ each chair ($X_1$) requires 1 Hr and each table ($X_2$) requires 4 Hrs of processing. In section $S_2$, each chair requires 3 Hrs and each table 1 Hr and in section $S_3$ the times are 1 and 1 Hr respectively. The manufacturer wants to optimize his profits if sections $S_1$, $S_2$, $S_3$ can be availed for not more than 24, 21 and 8 Hrs respectively.

ANS:

Let Chair = $X_1$

Table = $X_2$

Maximum $Z = 20X_1 + 40X_2$

| | Chair | Table | Total |
|---|---|---|---|
| $S_1$ | 1 | 4 | 24 |
| $S_2$ | 3 | 1 | 21 |
| $S_3$ | 1 | 1 | 8 |

Subject to :

$X_1 + 4X_2 \leq 24$ $(C_1)$

$3X_1 + X_2 \leq 21$ $(C_2)$

$X_1 + X_2 \leq 8$ $(C_3)$

$X_1, X_2 \geq 0$ $(C_4)$

Where, $C_1$ is constraint No. 1.

$C_2$ is constraint No. 2.

$C_3$ is constraint No. 3.

$C_4$ is constraint No. 4.

Example 2: A firm can produce 3 types of cloth says A, B and C. Three kinds of wool are required for it say red wool, green wool and blue wool. One unit length of type A cloth needs 2 yards of red wool and 3 yards of blue wool. One unit length of type B cloth needs 3 yards of red wool, 2 yards green wool and 2 yards blue wool and one unit of type C cloth needs 5 yards of green and 4 yards of blue wool. The company has a stock of only 8 yards of red, 10 yards green wool and 15 yards of blue wool. The profit from sale of 1 unit length of type A is Rs 10, type B is Rs 8 and type C is Rs 5. Determine how the firm should use the available material so as to maximize the profit. Formulate this as LP problem.

ANS:

Let $x_1$, $x_2$ and $x_3$ be the no. of units of cloth of type A, type B and type C.

Objective is to maximize profit.

$Z = 10x_1 + 8x_2 + 5x_3$

| Requirement wool | Clothes | | | Availability of |
|---|---|---|---|---|
| | A | B | C | |
| Red | 2 | 3 | ___ | 8 |
| Green | ___ | 2 | 5 | 10 |
| Blue | 3 | 2 | 4 | 15 |

$2x_1 + 3x_2 \leq 8$

$2x_2 + 5x_3 \leq 10$

$3x_1 + 2x_2 + 4x_3 \leq 15$

Example 3 : A company produces two types of dolls A and B. Doll A is of superior quality and B is of lower quality. Profit on doll A and B is Rs 5 and Rs 3 respectively. Raw material required for each doll A is twice that is required for doll B. The supply of raw material is only 1000 per day of doll B. Doll A requires a special crown and only 400 such clips are available per day. For doll B 700 crowns are available per day. Find graphically the product mix so that the company makes maximum profit.

ANS:

$\text{Max. } Z = 2x_1 + x_2$

$2x_1 + x_2 \leq 1000$

$x_1 \leq 400$

$x_2 \leq 700$

$x_1, x_2 \geq 0$

## Graphical method:

1st step:

Formulate the LPM.

$\text{Max } Z = 20x_1 + 40x_2$

Subjected to $x_1 + 4x_2 \leq 24$ ($c_1$)

$3x_1 + x_2 \leq 21$ ($c_2$)

$x_1 + x_2 \leq 8$ ($c_3$)

$x_1, x_2 \geq 0$ ($c_4$)

$c_1$ is constrain no. 1 and so on.

2nd step:

2nd steps convert the constraint inequalities temporarily into equations.

$x_1 + 4x_2 = 24$ ($c_1$)

$3x_1 + x_2 = 21$ ($c_2$)

$x_1 + x_2 = 8$ ($c_3$)

3rd steps: Axis are marked on the graph paper and labeled with variables $x_1$ & $x_2$.

4th steps:

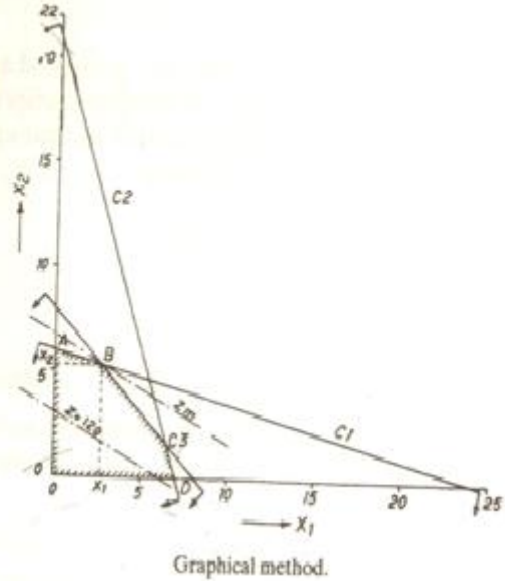
4th step is draw straight lines on the graph paper using constraint equations and to mark feasible solution on the graph paper.

Taking 1st constraint equation,

$x_1 + 4x_2 = 24$

$x_1 = 0$, $x_2 = 6$

$x_2 = 0$, $x_1 = 24$




Graphical method.

Mark the point of 24 at $X_1$ axis and point 6 on $x_2$ axis. The straight line represents $c_1$ equation.

Similarly, $c_2$ and $c_3$ can be plotted.

$3x_1 + x_2 = 21$ $x_1 + x_2 = 8$

$x_1 = 0, x_2 = 21$ $x_1 = 0, x_2 = 8$

$x_2 = 0, x_1 = 7$ $x_2 = 0, x_1 = 8$

According to constrain $c_4$, $x_1$ & $x_2$ are greater than or equal to zero, hence the marked area between $x_1 = x_2 = 0$ and $c_1$, $c_2$, $c_3$ represents the feasible solution.

5th step:

A dotted straight line representing the equation Z is drawn, assuming any suitable value of Z say 120.

$X_1 = 0, x_2 = 3$

$X_2 = 0, x_1 = 6$

6th steps:

A straight line $Z_m$ is drawn parallel to the line Z, at the furthest point of the region of feasible solution i.e. point B, at the intersection of $c_1$ & $c_3$.

The co-ordinates at point B can be found by solving equation $c_1$ & $c_3$.

$x_1 + x_2 = 8$ $(c_3)$

$x_1 + 4x_2 = 24$ $(c_1)$

$3x_2 = 16 \Rightarrow x_2 = 5.3$

$3x_1 = 8 \Rightarrow x_1 = 2.7$

These values of $x_1$ and $x_2$ can also be read from the graph itself.

∴ The maximum value of Z is

$$Z_m = 20x_1 + 40x_2 = 20 \times \frac{8}{3} + 40 \times \frac{16}{3} = 266.6$$

# NETWORK ANALYSIS

It is a system which plans projects both large and small by analyzing the project activities. Projects are broken down to individual tasks or activities, which are arranged in logical sequence.

## *Projects:*

Project is any task which has definable beginning and definable end expenditure of one or more resources.

It is essential to manage effectively the projects through proper planning, scheduling and control as project requires a heavy investment, and is associated with risk and uncertainties.

## *Network scheduling:*

It is a technique used for planning and scheduling large projects in the field of constructions, maintenance, fabrication and any other areas.

This technique is the method of minimizing the bottlenecks, delays and interruptions by determining the critical factors and coordinating various activities.

## *A network diagram:*

A network diagram is constructed which presents visually the relationship between all the activities involved. Time, costs and other resources are allocated to different activities.

It helps designing, planning, coordinating, controlling and decision making in order to accomplish the project economically in the minimum available time with the limited available resources.

There are two basic planning and control techniques. They are Critical Path Method (CPM) and Program Evaluation and Review Techniques (PERT).

## *Objective of Network Analysis:*

1. A powerful coordinating tool for planning, scheduling and controlling of projects.
2. Minimization of total project cost and time.
3. Effective utilization of resources and minimization of effective resources.

4. Minimization of delays and interruption during implementation of the project.

## *Application of Network Analysis (PERT and CPM):*

1. Research and development projects.
2. Equipment maintenance and overhauling.
3. Construction projects (building, bridges, dams)
4. Setting up new industries
5. Planning and launching of new products.
6. Design of plants, machines and systems
7. Organization of big programs

## *Basic concepts in network:*

### Network:

It is a graphical representation of the project and it consists of series of activities arranged in a logical sequence and show the interrelationship between the activities.

### Activities:

An activity is a physically identifiable part of the project, which consumes time and resources. Each activity has a definite start and end. It is represented by an arrow (→).

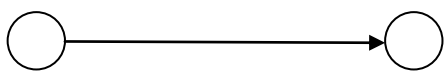
### Event:

An event represents the start or completion of an activity. The beginning and end points of an activity are events.

Ex – Machining a component is an activity.

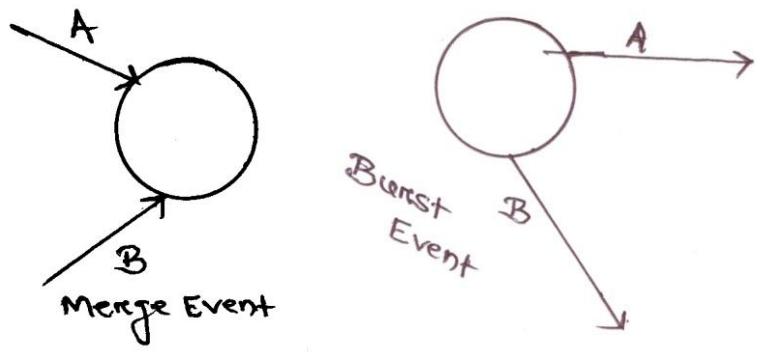
Start machining is an event.

Machining completed is an event.



Tail event Head event

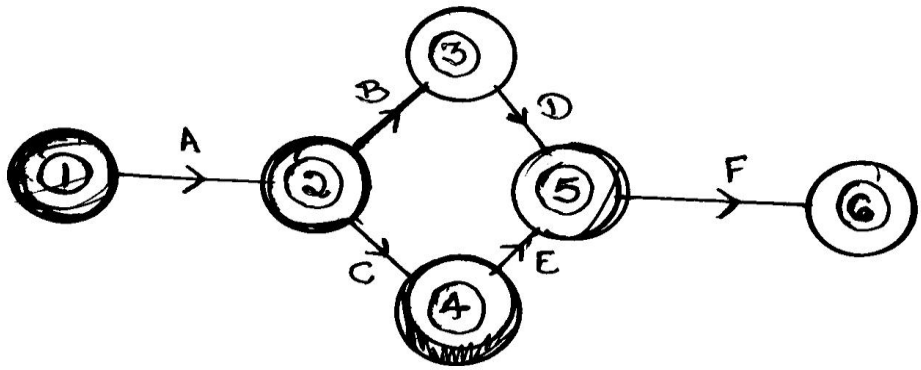
In a network a no. of activities may terminate into single node called merge node and a no. of activities may emanate from a single node called burst node.




## Predecessor and successor activities:

All those activities, which must be completed before starting the activity under consideration are called its predecessor activities.

All the activities which nave to follow the activity under consideration are called its successor activities.




2-3, 2-4 are immediate successors

2-3 &2-4, 3-5, 4-5&5-1 are its successor's activities.

1-2, 2-3 are predecessors to 3-5.

2-3 is the immediate predecessors.

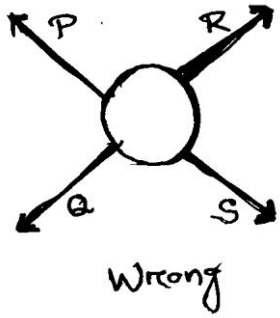
## Path:

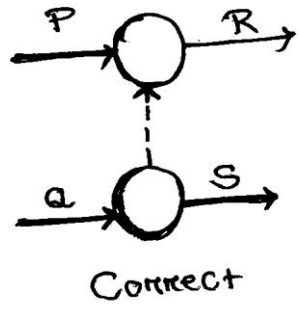
An unbroken chain of activities between two events is called a path.

Ex – A-B-D-F is a path connecting 1 & 6.

## Dummy activity:

An activity which depicts the dependency or relationship over the other but does not consume time or resources. It is used to maintain the logical sequence. It is used to maintain the logical sequence. It is indicated by a dotted line.




## *Terms related to network planning methods:*

## Event (node):

An event is a specific instant of time which marks the start and the end of an activity. Event consumes neither time nor resources. It is represented by a circle and the event no. is written within the circle.

Ex – start the motor, loan approved.

## Activity:

Every project consists of a no. of job operations or tasks which are called activities. An activity is an element of project and it any be a process, a material handling or material procurement cycle.

Ex – install machinery, arrange foreign exchange.

It is shown by an arrow and it begins and ends with an event. An activity is normally given a name like A, B, C etc i.e. marked below the arrow and the estimated time to accomplish the activity is marked above the arrow.

## *Activities are classified as:*

1. Critical activities:

   In a network diagram, critical activities are those which if consume more than their estimated time the project will be delayed. An activity is called critical if its earliest start time plus the time taken by it is equal to the latest finishing time. A critical activity is marked either by a thick arrow or (//).

2. Non critical activities:

   Such activities have provision (slack or float) so that even if they consume a specified time over and above the estimated time, the project will not be delayed.

3. Dummy activities:

   When two activities start at the same instant of time, the head events are joined by a dotted arrow and this is known as dummy activity. It does not consume time. It may be non-critical or critical. It becomes a critical activity when its EST = LFT.

## *Critical path*:

It is that sequence of activities which decide the total project duration. It is formed by critical activities. A critical path consumes maximum resources. It is the longest path and consumes maximum time. It has zero float. The expected completion data cannot be met, if even one critical activity is delayed. A dummy activity joining two critical activities is also a critical activity.

## *Duration:*

Duration is the estimated or actual time required to complete a task or an activity.

## *Total project time:*

It is the time which will be taken to complete the project and is found from the sequence of critical activities. It is the duration or critical path.

## *Earliest start time (EST):*

It is the earliest possible time at which activity can start and is calculated by moving from first to last event in a network diagram.

## *Earliest finish time (EFT):*

It is the earliest possible time at which activity can finish. i.e. (EST + D)

## *Latest finish time (LFT):*

It is calculated by moving backward i.e. from last event to first event of the network diagram. It is the last event time of the head event

## *Latest start time (LST):*

It is the least possible time by which an activity can start.

LST = LFT – duration of that activity

## *Float or slack:*

Slack is with reference to an event and float is with respect to an activity. It means spare time, a margin of extra time over and above its duration which a noncritical activity can consume without delaying the project.

Float is the difference between the time available for completing an activity and the time necessary to complete the same.

There are three type of float.

1. Total float:

   It is the additional time which a non-critical activity can consume without increasing the project duration.

TF = LST – EST or LFT – EFT and it can be – ve.

2. Free float:

   If all the non critical activities start as early as possible, the time is the free float.

   FF = EST of tail event – EST of head event – activity duration

3. Independent float:

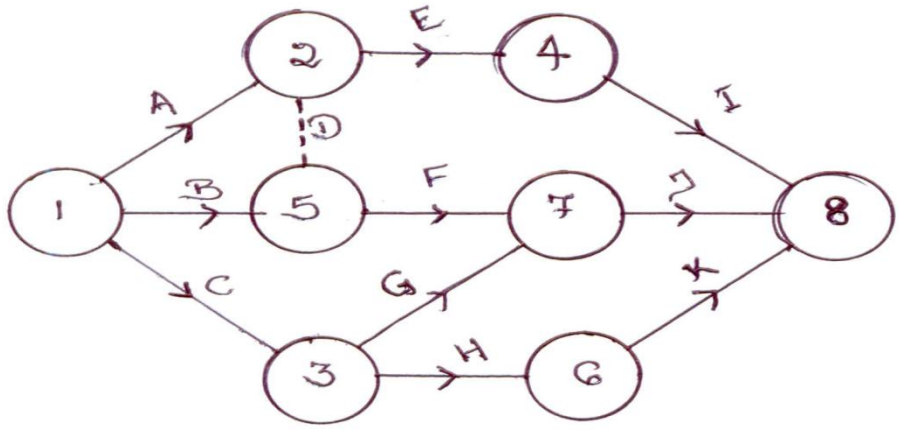
   It can be used to advantage. If one is interested to reduce the effort on a non-critical activity in order to apply the effort on a critical activity by reducing the project duration.

   IF = EST of tail event – LFT of head event – activity duration.

   If IF is negative, then taken as 0.

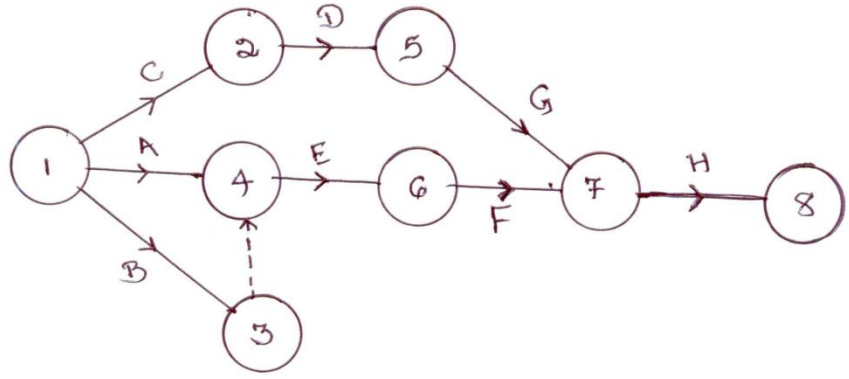
*Numbering of events (Fulkerson's rule):*

1. The initial event which has all outgoing arrows with no incoming arrow is numbered '1'.
2. Delete all arrows coming out from node 1. This will convert some more nodes into initial events number these events 2, 3 etc.
3. Delete all the arrows going out from these numbered events to create more initial events. Assign next number to these events.
4. Continue until the final or terminal node which has all arrows coming in, with no arrow going out is numbered.



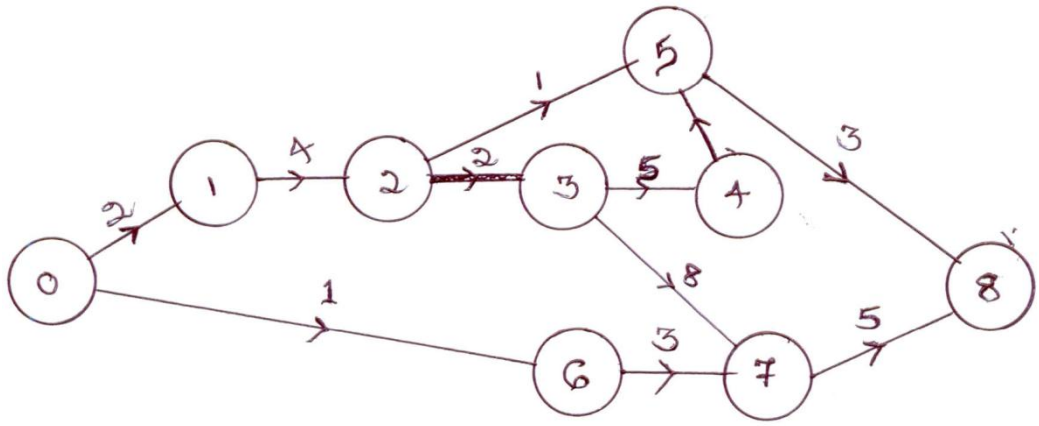
1. Construct the network from the information.

| Activity | Immediate predecessor | Time |
|---|---|---|
| A | ------ | 6 |
| B | ------ | 10 |
| C | ------ | 14 |
| D | C | 6 |
| E | A, B | 14 |
| F | E, D | 6 |
| G | D | 4 |
| H | F, G | 4 |



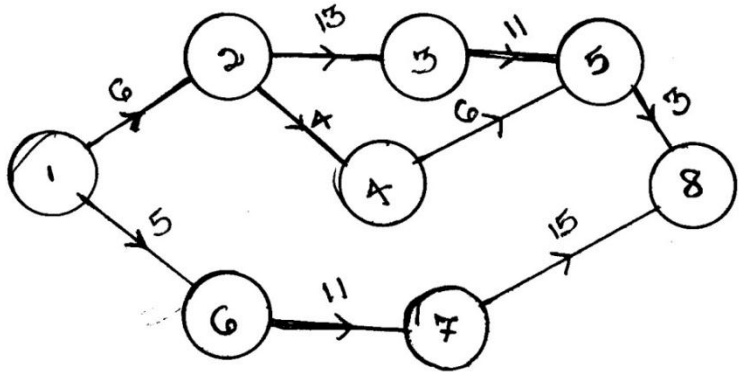

2. Construct the network from the information.

| Activity No. | Duration | Activity No. | Duration |
|---|---|---|---|
| 0-1 | 2 | 0-6 | 1 |
| 1-2 | 4 | 3-7 | 8 |
| 2-3 | 2 | 6-7 | 3 |
| 3-4 | 5 | 5-8 | 3 |
| 2-5 | 1 | 7-8 | 5 |
| 4-5 | 1 | | |




3. Construct the network from the information.

| Activity | Time | Activity | Time |
|---|---|---|---|
| 1-2 | 6 | 3-5 | 11 |
| 1-6 | 5 | 4-5 | 6 |
| 2-3 | 13 | 6-7 | 11 |
| 2-4 | 4 | 5-8 | 3 |
| ------ | ------ | 7-8 | 15 |




## *Critical Path Method:*

In the critical path method the activity times are known with certainty. For each activity EST and LST are computed. The path with the longest time sequence is called critical path. The length of the critical path determines the minimum time in which the entire project can be completed. The activities on the critical path are called critical activities.

## Objective:

1. Determining the completion time for the project.
2. Earliest time when each activity can start.
3. Latest time when each activity can start without delaying the total project.
4. Determining the float for each activity.
5. Identification of the critical activities and critical path.

## Example:

A small engineering project consists of 6 activities namely A, B, C, D, E & F with duration 4, 6, 5, 4, 3 & 3 days respectively. Draw the network diagram and calculate EST, LST, EFT, LFT and floats. Mark the critical path and find total project duration

| Activity | Duration (days) | EST | LST (LFT - D) | EFT (EST + D) | LFT | TF |
|---|---|---|---|---|---|---|
| A | 4 | 0 | 0 | 4 | 4 | 0 |
| B | 6 | 4 | 4 | 10 | 10 | 0 |
| C | 5 | 10 | 10 | 15 | 15 | 0 |
| D | 4 | 4 | 8 | 8 | 12 | 4 |
| E | 3 | 8 | 12 | 11 | 15 | 4 |
| F | 3 | 15 | 15 | 18 | 18 | 0 |

Critical path = 1-2-3-5-6

Total project duration = 4+6+5+3 = 18 days

## *Programme Evaluation Review Technique (PERT):*

PERT takes into account the uncertainty of activity times. It is a probabilistic model with uncertainty in activity duration.

It makes use of three time estimates.

I. Optimistic time ($t_0$)
II. Most likely time ($t_m$)

III. Pessimistic time ($t_p$)

I. Optimistic time ($t_0$):

It is the shortest possible time in which an activity can be completed if everything goes perfectly without any complications.

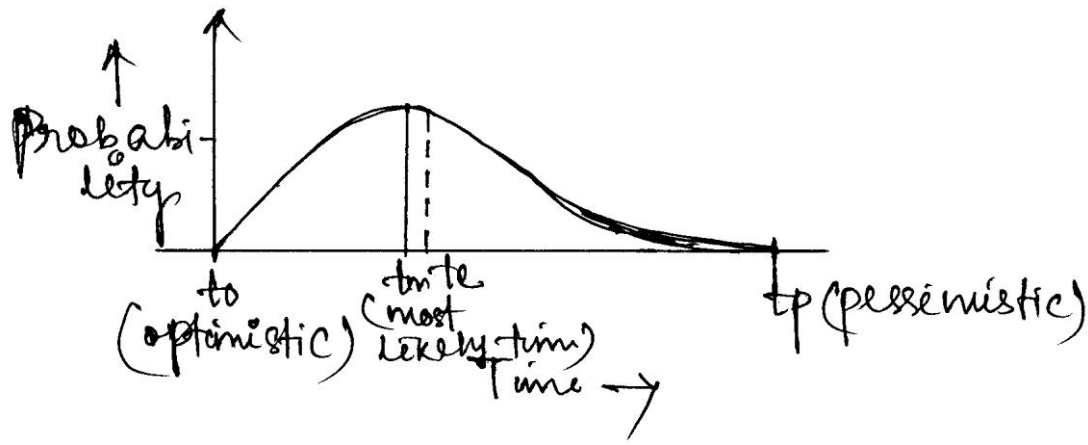
It is an estimate of minimum possible time to complete the activity under ideal condition.

II. Pessimistic time ($t_p$):

It is the longest time in which an activity can be completed if everything goes wrong.

III. Most likely time($t_m$);

It is the time in which the activity is normally expected to complete under normal contingencies.




According to the $\beta$ distribution curve

$$T_e = \frac{1}{6}t_0 + \frac{2}{3}t_m + \frac{1}{6}t_p$$

$$= \frac{t0 + 4tm + tp}{6}$$

The standard deviation of time required to complete each activity.

$$\text{Standard deviation}(\sigma) = \frac{tp - t0}{6}$$

$$\text{Variance } \sigma^2 = \left(\frac{tp - t0}{6}\right)^2$$

Standard deviation of the time $t_p$ to complete the project

$$= \frac{tp1-to1}{6} + \frac{tp2-to2}{6} + \ldots\ldots\ldots\ldots\ldots\ldots + \frac{tpn-to1}{6}$$

## Mean, variance, standard deviation:

No. of days taken to dig a certain length of trench under varying condition.

48 76 52 40 50

49 60 62 53 50

53 56 67 62 60

61 46 72 70 58

Mean time or average time = 52.5 days

## Standard deviation for each entry:

48 – 52.5 = -4.5

49 – 52.5 = -3.5

.

.

.

Square the variation

$(-4.5)^2 = 20.25$

$(-3.5)^2 = 12.25$ …….. so on

$\frac{20.25+12.25+\cdots\ldots\ldots}{Total\ no.of\ \ jobs\ (20)}$ = 6.52

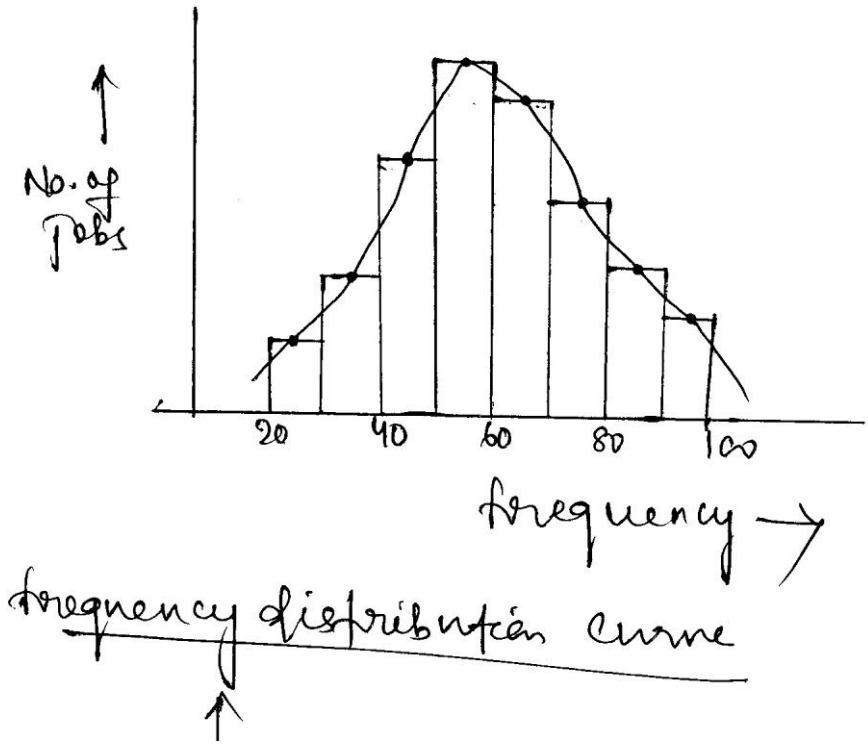
Square the deviations, add them and divide by no. of jobs to get variance.

Square rating the variance standard deviation can be found.

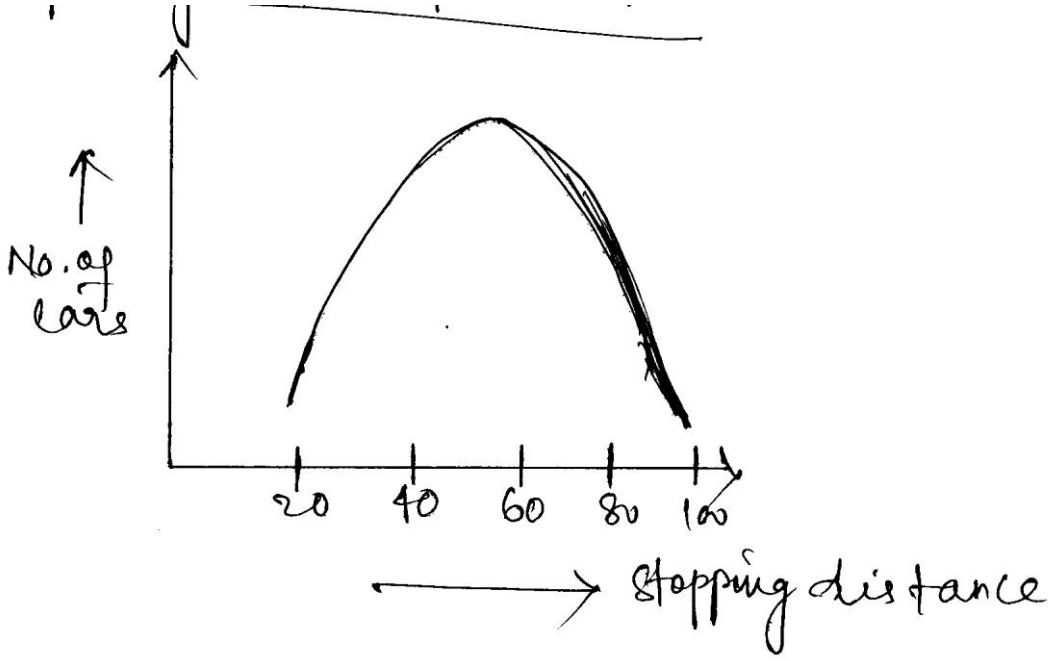
Example-1 : Stopping distance of a car is given

| | | | | | | |
|---|---|---|---|---|---|---|
| 76 | 53 | 64 | 40 | 56 | 60 | 61 |
| 62 | 30 | 34 | 44 | 38 | 58 | 42 |
| 39 | 43 | 44 | 54 | 76 | 38 | 42 |
| 36 | 46 | 63 | 57 | 27 | 48 | 59 |
| 45 | 53 | 35 | 32 | 47 | 58 | 36 |
| 63 | 55 | 53 | 44 | 52 | 46 | 51 |
| 47 | 64 | 54 | 65 | 56 | 65 | 68 |
| 56 | 66 | 69 | 59 | 67 | 52 | 58 |
| 44 | 55 | 21 | 64 | 22 | 72 | 37 |
| 81 | 74 | 84 | 42 | 41 | 75 | 55 |

| Car interval (in meters) | Tally | Frequency |
|---|---|---|
| 20 to 29 | III | 3 |
| 30 to 39 | IIIII IIIII | 10 |
| 40 to 49 | IIIII IIIII IIIII I | 16 |
| 50 to 59 | IIIII IIIII IIIII IIIII | 20 |
| 60 to 69 | IIIII IIIII IIIII | 14 |
| 70 to 79 | IIIII | 5 |
| 80 to 89 | II | 2 |
| | | 70 |




frequency distribution curve



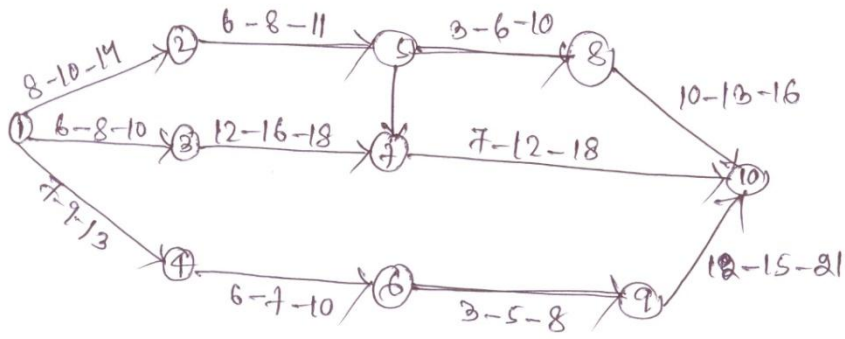

Probability of completion of the project within a scheduled time:

Time:

The probability of completion of the project within scheduled is computed as

1. Calculate the mean of the event time ($t_e$) by adding the times of the activities along the critical path leading to the event.
2. Calculate the variance of the event time by adding up the variances of the activities on the critical path. Take the square root of this variances to get T (standard deviation)
3. Compute standard normal variate

$$Z = \frac{Ts - Te}{\sigma T} \qquad Z = \frac{D - Te}{St}$$




There are 4 paths to reach 1 to 10.

A → 1-2-5-8-10

B → 1-2-5-7-10

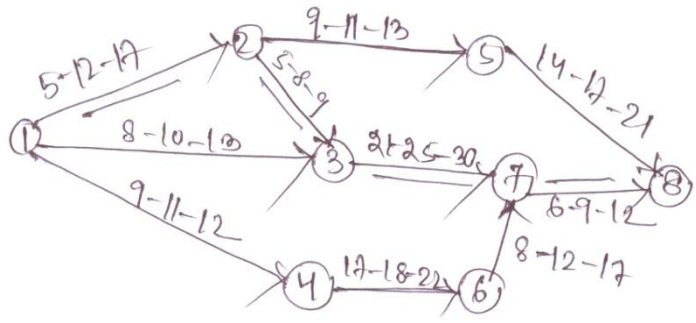
C → 1-3-7-10

D → 1-4-6-9-10

| | Activity | $t_0$ | $t_m$ | $T_p$ | $T_e$ | Sum of $t_e$ |
|---|---|---|---|---|---|---|
| Path A | 1-2 | 8 | 10 | 14 | 10.33 | 37.67 |
| | 2-5 | 6 | 8 | 11 | 8.17 | |
| | 5-8 | 3 | 6 | 10 | 6.17 | |
| | 8-10 | 10 | 13 | 16 | 13 | |
| Path D | 1-4 | 7 | 9 | 13 | 9.33 | 37.34 |
| | 4-6 | 6 | 7 | 10 | 7.33 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 6-9 | 3 | 5 | 8 | | |
| | 9-10 | 12 | 15 | 21 | | |
| Path C | 1-3 | 6 | 8 | 10 | | 35.84 |
| | 3-7 | 12 | 16 | 18 | | |
| | 7-10 | 7 | 12 | 18 | | |
| Path B | 1-2 | 8 | 10 | 14 | | 37.84 |
| | 2-5 | 6 | 8 | 11 | | |
| | 5-7 | 5 | 7 | 10 | | |
| | 7-10 | 7 | 12 | 18 | | |

Maximum time consumed is 37.84 is the critical path. So path B is the critical path.




Example – 2:

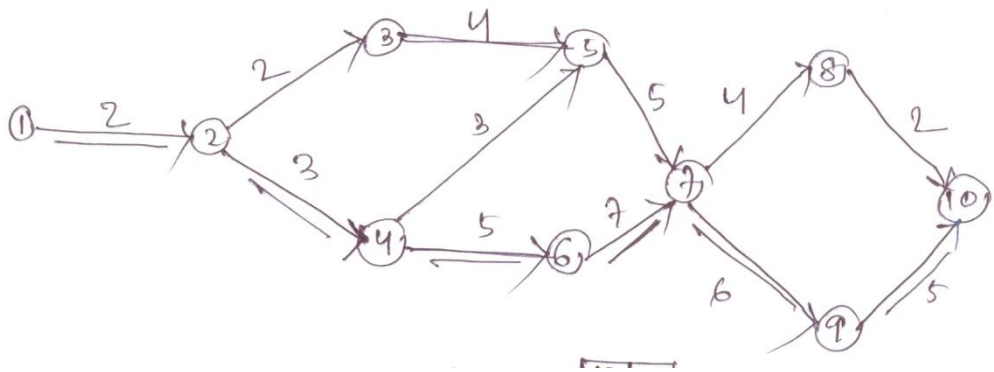
Construct the PERT network. Find the critical path and variance of each event. Find the project duration at 95 % probability.

| Activity | Optimistic time | Pessimistic time | Most likely time |
|---|---|---|---|
| 1-2 | 1 | 5 | 1.5 |
| 2-3 | 1 | 3 | 2 |
| 2-4 | 1 | 5 | 3 |

| | | | |
|---|---|---|---|
| 3-5 | 3 | 5 | 4 |
| 4-5 | 2 | 4 | 3 |
| 4-6 | 3 | 7 | 5 |
| 5-7 | 4 | 6 | 5 |
| 6-7 | 6 | 8 | 7 |
| 7-8 | 2 | 6 | 4 |
| 7-9 | 5 | 8 | 6 |
| 8-10 | 1 | 3 | 2 |
| 9-10 | 3 | 7 | 3 |

Solution:

| Activity | $t_o$ | $t_p$ | $t_m$ | $t_e$ | Variance |
|---|---|---|---|---|---|
| 1-2 | 1 | 5 | 1.5 | 2 | 4/9 |
| 2-3 | 1 | 3 | 2 | 2 | 1/9 |
| 2-4 | 1 | 5 | 3 | 3 | 4/9 |
| 3-5 | 3 | 5 | 4 | 4 | 4/9 |
| 4-5 | 2 | 4 | 3 | 3 | 1/9 |
| 4-6 | 3 | 7 | 5 | 5 | 4/9 |
| 5-7 | 4 | 6 | 5 | 5 | 1/9 |
| 6-7 | 6 | 8 | 7 | 7 | 4/9 |
| 7-8 | 2 | 6 | 4 | 4 | 4/9 |
| 7-9 | 5 | 8 | 6 | 6.16 | 1/4 |
| 8-10 | 1 | 3 | 2 | 2 | 1/9 |
| 9-10 | 3 | 7 | 3 | 5 | 4/9 |




The critical path is 1-2-4-6-7-9-10.

Expected duration of the project = 2+3+5+7+6.16+5 = 28.16 days

Project variance = 4/9+4/9+4/9+4/9+1/4+4/9 = 89/36

Z = $\frac{due\ date - expected\ date\ of\ of\ completion}{\sigma T}$

$= \frac{X-28.16}{89/36} = 0.8289$

⇨ X = 30.12 days

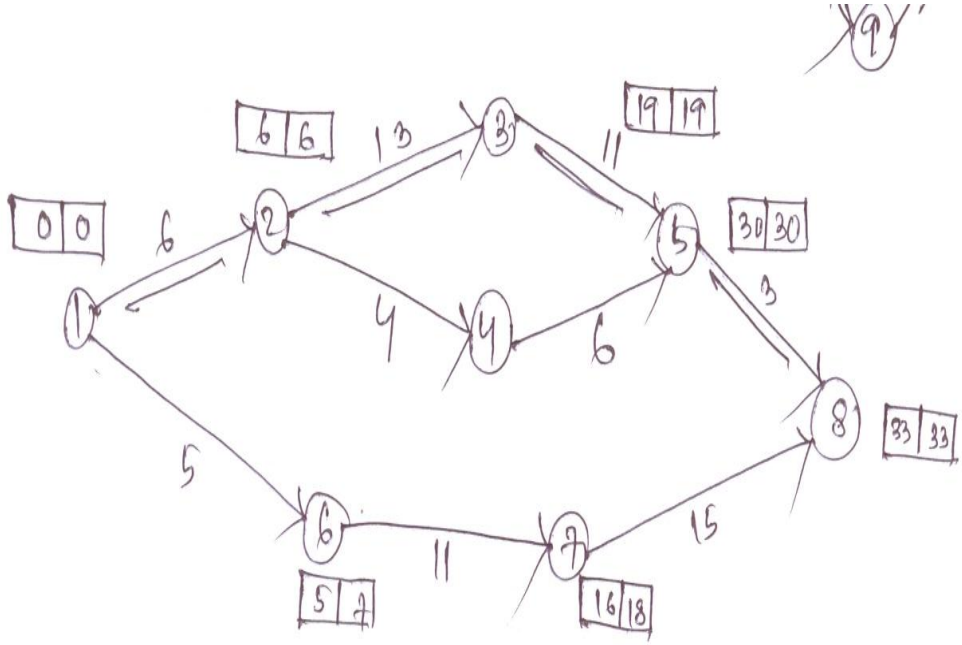
## Example- 3:

A small engineering project consists of an activity. Three time estimates for each activity are given

a) Calculate values of expected time ($t_e$), standard deviation ($s_t$) and variance ($v_t$) for each activity.
b) Draw the network diagram and mark $t_e$ on each activity.
c) Calculate EST and LFT and mark $t_e$ on each activity.
d) Calculate total slack for each activity.
e) Indentify the critical paths and mark on the network diagram.
f) Find the length of critical paths or total project duration.
g) Calculate variance of critical path.
h) Calculate the probability that the jobs on the critical path will be finished by the due date of 38 days.
i) Calculate the approx probability that the jobs on the next most critical path will be completed by the due date of 38 days.
j) Estimate the probability that the entire project will be completed by the due date of 38 days.
k) If the project due date changes to 35 days what is the probability of not meeting the due date.
l) Find the due date which has a probability of 94.5 % of being met.

## Solution:

| Activity | $T_o$ | $T_m$ | $T_p$ | $T_e$ | $V_t$ |
|---|---|---|---|---|---|
| 1-2 | 2 | 5 | 14 | 6 | 4 |
| 1-6 | 2 | 5 | 8 | 5 | 1 |
| 2-3 | 5 | 11 | 29 | 13 | 16 |
| 2-4 | 1 | 4 | 7 | 4 | 1 |
| 3-5 | 5 | 11 | 17 | 11 | 4 |
| 4-5 | 2 | 5 | 14 | 6 | 4 |
| 6-7 | 3 | 9 | 27 | 11 | 16 |
| 5-8 | 2 | 2 | 8 | 3 | 1 |
| 7-8 | 7 | 13 | 31 | 15 | 16 |




| Activity | EST | LST | LST - EST |
|---|---|---|---|
| 1-2 | 0 | 0 | 0 |
| 1-6 | 0 | 2 | 2 |
| 2-3 | 6 | 6 | 0 |
| 2-4 | 6 | 20 | 14 |
| 3-5 | 19 | 19 | 0 |
| 4-5 | 10 | 24 | 14 |
| 6-7 | 5 | 7 | 2 |
| 5-8 | 30 | 30 | 0 |
| 7-8 | 16 | 18 | 2 |

e) Critical path is 1-2-3-5-8 and it is marked on the network diagram.

f) The length of the critical path or total project duration ($T_e$) is the sum of the duration of each critical activity = 6 + 13 + 11 + 3 = 33 days

g) Variance of the critical path is two of the each critical activity = 4 + 16 + 4 + 1 = 25

h) The probability that the project will meet the scheduled or due date is calculated from the $Z = \frac{D-Te}{St}$

Where $T_e$ = total project duration

$S_t$ = standard deviation = $\sqrt{varience}$

D = Due or scheduled deviations

$\therefore Z = \frac{38-33}{\sqrt{25}} = \frac{5}{5} = 1$ For Z = 1, probability = 0.841.

i) The next most critical path is 1-6-7-8 of 31 days.

Variance = 1+16+16 = 33 $s_t = \sqrt{33}$

$Z = \frac{38-31}{5.74} = 1.22$

For Z = 1.22, probability = 0.888

# Chapter - 07
# Inspection and Quality Control

## 7.1 Definition of Inspection & Quality Control :-

**Inspection :-** An item or product which is manufactured, is required to perform certain functions. The act of checking wether a component actually does so or not is called inspection.

→ In other words, Inspection means checking the acceptability of manufactured product.

→ Inspection measures the qualities of a product or service in terms of ~~product~~ predecided standards.

### Objective of Inspection :-

(i) Inspection separates defective components from non-detective ones and thus ensures the adequate quality of products.

(ii) Inspection locates defects in raw materials and flaws in processes which otherwise cause problems at the final stage. For example, detecting the parts not having proper tolerances during processing itself, will minimize the troubles arising at the time of assembly.

(iii) Inspection prevents further working being done on semi-finished products already defected as spoiled.

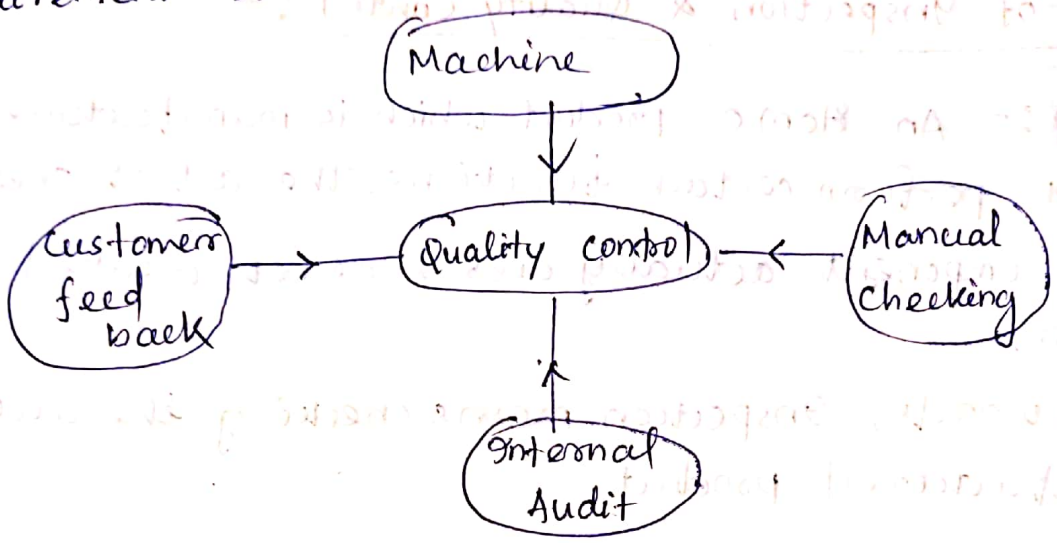
(iv) Inspection makes sure that the product works and it works without hurting anybody i.e its operation is safe.

(v) Inspection detects sources of weakness and trouble in the finished products and thus checks the work of designers.

(vi) Inspection buils up the reputation of the concern as it helps reducing the number of complaints from the customers.

## Quality Control :-

- Quality control is a procedure or set of procedures intended to ensure that a manufactured product or performed service adheres to a defined set of quality criteria or meets the requirements of the clinet or customer.




## Objective of Quality Control :-

(i) Improvement of quality of products
(ii) Reduction of scrap and rework
(iii) Efficient use of man and machines
(iv) Decreased inspection costs
(v) Scientific evaluation of quality and production.
(vi) Quality caution at all levels
(vii) To decide about the standards of quality of a product that is easily acceptable to the customer.
(viii) To check the variation during manufacturing
(ix) To prevent the poor quality product reaching to customer

## Types of Inspection :-

(a) Roving or patrolling or floor inspection
(b) Fixed inspection
(c) Key point inspection
(d) Final inspection

### (a) Roving or Patrolling or Floor Inspection :-

- The inspector walks round on the shop floor from machine to machine and checks samples of the work of various machine operators or workers.
- Floor inspection helps catching errors during process itself i.e before the final production is ready.
- → It is more effective and desirable because the work need not be transported to a centralized place.

### (b) Fixed Inspection :-

- The work is brought at intervals for inspection to check.
- Fixed inspection discovers defects after the job has been completed
- Fixed inspection is used when inspection equipments and tools cannot be brought on the shop floor.
- It is a sort of centralized inspection, the worker and the inspector do not come in contact with each other; thus it eliminates any chances of passing a doubtful product.

### (c) Key point Ispection :-

- Every product has a key point in its process of manufacture. A key point is a stage beyond which either the product requires an expensive operation or it may not be capable of rework
- Inspection at a key point segregates and thus avoids unnecessary further expenditure on poor and subsequent substandard parts which are likely to be rejected finally.

(d) Final Inspection :-

- The final inspection of the product may check its appearance and performance.
- Many destructive and nondestructive inspection and test methods such as tensile, fatigue, impact testing etc. and ultrasonic inspection, x-ray radiography, etc respectively are available for final inspection of the products manufactured.
- Final inspection is a centralized inspection and it makes use of special equipments.

Statistical Quality Control :- (SQC)

→ A quality control system performs inspection, testing and analysis to conclude whether the quality control when statistical techniques are employed to control quality or to solve quality control problems.

→ Statistical quality control makes inspection more reliable and at the same time less costly. It controls the quality level of the outgoing products.

Factors influencing the quality of manufacture :-

(i) Market :- Because of technology advancement, we could see many new products to satisfy customer wants.

- Market for the product must exist before quality of the product is emphasized by management. It is unless to talk about the quality when the market for the product is lacking e.g. there is no demand for woolen garment in the hot climate

(ii) Money :- Most important factor affecting the quality of a product is the money involved in the production itself.

- In the present day of tough and cut throat competition, companies are forced to invest a lot in maintaining the quality of products.

(iii) Materials :- To turn out a high quality product, the raw material involved in production process must be of high quality.
- Selection of proper materials to meet the desired tolerence
(iv) & limit is also an important consideration.

(iv) Management :- Quality control and maintenance programmes should have support from top management. If the management is quality consious rather than merely quality conscious, organisation can maintain adequate quality of products.

(v) Men / People :- People employed in production in designing the products must have knowledge and experience in their respective areas.

(vi) Machines and Methods :- To maintain high standards of quality companies are investing in new machines and following new ~~prod~~ procedures and methods these days.

## Control Charts :-

- Control charts are based on statistical sampling theory, according to which an adequate sized sample drawn, at random, from a lot represents the lot.
- Control chart is a graphical presentation of the collected information. The information pertains to measured or otherwise judge quality characteristics of the items or the samples.
- A control chart detects variations in the processing and warns if there is any departure from the specified tolerance limits.

## Advantages of Control Chart :-

- It indicates whether the process is in control or out of control.
- It determines the process variability & detects the unusual variations taking place in a project.
- It ensures the product quality level.

(iv) It provides information about the selection of process & setting of the tolerance limit

- It builds up the reputation of the organisation through customer satisfaction.

## Types of Control charts :-

(i) $\bar{X}$ chart
(ii) R chart
} variables or measurement chart

(iii) P chart
(iv) C chart
} Attribute chart

## (i) $\bar{X}$ Chart :-

- It shows changes in process average and is affected by changes in process variability.
- It is a chart for the measure of central tendency.
- It shows erratic or cyclic shifts in the process.
- It detects steady progress changes like tool wear.
- It is the most commonly used variables chart.

## (ii) R Chart :-

- It controls general variability of the process and is affected by changes in process variability.
- It is a chart for measure of spread.
- It is generally used along with an $\bar{x}$ chart,

## Plotting of $\bar{x}$ & R chart :-

A good number of samples of items coming out of the machine are collected at random at different ~~time~~ intervals of time and their quality characteristics are measured.

- For each sample, the mean value and range is found out. For example if a sample contain 5 items, whose diameters are $d_1, d_2, d_3, d_4$ & $d_5$ the sample average.

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

And, range R = Maximum diameter − Minimum diameter

A number of samples are selected and their average values and range are tabulated.

Example:-

| 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 |
| 6 | 11.0 | 4 |
| 7 | 11.5 | 3 |
| 8 | 4.0 | 2 |
| 9 | 3.5 | 3 |
| 10 | 4.0 | 2 |
| | $\Sigma\bar{X} = 76$ | $\Sigma R = 26$ |

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

Average of R, $\bar{R} = \frac{\Sigma R}{\text{No. of samples}}$

Therefore, $\bar{\bar{X}} = \frac{76}{10} = 7.6$

$\bar{R} = \frac{26}{10} = 2.6$

For $\bar{X}$ chart; Upper control limit (UCL) $= \bar{\bar{X}} + A_2\bar{R}$

Lower control limit (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 values of various factors (like $A_2$, $D_4$ & $D_3$) based on Normal distribution can be found from the following table

| Sample size | $A_2$ Limit Average | $D_3$ 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 |

→ Values of $A_2$, $D_3$ and $D_4$ for sample size 7, 9 & 11 can be determined by taking the mean value of sample sizes 6 & 8, 8 & 10 and 11 & 12 respectively.

→ Sample size in this problem is 5, therefore $A_2 = 0.58$,
$D_3 = 0$
$D_4 = 2.11$

Thus for $\bar{x}$ chart; Upper control limit, $UCL = \bar{\bar{x}} + A_2\bar{R}$

$= 7.6 + (0.58 \times 2.6)$

$= 7.6 + 1.51$

$= 9.11$

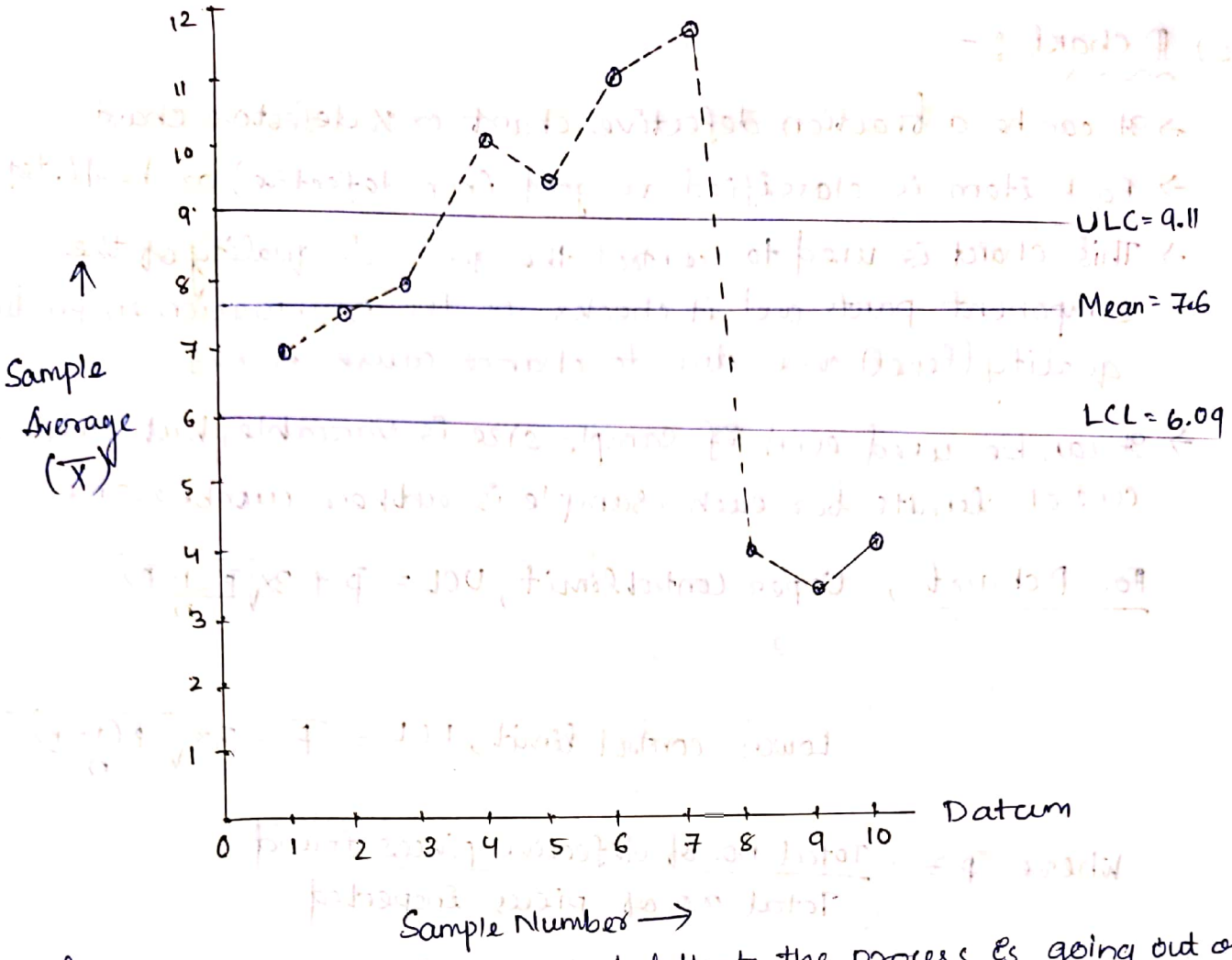
Lower control limit, $LCL = \bar{\bar{x}} - A_2\bar{R}$

$= 7.6 - 0.58 \times 2.6$

$= 6.09$

For R chart; $UCL = 2.11 \times 2.6 = 5.48$

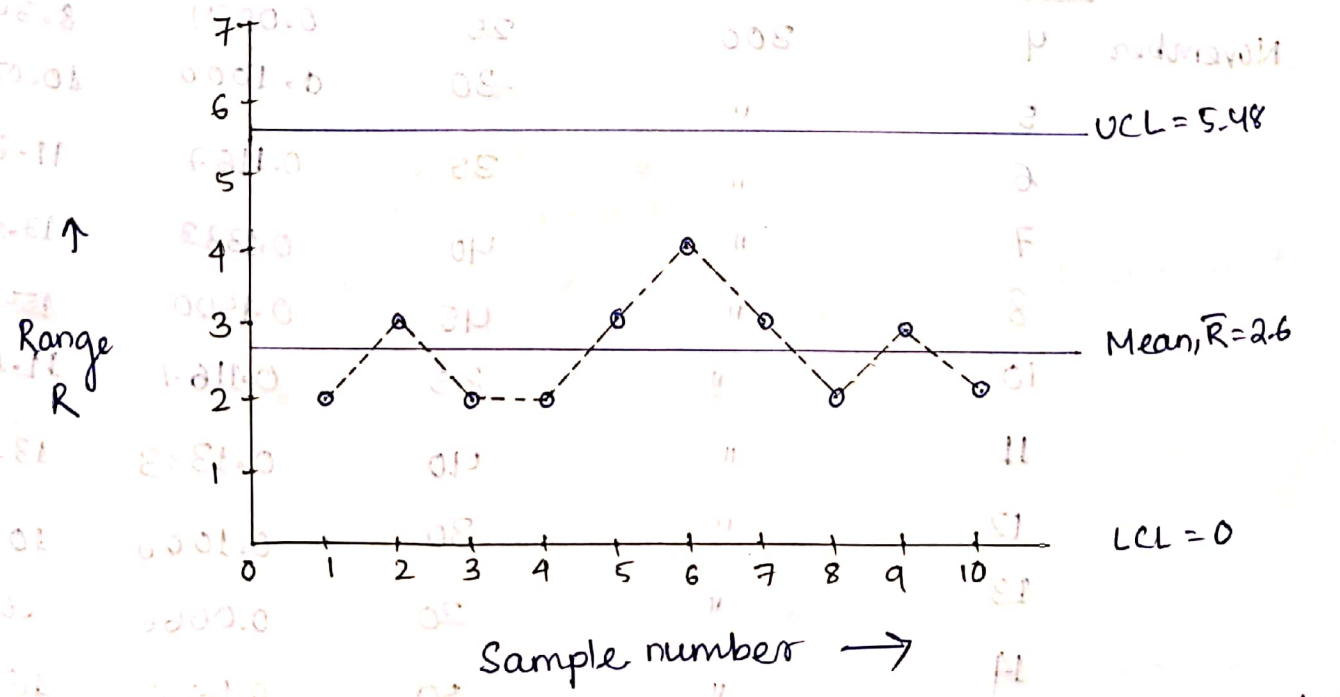
$LCL = D_3 \times \bar{R} = 0 \times \bar{R} = 0$




So from the $\bar{x}$ chart, it is concluded that the process is going out of control from the 4th sample onwards.

For R chart :- $UCL = D_4\bar{R} = 2.4 \times 2.6 = 5.48$ $\quad \bar{R} = \text{Mean} = 2.6$

$LCL = D_3\bar{R} = 0 \times 2.6 = 0$




→ From the R-chart it is concluded that all the range values are under control

## (c) P chart :-

→ It can be a fraction defective chart or % defective chart

→ Each item is classified as good (non defective) or bad (defective)

→ This chart is used to control the general quality of the component parts and it checks if the fluctuation in product quality (level) are due to chance cause alone.

→ It can be used even if sample size is variable, but calculating control limits for each sample is rather cumbersome.

For P chart, Upper Control limit, $UCL = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$

Lower control limit, $LCL = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$

Where $\bar{p} = \frac{\text{Total no. of defective pieces found}}{\text{Total no. of pieces inspected}}$

Example

| Date | Number of pieces inspected (a) | Number of defective pieces found (b) | Fraction defective p = (b)/(a) | % defective 100p |
|---|---|---|---|---|
| November 4 | 300 | 25 | 0.0834 | 8.34 |
| 5 | " | 30 | 0.1000 | 10.00 |
| 6 | " | 35 | 0.1167 | 11.67 |
| 7 | " | 40 | 0.1333 | 13.33 |
| 8 | " | 45 | 0.1500 | 15.00 |
| 10 | " | 35 | 0.1167 | 11.67 |
| 11 | " | 40 | 0.1333 | 13.33 |
| 12 | " | 30 | 0.1000 | 10.00 |
| 13 | " | 20 | 0.0666 | 06.66 |
| 14 | " | 50 | 0.1666 | 16.66 |
| Total number of days = 10 | Total = 3000 | Total = 350 | | |

For P-chart upper control limit, $UCL = \bar{p} + 3 \times \sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$

Lower control limit, $LCL = \bar{p} - 3 \times \sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$

$\because \bar{p} = \frac{\text{Total no. of defective pieces found}}{\text{Total no. of pieces inspected}} = \frac{350}{3000} = 0.1167$

And $n$ = number of pieces inspected every day = 300

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

$= 0.1167 + 3 \times \sqrt{\frac{0.1167(1-0.1167)}{300}}$

$= 0.1167 + 3 \times 0.01852$

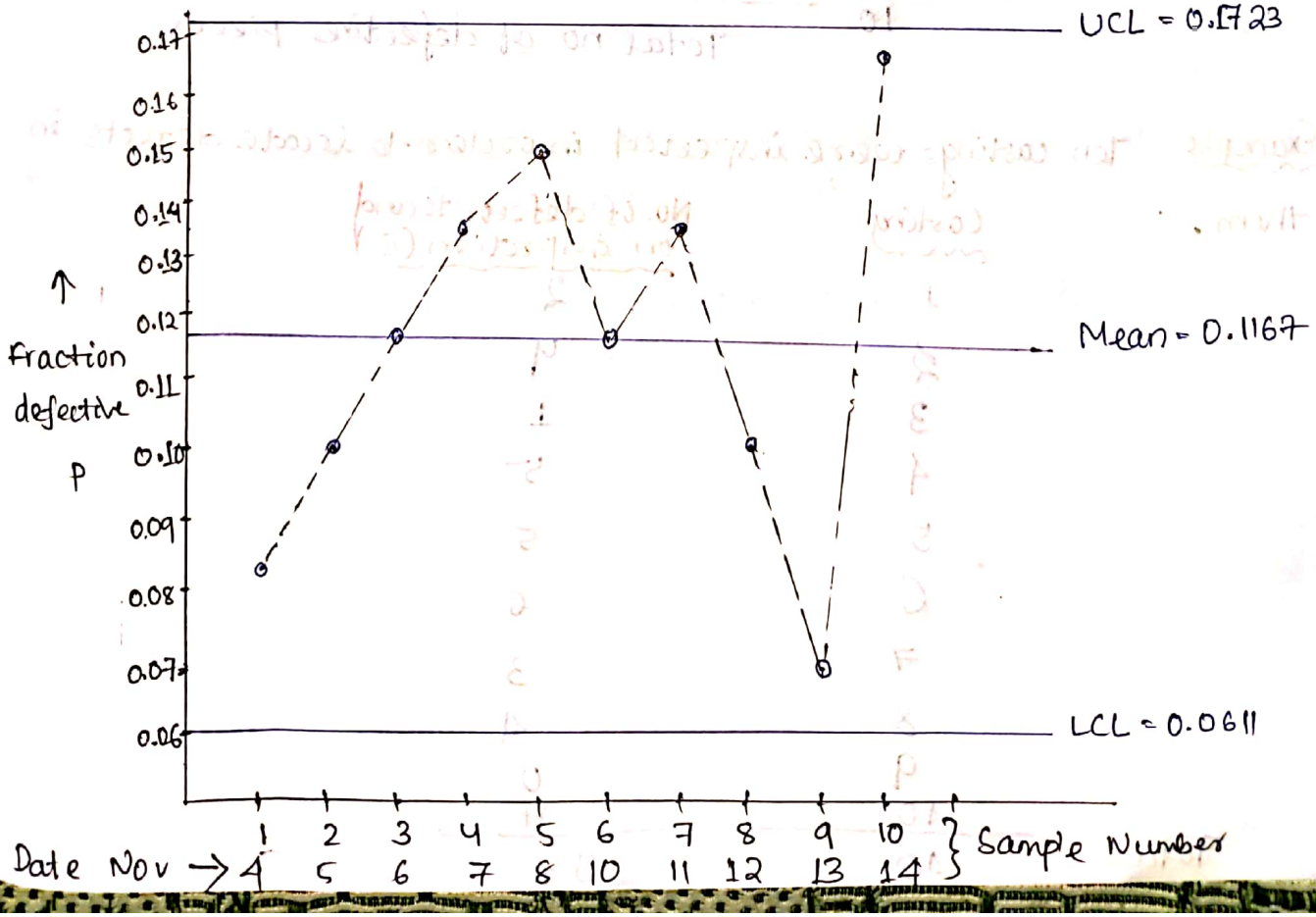
$= 0.17226 \approx 0.1723$ (Approximate)

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

$= 0.1167 - 3 \sqrt{\frac{0.1167(1-0.1167)}{300}}$

$= 0.1167 - 3 \times 0.01852$

$= 0.06114 \approx 0.0611$ (Approx)



It can be visualised that all the points lie within the control limit and hence the process.

(d) C - Chart

1. It is the control chart in which number of defects in a piece or sample are plotted.
2. It controls number of defects observed per unit or per sample.
3. Sample size is constant
4. The chart is used where average number of defects are much less than the number of defects which would occur otherwise if everything possible goes wrong.
5. The C chart is preferred for large and complex parts

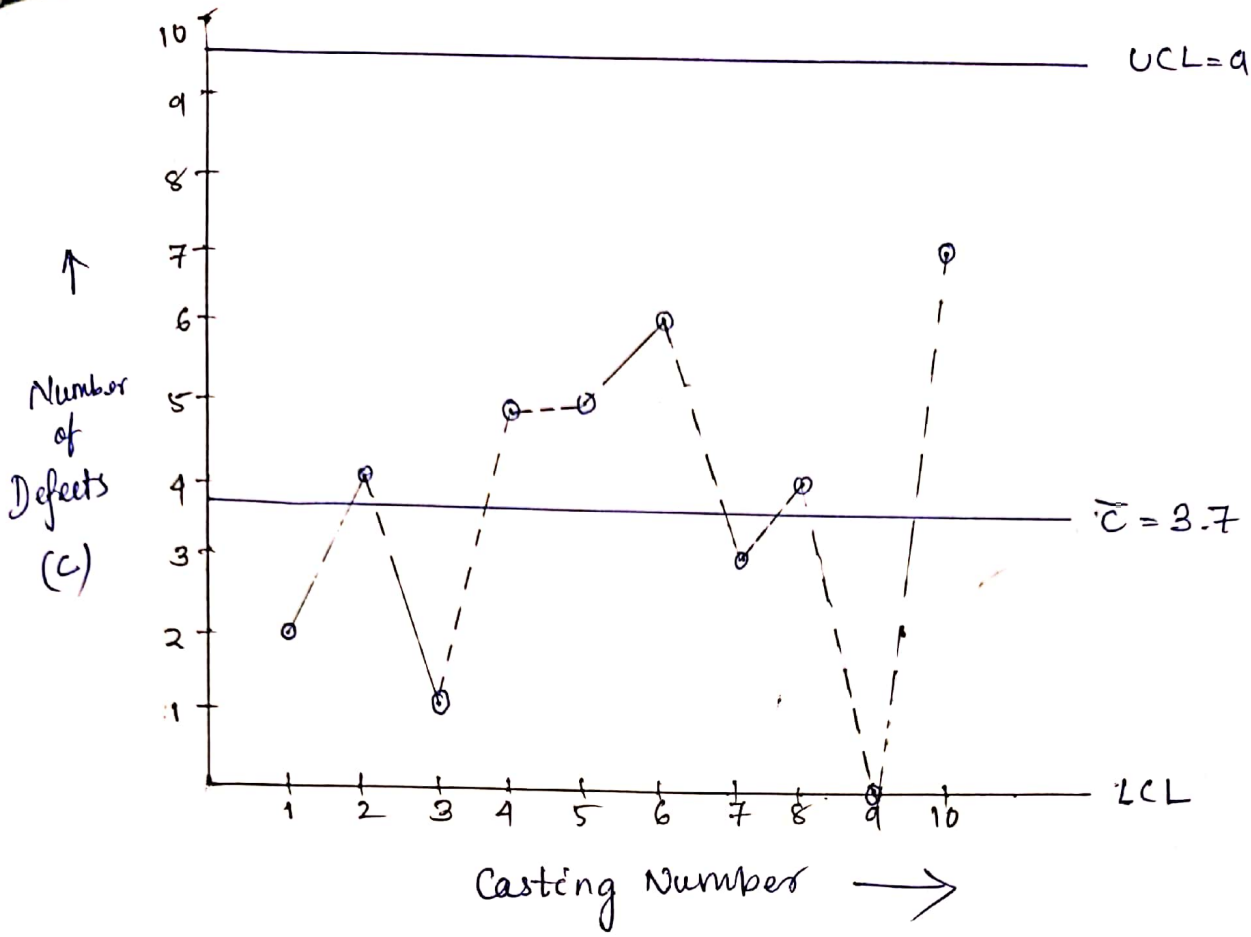
* Upper control limit, $UCL = \bar{c} + 3\sqrt{\bar{c}}$

Lower control limit, $LCL = \bar{c} - 3\sqrt{\bar{c}}$

Where $\bar{c} = \frac{27}{10}$ Total No. of defects found on inspection / Total no. of defective pieces

Example Ten castings were inspected in order to locate defects in them.

| Casting | No. of defects found on inspection (C) |
|---|---|
| 1 | 2 |
| 2 | 4 |
| 3 | 1 |
| 4 | 5 |
| 5 | 5 |
| 6 | 6 |
| 7 | 3 |
| 8 | 4 |
| 9 | 0 |
| 10 | 7 |
| Total 10 | 37 |




Therefore, $\bar{c} = \frac{\text{Total no. of defects found on inspection}}{\text{Total no. of defective pieces}}$

$= \frac{37}{10} = 3.7$ (Mean)

Upper control limit, $UCL = \bar{c} + 3\sqrt{\bar{c}} = 3.7 + 3\sqrt{3.7} = 9.472$

Lower control limit, $LCL = \bar{c} - 3\sqrt{\bar{c}} = 3.7 - 3\sqrt{3.7} = -2.072 \approx 0$

⇒ It is concluded that since all the values of 'c' lie with in the control limit and hence the process.

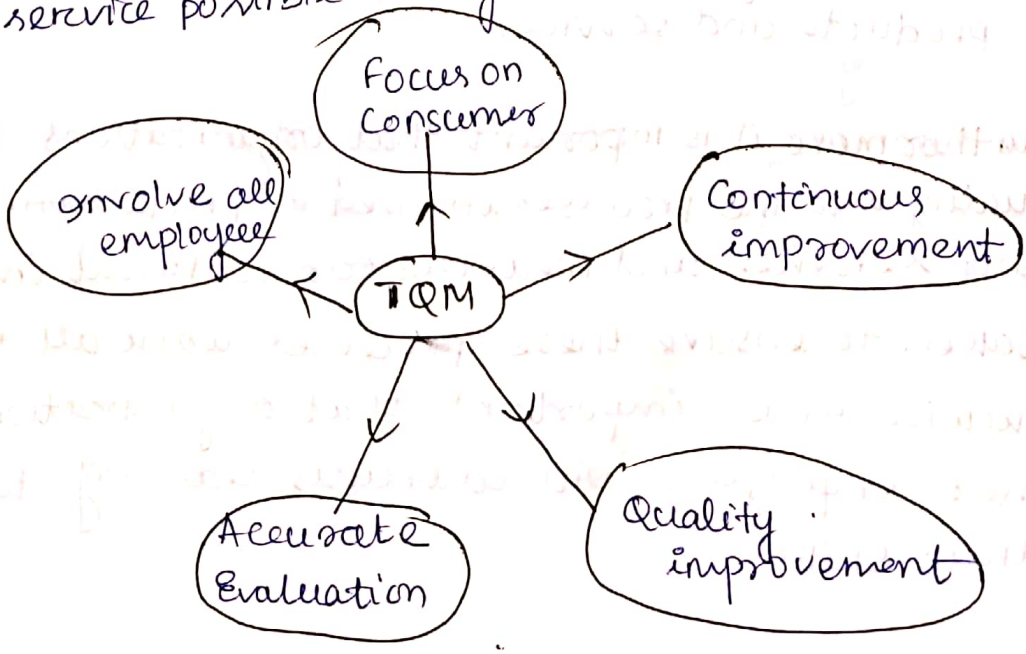
[∵ Lower control limit is negative & thus has been taken as zero]

# Chapter-08 Contemporary Quality Management Concept

## 8.1 Total Quality Management (TQM)

**Meaning and Definition :-** Total Quality management provides the concept that ensures continuous improvement in an organisation.

- The philosophy of TQM stresses on a systematic, integrated and consistent approach involving everyone and everything in an organisation.
- It aims at using all people in multifunctional teams to bring about improvements from within the organisation. Everyone associated with the organisation is fully involved in continuous improvement.
- Total Quality management is an approach to improving the effectiveness and flexibility of business as a whole. It is essentially a way of organising and involving the whole organisation, every department every activity, every single person at every level.
- TQM is a strategic approach to produce the best product and service possible through constant innovation.



## Principles of TQM :-

- With increased competion and market globalization, TQM principles and practices are now becoming more and more important for the leadership and management of any organization.
- Therefore for organizations that seek to continually improve their performance over a long term, focus on customers and address the needs of all other stakeholders, these total quality management principles will serve as a guide in the right direction.

## Principle -1 : Customer Focus

- This principle stresses that an organization should understand its customers; what they need and when they need it while trying to meet and exceed their expectations.
- A such, revenue is increased, and waste reduced when a business seeks opportunities to satisfy its customers.

## Principle-2 Leadership

- Good leaders help to unite an organization and give people a sense of direction. They create and nurture an environment where everyone's views are given careful consideration.
- Therefore without clear leadership, an organization loses its direction.
- This principle establishes that leaders are ~~clear~~ fundamental in setting clear goals and objectives and ensuring that employees are actively involved in achieving there objectives.

## Principle-3 People involvement :-

- People are the essence of any organization's existance.
- Research has shown that when people understand the importance of their contribution and role in an organization, they become innovative, eager to participate and creative in organization's objective.
- It helps to bridge the gap of communication between mangement & employees.

## Principle-4 Process Approach

- This principle states that an organization achieves its desired result when related resources and activities are managed as a process.
- Therefore this approach stresses efficiency, effectiveness, consistency & understanding.

## Principle-5 System Approach to management

This principle stresses that several processes are managed simultaneously in an ~~organization~~ organized system. This makes the system much more effective and greater than the sum of its individual parts.

## Principle-6 Continuous improvement

This principle states that continual change should be an active business objective. By doing so, Organizational flexibility increased ability to embrace new opportunity & improved performance are achieved.

# Concept of Total Quality Management

## (i) Continuous improvement of Quality :-

- Foremost among TQM concepts is the idea of continuous improvement of quality.
- The underlying aim of TQM is to improve the quality of products and services in any organization. By so doing, productivity, employability and customer service are improved.

## (ii) Focus on the customer :-

- The customers are the internal and external recipients of an organization's products.
- Therefore the needs of customers and their desires define quality for the organization.

## (iii) Operations improvement

- Every work done in an organization follows a chain or process. These processes account for 80-85% of the quality of work and productivity of employees.
- This concept establishes that work progress and processes should be studied through individuals or teams, to identify complexities or lapses.

## (iv) Human Resources :-

- These concepts of TQM are committed to employee learning & development. So these require that management trust that well-trained staff can do the jobs assigned to them properly.
- In addition, human resource development includes providing the training required in a quality improvement work environment as well as extensive education to help employees keep up-to-date on their jobs.

## ISO 9000

- ISO 9000 is a family of standards and guidelines related to the Quality Management system (QMS). It sets the requirements for the assurance of quality and for the mangement's involvement.
- When an organization demonstrates conformity to ISO 9000 to an independent resistar fiom, the register can to certify the organization. Registration provides assurance to customers worldwide that products or services from the organization can be expected to consistenty meet customer requirements.

- The ISO 9000 QMS is based on eight principles from Total Quality management system.

(i) Customer focus :- Understanding the customer's needs, meet the customer's requirements & strive to exceed the customer expectation.

(ii) Leadership :- Establish unity of purpose and organizational direction and provide an environment that promotes employee involvement and achievement of objectives.

(iii) Involvement of People :- Take advantage of fully involved employees using all their abilities for the benifit of the organization.

(iv) Process Approach :- Recognize that things accomplished are the results of process and that processes along with related activities and resources must be managed.

(v) System Approach to Management :-

The multiple interrelated processes that contribute to the organization's effectiveness are system and should be managed as a system.

(vi) Continual Improvement :- Continual improvement should be a permanent objective applied to the organization and to its people, process, system and products.

(vii) ~~Factual~~ Factual Approach to Decession making :-

Decisions a must be based on the analysis of accurate relevant and reliable data & information.

(viii) Mutually Beneficial Supplier Relationship :-

Both the organization and suppliers benefiting from one another's resources and knowledge results in value of for all.

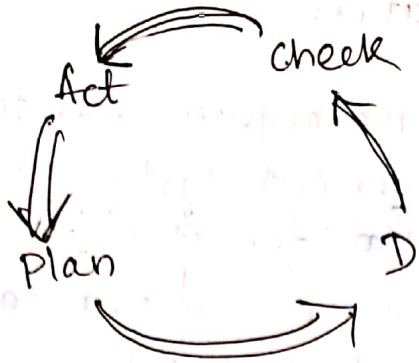
## Iso 9000's Operating principle

(i) Plan :- Establish objective & develop the plans to achieve them

(ii) Do :- Put the plans in to action.

(iii) Check :- Measure the results of the action ; that is planned action working or were the objectives met

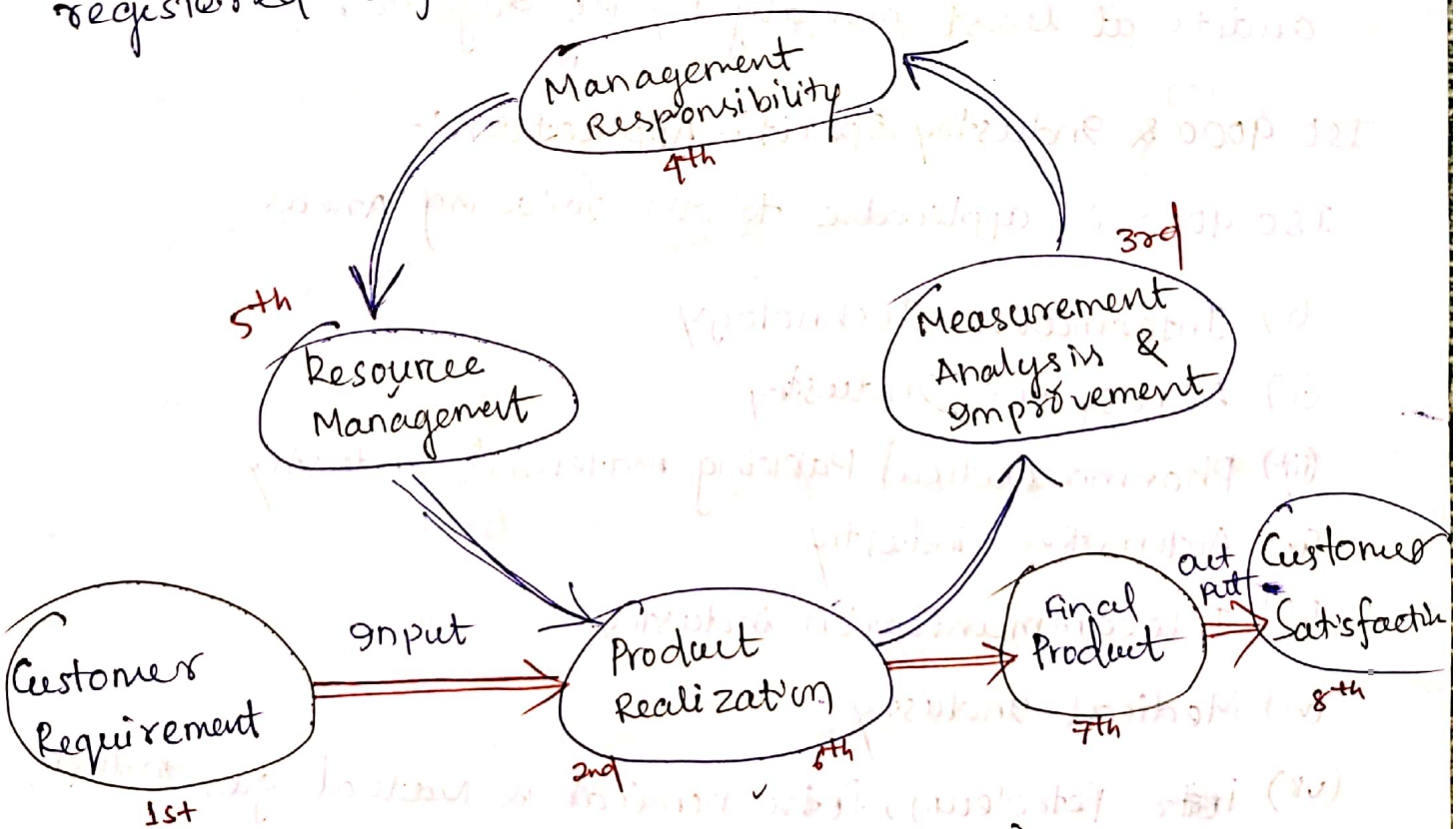
(iv) Act :- Learn from the results of the third (check step), make any necessary changes to the plans and ~~reapet~~ repeat the cycle.




( ISO 9000 operation prineiple )

2MD

- **Aim of ISO 9000** :- The original aim of ISO 9000 is to ensure that the product or services provided by registered organizations were consistenly fit for their intended purposes.
- The ISO 9000 raised the standard's aim to a new level i.e customer focus & continual improvement along with the other six quality management prineiples that have been incorporated into the standard, are intended to make registered organizations more competitive.




( Fig :- ISO 9000 process Approach )

## ISO 9000 Applied to Organization

The ISO 9001 lay down the requirements for what an organization's Quality management system must do, The organization determines that for itself and if seeking registration, employs an accredited registar firm to verify its conformance to ISO 9001

- Once the organization registered, must apply to QMS (Quality management system) to its operations according to the standard and exactly as the QMS states.
- And is also continually assess the effectiveness of the QMS & make changes to improve it and conduct periodic internal QMS audit.
- Then it submit to external (3rd party) surveillance audits at least annualy by its registar.

### ISO 9000 & Industry Specific Applications :-

ISO 9000 is applicable to the following Areas

(i) Information Technology
(ii) Aerospace industry
(iii) Pharmaceutical Packing Material industry
(iv) Automotive industry
(v) Telecommunication industry
(vi) Medical industry
(vii) Petroleum, Petrochemical & Natual gas industry

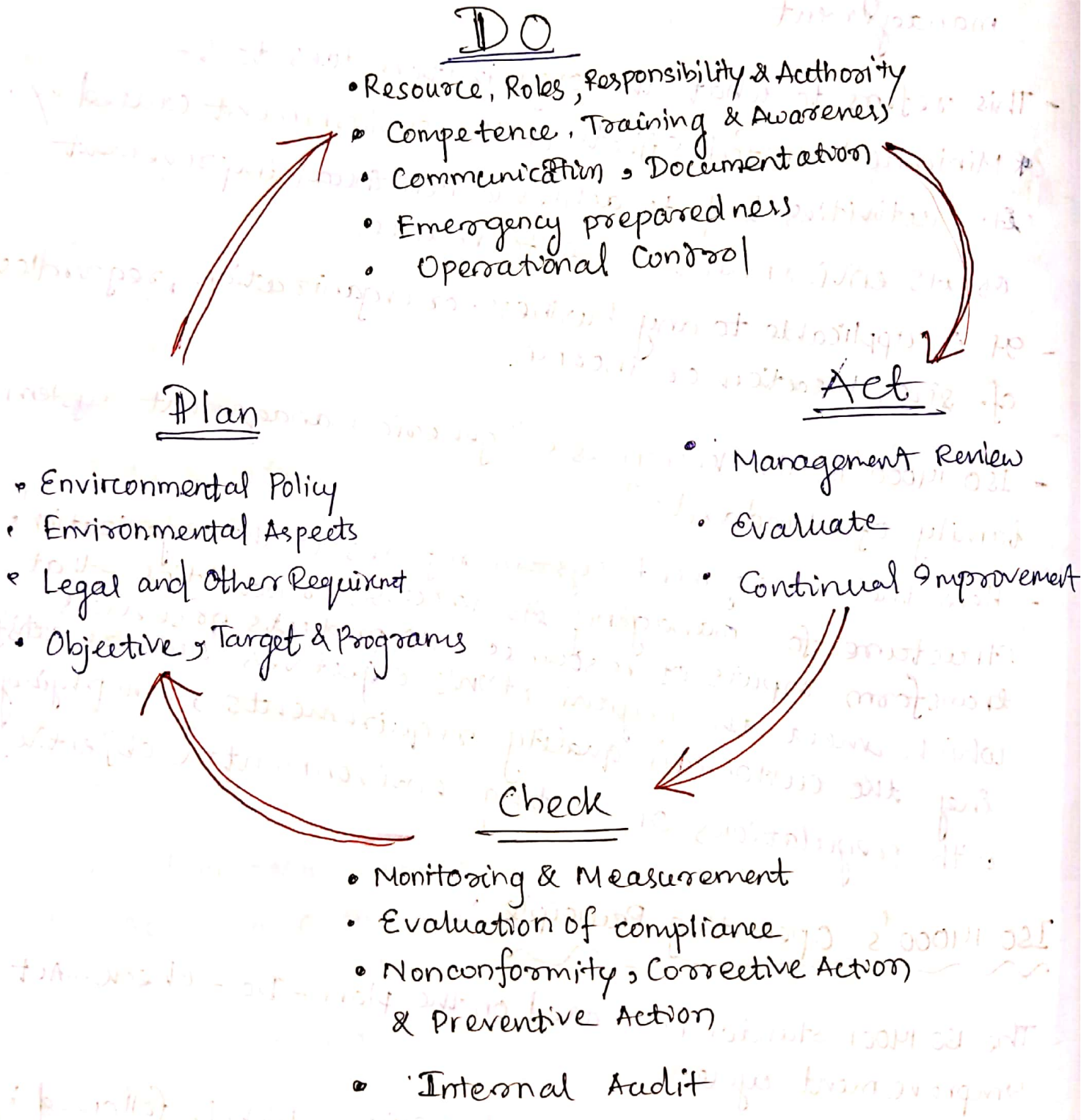
## ISO 14000 :-

- The designation "ISO 14000" is a general term referring to a family of standards concerned with environmental management
- This refers to what the organization does to :-
  * Minimize harmful effects on the environment caused by its activities and to achieve continual improvement of its environmental performance.
- It is applicable to any business or organization, regardless of size, location or income.
- ISO 14000 is also known as a "generic management system family of standards".
- Here the management system refers to the organizations structure for managing its processes or activities - that transform inputs of resources into products or services which meet the organization's objectives such as satisfying the customer's quality requirements, complying with regulations or meeting environmental objective.

## ISO 14000's Operating Principle :-

- The ISO 14001 standard is based on the plan - Do - Check - Act - improvement cycle.
- It begins with the enviormental policy, which is followed by planning, implementation and operation. checking & corrective action & management review.
- Plan :- What you will do?
  Do :- According to the plan.
  Check :- to see if you did what you planned.

Act – change or improve the part of your plan or Do that did not give you the results you intended.



# Evolution of ISO 14000

- ISO 14000 is a set of rules and standards created to help companies reduce industrial waste & environmental damage.
- the ISO 14000 ~~certified~~, series of standards was introduced in 1996 by the International Organization for Standardization (ISO) and most recently revised on in 2015.

- Overview of the ISO 14000 family of standards

ISO 14001 :- It is the world's most recognized framework for environmental management system (EMS) that helps organizations both to manage better the impact of their activities on the environment & to demonstrate sound environmental management.

* ISO 14001 : 2015 : Environmental Management systems Requirements with guidance for use.

- ISO 14004 : which complements ISO 14001 by providing additional guidance and useful explanations.

* ISO 14004 : 2016 :- ~~Envi~~ General guidelines on principles, systems and support technique.

* ISO 14005 : 2019 :- Guidelines for a flexible approach to a phased implementation.

- ISO 14007 : Determining environmental costs and Benefitits.
- ISO 14008 : Monetary valuation of environmental impacts from specific emissions and use of natural resources.
- ISO 14006 : 2011 :- Environmental management system guidelines for incorporating ecodesign.
- ISO 14009 : EMS guidelines for applying the ISO 14001 framework to environmental aspects and environmental condition by environmental topic areas.

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ISO 14010 to ISO 14015 :- Environmental Auditing & Related Activities

ISO 14020 to ISO 14024 – Environmental labeling

ISO 14031 & ISO 14032 – Environmental performance Evaluation

ISO 14040 – ISO 14043 :- Life cycle Assessment

ISO 14050 – Terms & Conditions

ISO 14064 – Green house gas accounting & verification

## Implication of ISO 14000

- The ISO 14001 standard provides specific requirements for an Environment Management system (EMS) and focuses on Environmental Protection.

= An effective ESM provides many benifits to the implementing organization, its customers and stakeholders and to regulators including :

- i- reduced environmental risk
  ii- Proactive environmental management
  (iii) improved employee environmental awareness and performance.
  (iv) increased operating efficiency and cost effectiveness

# JIT (Just In Time)

The main focus of JIT is to identify and correct the obstacles in the production process. It shows the hidden problems of inventory.

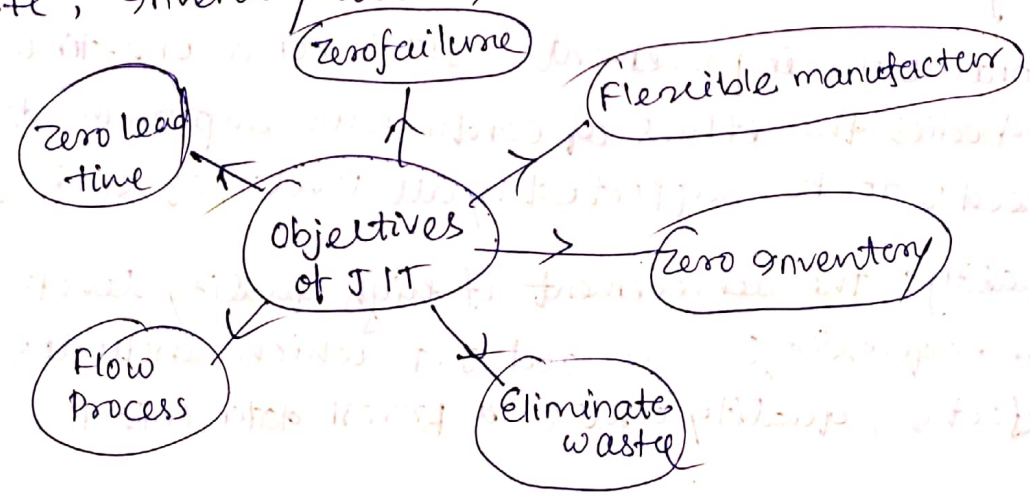
- JIT method prevents a company from using excessive inventory and smooth on production operations.
- JIT is a philosophy of manufacturing based on planned elimination of waste & continuous improvement of productivity.

**History :-** It is evolved in Japan after world war II as a result of their diminishing market share in the auto industry.

* Toyota motor company first to implement fully functional & successful JIT system in 1970's

**Function of JIT :-** Zero inventory
Zero lead time
Zero failure

* **Eliminating waste :-** There are 7 types of waste. waste from overproduction, waste of waiting time, transportation waste, inventory waste, waste from product defects.



# JIT

**Def$^n$ of JIT:-** The Just-in-time (JIT) inventory system is a management strategy that minimizes inventory & increases efficiency.

or In other words, JIT is an inventory management method where by materials, goods and labours are scheduled to arrive or be replenished exactly when needed in production process.

- JIT can be summarized as a system of eliminating waste and achieve excellence in an entire organization. The sole purpose of JIT is to eliminate waste.

## Elements of JIT:-

(i) Automation & Autonomation:- means "to build in a mechanism to prevent mass production of defective work in machines or product lines." The autonomous machine ensures that 100% good units flow to the subsequent process in an uninterrupted manner.

(ii) Bufferstock Removal:- constant elimination of buffer stocks is emphasized to highlight production problems previously shielded by high inventory levels.

(iii) Computer integrated manufacturing:- The use of computers to automate manufacturing operations such as changing the type & ~~quadit~~ quantity of products through minimal changes

(iv) Continuous improvement:- JIT is not a one-time effort, it embodies the ethics of continuous improvement which needs to be supported by all levels of staff.

(v) Quality:- The achievement of high quality levels is a prerequisite of successful JIT which includes zero defects, quality circles & process data collection.

- Smooth Production :- Production smoothing enables the system to adapt smoothly to the variation in customer demand by gradually changing the frequency.

## Benefits of JIT

- Improved competitive position,
  - " Worker efficiency
  - " equipment efficiency
- Increased flexibility
  - " teamwork
  - " profit margin
  - " quality & Productivity
- Less Scrap
- Lower overhead
- Reduce inventory & labour requirements.
  - " Production lead time.
- Closer Relationship with suppliers.

## Disadvantages

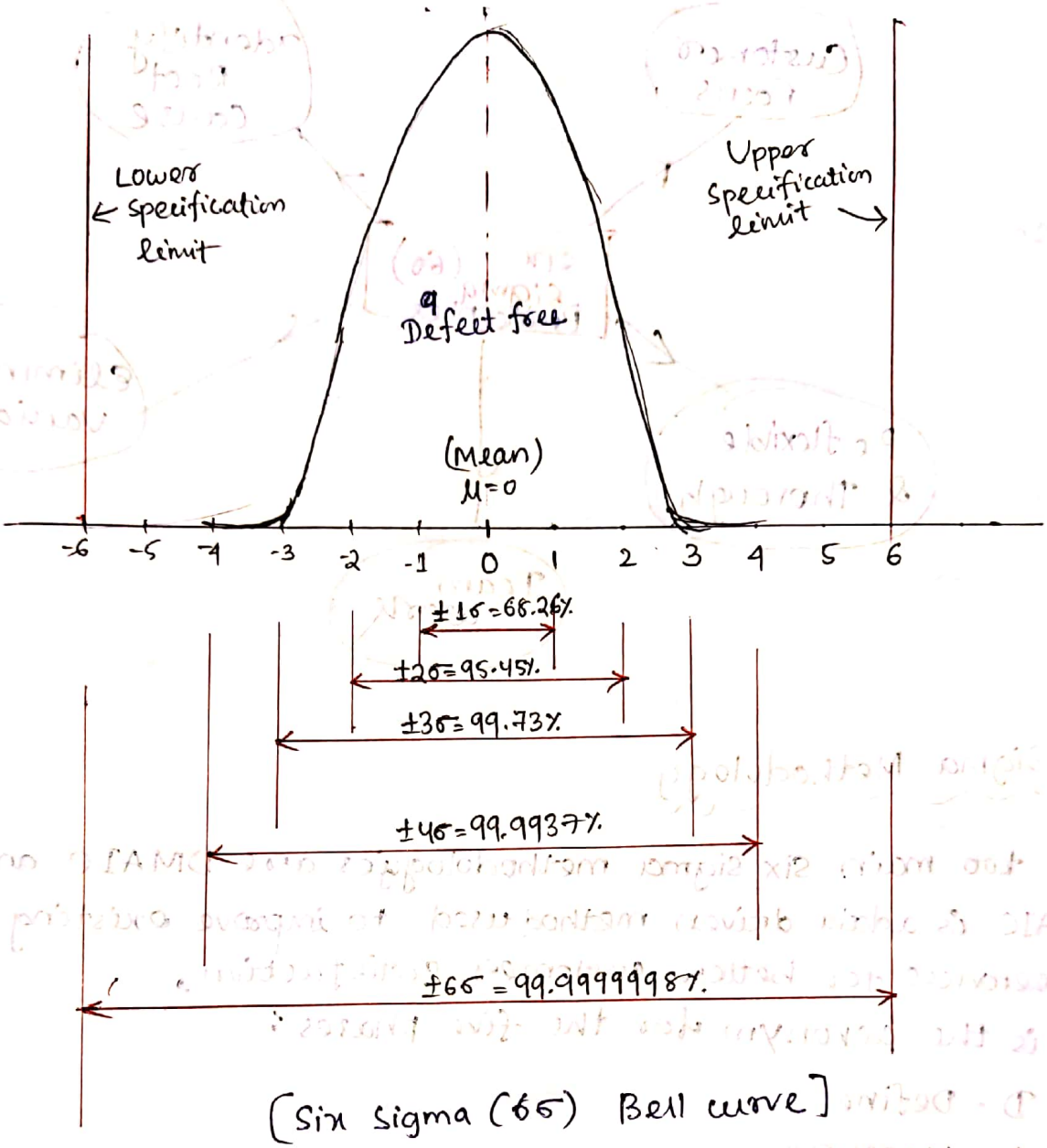
- Production may be stopped if suppliers are delayed
- Sales may be lost if not meeting customer demands
- Increased ordering & admin cost
- Depending on the efficiency of supplier.
- Less time for quality control on arrival of materials.

## Six Sigma :- (6σ)

- Six sigma is a ~~deep~~ disciplined, statistical-based, data driven approach and continuous improvement methodology for eliminating defects in a product, process or service.
- It was developed by Motorola for the first time during 1980s.

- Sigma(σ) represents the population standard deviation which is a measure of the variation in a data set collected about the process.
  of a defect is defined by specification limits, separating good from bad outcomes of a process - mean (average) i.e six standard deviations from the nearest specification limit.

- Six sigma comes from the bell curve used in statistics where one sigma symbolizes a single standard deviation from the mean.
  of the process has six sigmas, three above and three below the mean, the defect rate is classified as "extremely low"




[Six sigma (6σ) Bell curve]

## Principles of Six Sigma

Six sigma success is based on five key ~~point~~ principles.

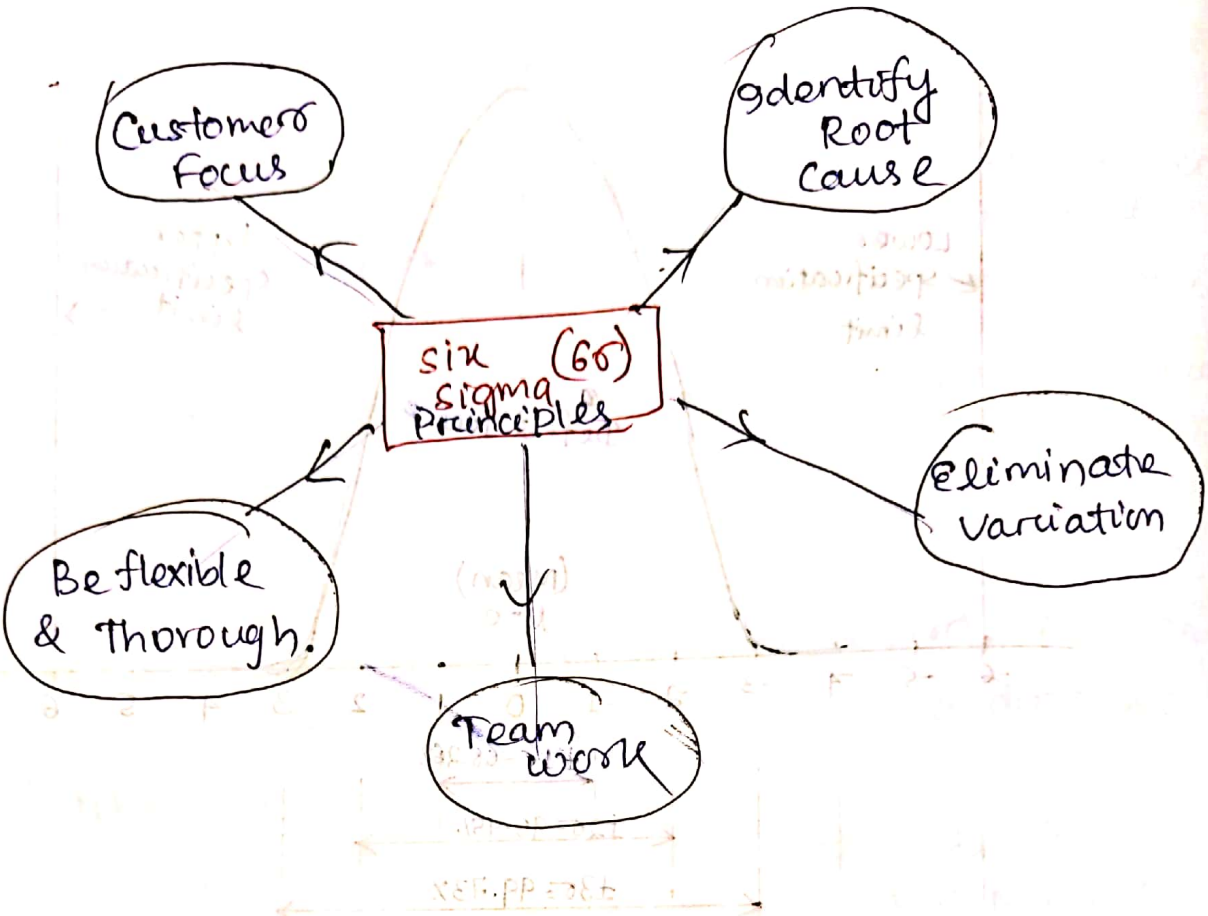
i- Focusing on customer requirements

ii- Using extensive measurement and statistical analysis to understand how work gets done and to identify the root cause of problems (variations)

(iii) Being proactive in eleminating variation & continually improving the process.

(iv) Involving people in six sigma cross-functional teams.

(v) Being Flexible & thorough.




## Six Sigma Methodology

- The two main six sigma methodologies are DMAIC and DMADV.
- DMAIC is a data driven method used to improve existing products or services for better customer satisfaction.

It is the acronym for the five phases:

D - Define
M - Measure
A - Analyse
I - Improve
C - Control

- DMAIC is applied in the manufacturing of a product or delivery of a service.

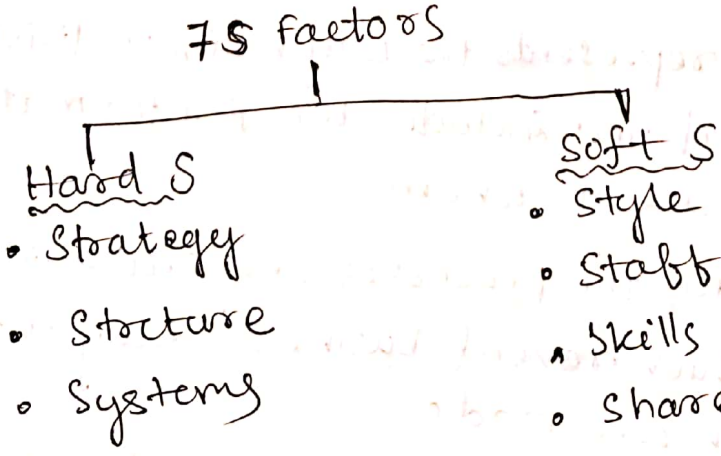
* DMADV is a part of the Design for six sigma process used to design or re-design different processes of product manufacturing or service delivery.

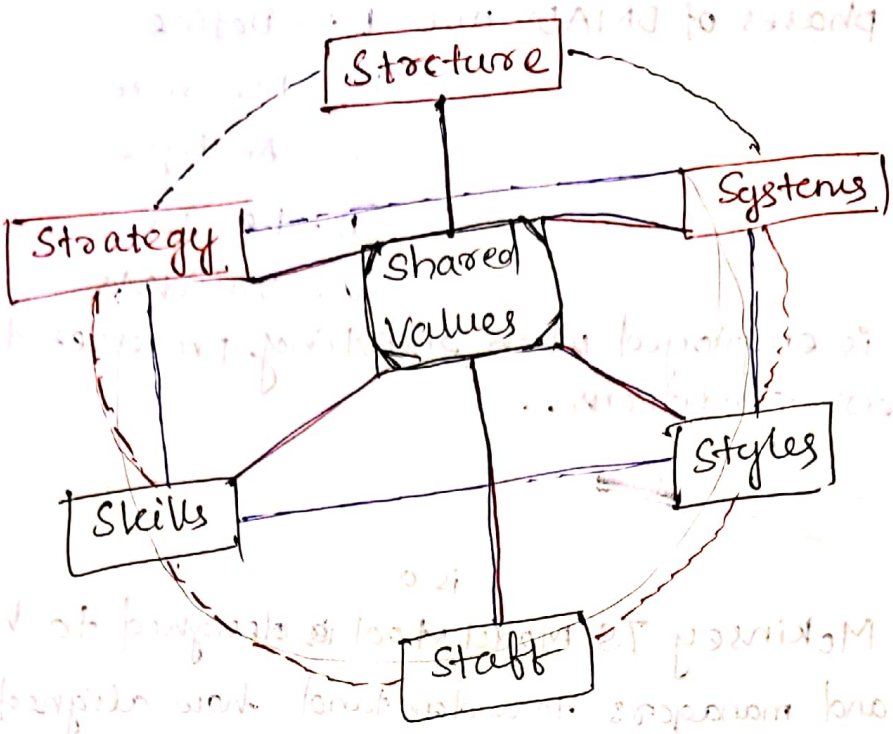
The five phases of DMADV are D - Define
M - Measure
A - Analyse
D - Design
V - Validate

- DMADV is employed when existing processes donot meet customer conditions..

## * 7S

- 7S or Mckinsey 7S Model is a tool is designed to help business owners and managers to understand how aligned their organization is and how it can be improved.
- Mc kinsey 7S model was developed in 1980s by Mckinsey consultants which analyzes firm's organizational design by looking at 7S key internal elements :- Strategy, Structure, Systems, Shared values, Style, Staff and Skills
- The goal of the model is to show how 7S of the company can be aligned together to achieve effectiveness in a company & its objectives.
- The 7S are interconnected with eachother and divided into two parts. ie one is Hard S and another Softs






- Strategy, structure and systems are hard element that are much easier to identify and manage when compared to soft elements.
- On the other hand, soft areas although harder to manage, are the foundation of the organization and are more likely to create the sustained competitive advantage.

Strategy :- is a plan developed by a firm to achieve sustained competitive advantage and successfully complete in the market.

Structure :- represents the way business divisions and units are organized and includes the information of who is accountable to whom.

System :- are the processes and procedures of the company which reveal business' daily activities and how decision are made.

- Systems are the area of firm that determines how business is done and it should be the main focus

for managers during organizational change.

Skills :- are the abilities that firm's employees perform very well. they also include capabilities and competences.

Style :- represents the way, company is managed by top-level managers, how they interact, what action do they take & their value.

Shared values :- are the core of McKinsey 7s model They are the norms and standards that guide employee behavior & company actions and thus are the foundation of every organization.

Staff :- element is concerned with what type & how many employees an organization will need & how they will be recruited, trained, motivated & rewarded.

## Lean Manufacturing :-

- Lean manufacturing is a methodology that focuses on minimizing waste within manufacturing systems while simultaneously maximizing productivity.
- The benefits of lean include reduced lead times, reduced operating costs and improved product quality to name just a few.

- The five Lean Manufacturing Principles

(1) Identify Value :- The first lean principle, identifying value, is also the 1st step in the journey to become lean.
- This step requires businesses to define what customer value and how their products or services meet those values. i.e Designing of products.

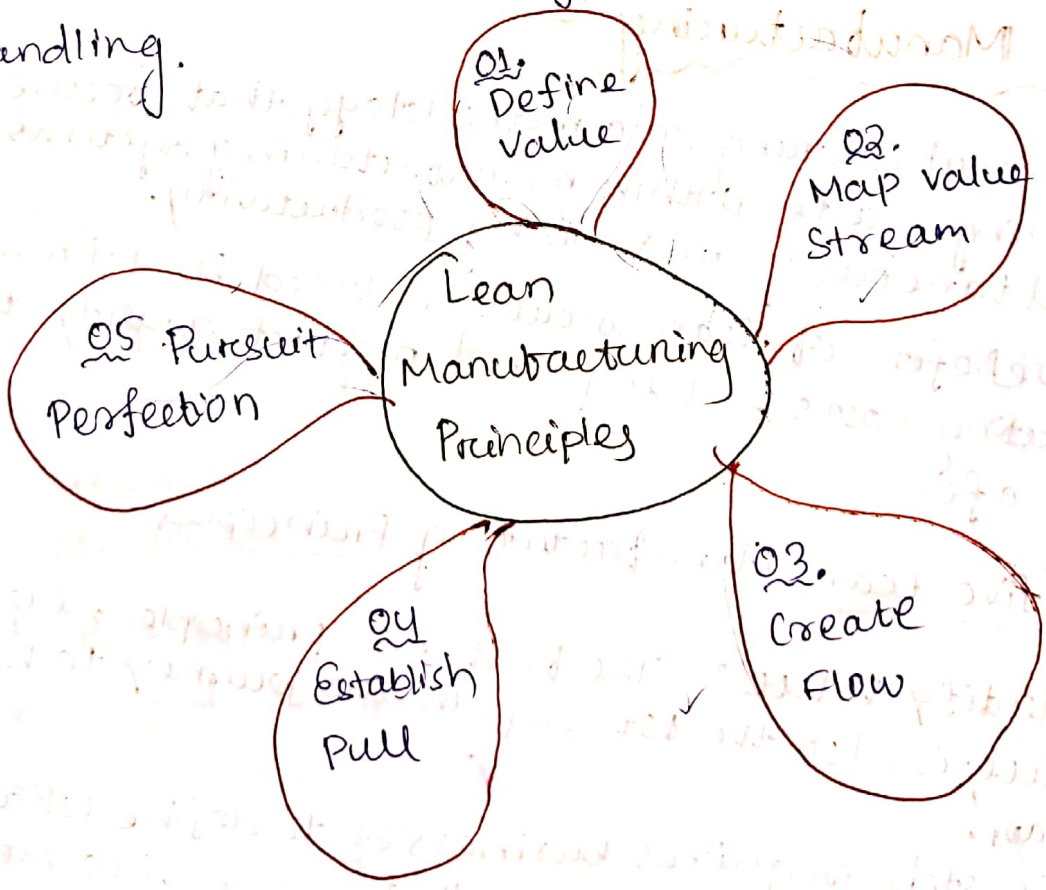
(2) Map the Value Stream :-

A value stream is the complete lifecycle of a product, which includes the product's design, the customer's use of the product & the disposal of the product.

- That is mapping of entire product flow to minimize steps that don't add value.

(3) Create Flow :-

- Efficient product flow requires ~~to~~ items to move from production to shipping without interruption and can be achieved by strategically organizing the work floor.
- A well organized work floor will result in reduced production time, inventory size and material handling.




(04) Establish Pull :- closely related to creating flow, the fourth lean principles requires businesses to use a pull-based production system.

- Traditional production system use a push system, which starts with purchasing supplies & proceeds by manufacturing process, even though there is not an order. and it leads to result in large inventories. & significan amount of work-in-process.
- A pull system, however, pulls a customer's order from the shipping department then prompts new items to be manufactured.
- Using a pull system, busines will; increase output reduce inventories, eliminate overproduction.

## 05 Pursuit Perfection :-

The final lean manufacturing principle requires companies to seek perfection. It is often one of the most difficult principles to successfully apply in workplace.

- Seeking perfection requires companies to continuously improved their practices and often requires a shift in the workplace culture.

Full Marks: 80

Time : 3hours

Answer any five Questions including Q.No - 1 & 2.

Q-1 [2×10=20]

(a) What is ideal Plant location?

(b) Define PERT & CPM?

(c) Define Inventory and Classify it?

(d) Define TQM?

(e) What do you mean by critical Activity?

(f) Write the objectives of Inspection?

(g) What is EOQ?

(h) What do you mean by JIT?

(i) Classify the types of Plant maintenance?

(j) What is LPP?

Q-2 [6×5=30]

(a) Write down the Advantages and Limitation of Urban location of Plant?

(b) Maximize $12x + 24y$ · Subjected to $x + 4y \leq 20$

$3x + y \leq 15$

$x, y \geq 0$

Use graphical Method

(c) Write about ABC analysis?

(d) What are the objectives and benefits of Inventory Control?

(e) Write shorts notes on ISO 9000?

(f) Explain factors influencing the quality of Manufacture?

(g) Explain about Breakdown maintenance?

[10]

Q-3 Write the objective of Plant layout? Write the factors which affect plant layout?

[10]

Q-4 A small Engineering project consists of six activities namely A, B, C, D, E & F with duration of 5, 7, 6, 5, 4 & 4 days respectively. Draw the network diagram and calculate EST, LST, EFT, LFT and Float. Find the total project duration?

[10]

Q-5 What do you mean by control chart? Calculate UCL & LCL of P, $\bar{x}$ and R chart of the following data sample no.: '1' to 10

$\bar{x}$ → 3290, 3180, 3350, 3470, 3080, 3240, 3260, 3310, 3640, 4110

R → 560, 410, 200, 300, 90, 650, 890, 410, 1120, 520.

Where $A = 1.342$, $A_1 = 1.596$, $A_2 = 0.577$, $D_1 = 0$, $D_2 = 4.982$, $D_3 = 0$
$D_4 = 2.115$

[10]

Q-6 Explain about different stages of implementaion of TQM and its concept?

[10]

Q-7 What are the duties, functions and Responsibilities of plant maintenance department?

———×———

# INDUSTRIAL ENGG. AND QUALITY CONTROL
(Code: MET 601)

Time: 3hours

Full Marks: 80

Answer any FIVE Questions including Q.No.-1&2

1. [2×10]
(a) Define plant layout.
(b) What are the objectives of plant layout?
(c) Define Operation Research.
(d) What is TQM?
(e) Define Inventory.
(f) What is JIT Technique?
(g) Differentiate between critical and non-critical path.
(h) Define three time estimates in PERT.
(i) Write down the evolution of ISO-9000.
(j) Classify inspection.

2. Answer any SIX questions. [5×6]
(a) Define process layout, product layout and combination layout.
(b) Explain distinct features of PERT with respect to CPM
(c) Write down the steps for graphical solution method.
(d) Define and explain ABC analysis.
(e) Describe the objectives of plant maintenance.
(f) Explain Six Sigma in quality management.
(g) Write down the factors influencing the quality of manufacture.

3. Describe the features of governing plant location. [10]

4. Minimize $Z = 2x + 3y$ [10]

subject to $x + y \geq 6$

$2x + y \geq 7$

$x + 4y \geq 8$

$x, y \geq 0$

using graphical method.

5. Calculate EOQ, given that [10]

Annual usage = 100 units

Procurement cost = Rs. 25/ order

Cost per 10 pieces = Rs. 1000

Cost of carrying Inventory = 15 %.

6. Describe different types of maintenance. [10]

7. What are the different types of control chart ? [10]
Explain any two charts.

— o —

BEST OF LUCK.



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