Plant location & Layout CH-1

Q) Define Plant layout?

Ans:- Plant layout can be defined as the most effective physical arrangement either existing or in plans of industrial facilities.

→ Facilities include arrangement of mechinaries process of equipment and service department.

→ Due to this we achieve greatest co-ordination and efficiency of 4M's (men, material, mechinary, method) in a plant.

* A plant layout is an arrangement of facilities and service in the plant. It outlines relationship between production centres and departments.

According to Eng Moore:

→ Plant layout can be defined as an optimum arrangement of industrial facilities, including personnel, equipments, storage space, material handling equipments and all other supporting services in an existing or proposed plants.

→ Plant layout can also be defined as "A technique of locating machines, process and plant service within the factory, in order to secure the greatest possible output of high quality at the lowest possible total cost of production.

OBJECTIVE OF PLANT LAYOUT

Q) What are the different factors that govern plant location?

Ans:- The problem of site selection of a factory can be solved in the following three stages.

1. Selection of the region
2. Selection of the locality
3. Selection of actual site.

① Selection of the region :-

Generally, the geographical area is divided on the basis of natural regions or political boundries within the nation. (i.e. Maharastra, State, UP, Gujrat etc) The suitability of various regions are considered on the basis of comparative cost advantages available out of the possible regions.

Generally availability and proximity of raw-materials, labour supply, climate condition etc are some of the major consideration in selecting the region.

② Selection of the locality :-

After selecting the region, the specific locality within the region is considered. Generally following alternative are open in selecting the locality

(a) Urban area
(b) Rural area.
(c) Sub-urban area.

The comparative advantages of each locality are considered at this stage.

The following factor must be considered while selecting the location of the factory.

(i) Availability of raw material
(ii) proximity to markets
(iii) Availability of labour.
(iv) Transport and communication facilities
(v) Availability of power and fuel
(vi) Climate condition.
(vii) Availability of water.
(viii) Fanancial and other aids.
(ix) Bussiness & commercial facilities.
(x) facility of future expansion.
(xi) Ancillary industries.
(xii) presence of relevated industry.

(i) Availability of Raw material :-

As far as possible the site selected should be near the source of raw materials, so that the cost of transportation can be minimized and the storing cost can be reduced due to shorter lead time.

(ii) proximity of markets :-

The cost of transporting finished goods, advertising and distribution etc. will be greatly reduced if the factory is located near the market. Nearness to market is an important factor in the following cases.

* Industries using light raw material of high value
* Industries producing perishable, fragile, or heavy products.
* For the industries providing technical advice and service this will help in ensuring prompt service to customers.

(ii) Availability of labour :-

Availability of right kind of labour force in required number at reasonable rates is also a deciding factor in selection of site. Unskilled labour is amply available at major industrial centres and rural areas. However, the firms requiring skilled labour should be situated near the urban areas.

(iii) Transport and communication facility :- Transport facilities are needed for transporting raw materials, parts and finished goods. Generally industries have a tendency to locate the industrial units near the railway station, highway or port area.

→ Communication facilities like mail, telephone, telegraph etc must be adequate. Regularity of service, safety, speed & low cost are essential both for transport and for communication.

(iv) Availability of power and fuel :- Coal, electricity, oil and natural gas are the important sources of power in the industries, the availability of reliable & cheap power supply is an important factor in the location of electro chemical industries.

(v) Climatic condition :-

Climatic condition largely effect certain production process and also the efficiency of the employee.

(vi) Availability of water :-

Water is used in industries for processing as in paper in chemical industries, for generation of p in hydroelectric power plants & is also required drinking, sanitary purpose etc.

(viii) Ancillary industries :-

The existance of ancillary industries in the nearby area may avail certain economic advantages. Many industries such as processing and assembly industries are not producing all the part of their product but purchase some of these parts from ancillary industries producing it.

(ix) Financial and other aids :-

For the development of backward regions central as well as state goverment provide certain incentives and facilities such as cash subsidy, concessional financial assistance, land, power.

(x) Bussiness & commercial facilities :-

For day to day management of finance and working capital needs, banking services are considered highly desirable.

Advantage of Urban area	Disadvantage of Urban area.
(1) Transportation facility	(1) High land cost.
(2) Excellent communication network	(2) Scarcity of availability of land
(3) Availability of skill & trained man power.	(3) High labour cost.
(4) Good educational, recreational & medical facilities.	(4) Community attitude
(5) Availability of service consultent.	(5) Industrial unrest due to trade union activities.
(6) Training institute & trainees.	(6) Management of labour relation are much influence by trade union activities.

⑦ Excellent sourcing facilities.

⑧ Marketing facilities.

⑦ Municiple & other authority restriction on building.

⑧ High labour turnover.

⑨ Environmental pollution.

Rural Advantage

* Cheaper land cost
* Cheaper labour cost.
* less labour turnover.
* No municiple tumover.
* Scope of expansion.
* Good industrial relation
* Less environmental pollution

Rural Disadvantage

* poor transportation network.
* poor communication facilities.
* No educational & medical facilities.
* Sourcing of component & material from outside

Sub-Urban

⇒ Land available at cheaper as compare to urban.

⇒ Infrastructure facility are developed by promotional agency.

⇒ Because of nearness to city availability of skilled man power.

⇒ Educational, medical facilities are available due to ~~me~~ nearness to city

⇒ Due to concentration the sub urban area will become crowdy & will be urban within short period.

⇒ High mobility of workers & hence higher labour turn over.

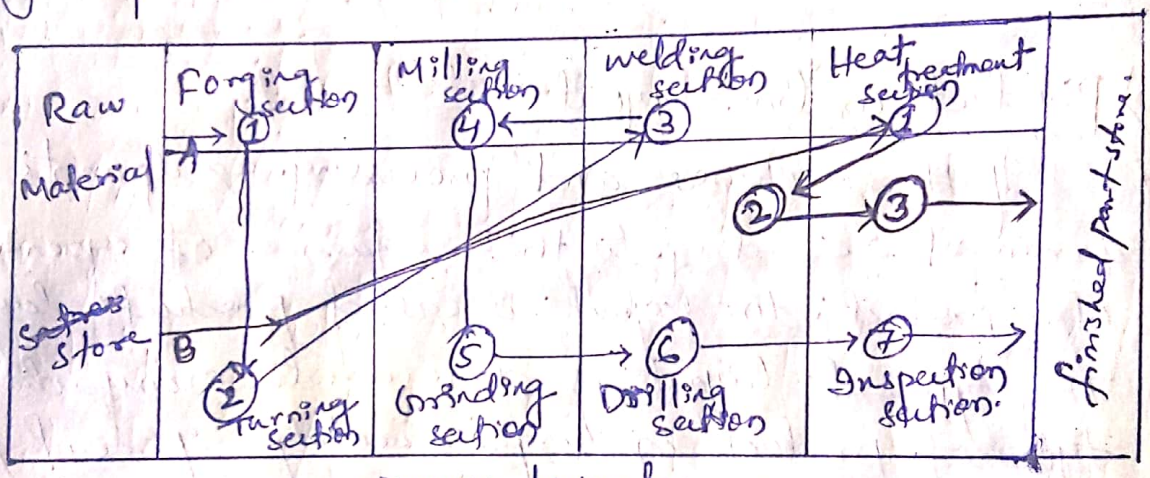
⇒ Government incentive and subsidy to promote industry.

Types of plant layout :-

a) Functional or process layout :-

If the machine are arranged according to the nature or type of operations, it is called process layout. All machines performing similar type of operations are grouped at one location in the process layout e.g. all lathes in one section, all drilling machines in other etc. etc.

This layout is recommended for job type or batch type production system.



Process layout

dvantages :-

i) Flexibility of equipment and personnel.

ii) Lower investment or account of comparatively less number of m/c and lower cost of general purpose machines.

iii) Higher utilisation of production facilities.

iv) Variety of jobs makes the job challenging and interest in.

v) workers in one section are not affected by the nature of the operations carried out in another section.

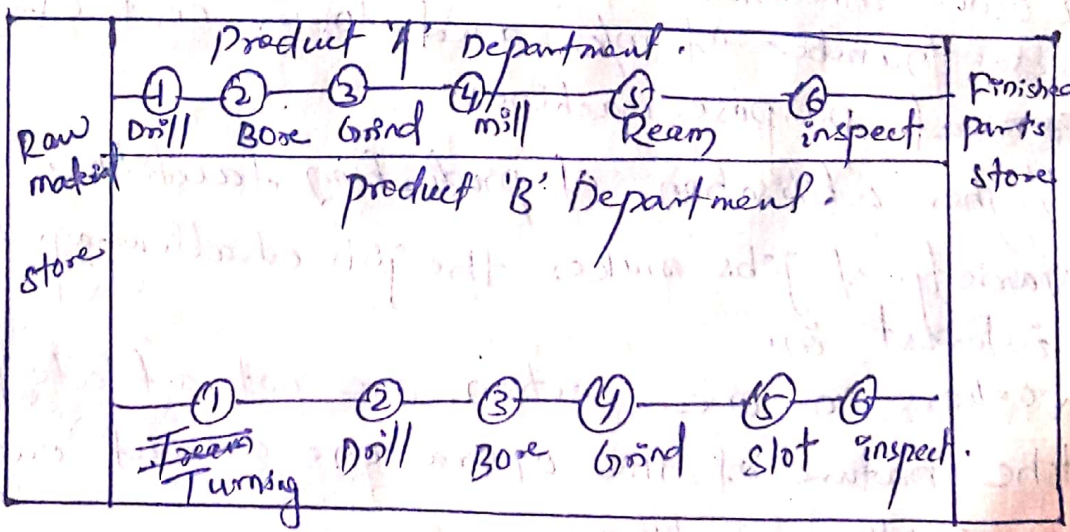
vi) Better product quality.

Disadvantages :-

1) Back tracking and long movements may occur in handling of materials thus reducing material handl efficiency.
2) More space required in comparison to product layout.
3) production control become difficult.
4) work in process inventory is large.
5) Automatic material handling is difficult.
6) Needs more inspection and efficient co-ordina

b) Product or line layout :-

If the machines and processing equipments are arranged according to the sequence of operation of a product, the layout is called product layout. This type of layout is done to manufacture on type of product in large quantity. Special purpo machine are used which perform the required function quickly and reliably. separate layouts are neccessary for different types of products.



Product layout.

Advantages :-

1) Reduce material handling cost due to mechined handling systems and straight flow.
2) Less space requirement for same volume of production
3) Less in process inventory.
4) Simplified production, planning and control.
5) Unskilled workers can manage the production.
6) Smooth and continious work flow.
7) product complete in lesser time.

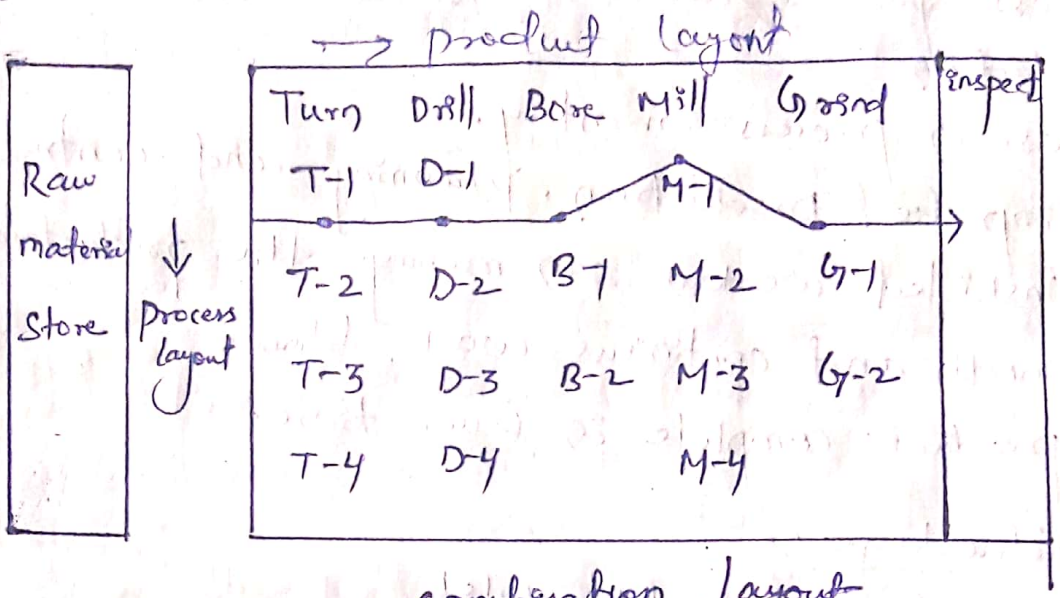
Disadvantages :-

1) Lack of layout flexibility.
2) Large capital investment.
3) If one machine in the line fails, it may lead to shut down of the complete production line.
4) ~~Peace~~ pace or rate of work depends upon the output rate of the slowest machine, if production line not proper balanced.
5) Dedicated or special purpose machines means high investment.

c) Combination, hybrid or mixed type layout :-

A combination of process and product layout combine, the advantages of both types of layout. For example T.V, refrigerator, music system etc. uses a combination layout. The process layout is used to produce different parts in various operation like stamping, welding, machining, heat treatment etc. The final assemble of the product is done in product type layout.

Thus for manufacturing various components pa process layout is used and for assembly produ layout is used.



combination layout

(d) Fixed position Layout :-

In this type of layout, the material or major components remain in a fixed location an tool, machinery, men and other materials are brought to this location.

In other type of layout, the produ moves past stationary production equipment, whereas in this case the reverse applies; men and equipme are moved to the material, which remain at one place and the product is completed at that place where the material lies.

Ex :- Ship building, air craft manufacturing etc.

Advantages :-

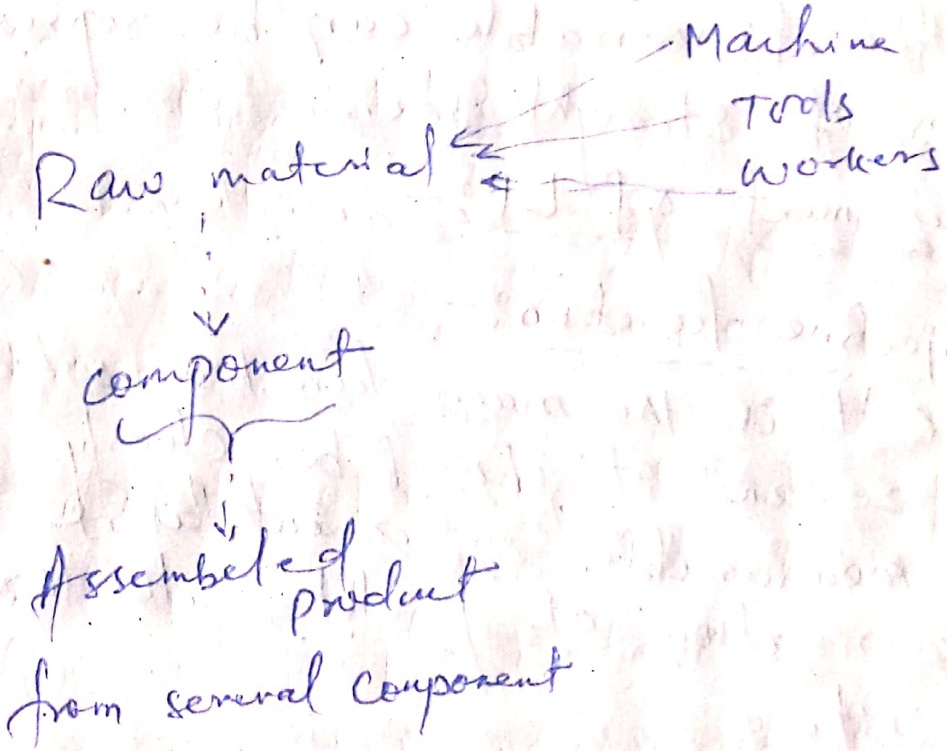
1) It involves cost movement of material.
2) Maximum flexibility for all sorts of change in product & process.
3) Layout capital investment is lower.

4) A number of quite different projects can be taken with the same layout.

5) possible to assign one or more skilled workers to a project from start to finish in order to ensure continuity of work.

Disadvantages :-

1) Usually low content of work-in progress.
2) Low utilization of labour and equipment.
3) It involves high equipment handling cost.
4) Highly skilled workers are required.



CH-2 OPERATIONS RESEARCH

Linear programming :- (L.P.)

George B Dantzing - Father of linear programing

→ Linear programming is used for optimization of our limited resources when there are no number of alternate solution possible for the problem, It is a mathematical technique and the term linear is used for the variable and it simply means that the relationship between different variable can be represented in the form of straight line.

Requirement of LP :-

1. Objective function :-
   It is the main function which we need to optimize and it should be clearly identifiable and measurable in quantitative term like maximization of profit, sales or minimization of cost.
2. Constraints / condition :-
   There are the restriction or limited resources within which we need to optimize our objective function.
3. All the variables for the objective function and constraints should be linear and non-negative

Laws or Rules in L.P :-

1. Law of Certainity :-
   In LP model the various parameter like objective function coefficient, constraints

and resources are known exactly and their value doesn't change with time.

2. Law of proportionality :-
Let profit for 1 product x, then for n product nx.

3. Law of addition or summation.

4. Law of continuity or divisibility :-
In LP model decision variable are continous that they are permitted to take any non-negative value that satisfy all the constraints.

General statement of LP :-

Objective function :-

$$\text{Max. } Z = c_1x_1 + c_2x_2 + \cdots + c_nx_n$$

Constraints or condition :-

$$\begin{aligned} a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n &\leq b_1 \\ a_{21}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n &\leq b_2 \\ &\vdots \\ a_{m1}x_1 + a_{m2}x_2 + \cdots + a_{mn}x_n &\leq b_m \end{aligned}$$

Non negative condition $\rightarrow x_1, x_2, \cdots x_n > 0$

Where a_{ij}, b_i, c_j are constant and x_j are variable.

$i = 1, 2, \cdots, m$

$j = 1, 2, \cdots, n$

a_{ij} = Technological co-efficient or substitution.

b_i = Resource value

c_j = Profit co-efficient.

x_j = Decision or choice variable.

1. Graphical Method :-

Steps in graphical :-

1. Identify the problem and define decision variable, objective function and constraint.
2. Draw a graph that include all the constraints and identify the common feasible region.
3. Find out the point with in the feasible region that optimizes the objective function. This point gives the final solution.

Question :-

② Two product A & B are to be machined on three machine tools, P, Q and R. Product A takes 10hr on machine P, 6 hr on m/c Q and 5hr on m/c R. The product B takes 7.5hr on m/c P, 6hr on m/c Q and 13 hr on m/c R. The machining time available on these m/c tools P, Q, R are respectively 75hr, 54hr and 65hr per week. The producer contemplates profit of ₹60 per product A, and ₹70 per product B. Formulate LP model for the above problem and show the feasible region graphically/geometrically. what are the basic feasible solutions to the above problem? Estimate graphically/geometrically, the optimum product mix for maximizing the profit. Explain why one of the various vertices of the feasible region becomes the optimum solution point.

Q) 1)

Sol") Max $z = x_1 + 3x_2$

$x_1 + 2x_2 \leq 10 \Rightarrow x_1 + 2x_2 = 10$

$x_1 - x_2 \leq 8 \Rightarrow x_1 - x_2 = 8$

$x_1, x_2 \geq 0$

(2)

Hint:-

MC / product	→	P	Q	R	Profit/unit
x_1 — A		10	6	5	60
x_2 — B		75	9	13	70
Max hrs/week		75	54	65	

Step-1
Key decision is to determine no. of units produce of product A & B in a week.
Let these are x_1 & x_2 respectively.

Step-2:-
Feasible alternatives are all the value of x_1, x_2 greater than equal to zero.

Step-3:-
Objective is to maximize weekly profit when the profit per unit is given. So the objective function. Max $z = 60x_1 + 70x_2$

Step-4
Restriction is on the max^n m/c time available for the 3 m/cs in a week.

So the constraints are

Towards origin

For P m/c → $10x_1 + 7.5x_2 \leq 75$

For Q m/c → $6x_1 + 9x_2 \leq 54$

For R m/c → $5x_1 + 13x_2 \leq 65$

Step 5:-

All the constraints are plotted on a graph to get feasible region.

$10x_1 + 7.5x_2 = 75 \Rightarrow \frac{x_1}{7.5} + \frac{x_2}{10} = 1$

$6x_1 + 9x_2 = 54$

$5x_1 + 13x_2 = 65$

Feasible region = shading out region

Finding out pt. B & Pt. C, we get (By solving eqn. Do in detail)

B(3.54, 3.63)

C(6, 2)

$Z_O =$

$Z_A = 60 \times 0 + 70 \times 5 = 350$

$Z_B =$

$Z_C =$

$Z_D =$

Step

Shaded region OABCD is the region of feasible solution and any within this region can be our solution under the given constraint.

Step:-

Now put the values of corner pt. of the feasible region in the objective function the point which optimizes the objective function give the final solution.

Z_A :- - - - -

Z_B :- - - -

$x_1 = 6$, $x_2 = 2$

One of the vertex of feasible region give the final solution because objective function is a straight line with constant slope and as it moves away from origin its value increase and the optimum value will be at one of the extreme corner point. At this point objective function will be tangent & gives the optimum solution.

Binding & Non-Binding constraint :-

$x_1 = 6$, $x_2 = 2$

P → $10x_1 + 7.5x_2 \leq 75$ → $75 = 75$ - Binding

Q →

R →

→ $56 < 65$ - non binding

when we put the value of optimum solution in the constraints & LHS = RHS the constraints is termed as binding otherwise non-binding. Final solution is always obtained from the binding constraint.

Redundant constraints :-

Constraints which doesnot become part of the boundary making feasible region is termed as redundant constraints. Inclusion or exclusion of such constraints does not have any effect on the optimum solution of the problem.

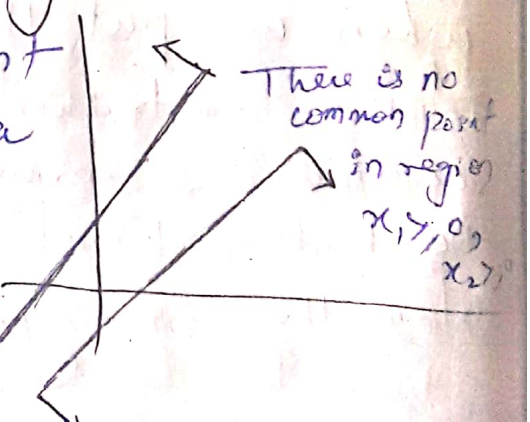
Special cases :-

1. Infinite or multi optimum solution :-

Infinite solution means we get the same optimum value of objective function for different varying variable. we always get a unique solution when the slope of objective function is different from constraint. Infinite number of solution is obtained when slope of objective function becomes equal to one of the binding constraints.

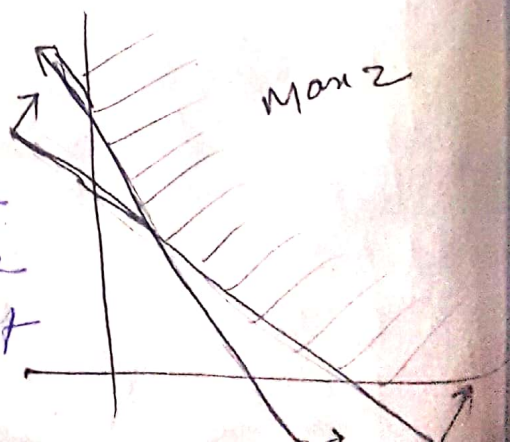
2. No solution or infeasibility :-

In some condition constraint may be inconsistant in such a manner that, it is not possible to find a feasible solution which satisfy all the constraint. There is no solution to such problem.



3. Unbounded solution :-

In some condition the highest value of objective function goes up to infinite and it simply means that the common feasible region is not



bounded by limit on the constraint. It is termed as unbounded solution.

By simplex Method :-

It is a step by step procedure in which we proceed in a systematic manner from an initial feasible solution with an improve upon that initial solution until, a in certain number of steps we reach the optimum final sol°. This method also check the corner point of the feasible region but in multi-dimension depending upon variables.

Std. form for simplex :-

1. All the resources value for the given constraints should be non-negative.

$2x_1 - 5x_2 \leq -70 \Rightarrow -2x_1 + 5x_2 \geq 70$

2. All the inequalities of the given constraints should be converted in to equalities.

$3x_1 + x_2 \leq 40 \Rightarrow 3x_1 + x_2 + s_1 = 40$ (s_1: slack variable)

$5x_1 + 3x_2 \geq 80 \Rightarrow 5x_1 + 3x_2 - s_1 = 80$ (s_1: surplus variable)

3. Each of the decision variable for the constraints & objective function should be linear & non-negative.

$x_j \geq 0.$

⇒ Q1

Objective function

$$\text{Max } z = x_1 + 3x_2$$

constraints

$$x_1 + 2x_2 \leq 10$$

$$x_1 - x_2 \leq 8$$

Non negative cond^n $x_1, x_2 \geq 0$

Sol^n

Then convert the constraint inequalities to equation.

$$x_1 + 2x_2 = 10 \quad \text{---} \quad (i)$$

$$x_1 - x_2 = 8 \quad \text{---} \quad (ii)$$

from equ^n (i)

$$x_1 + 2x_2 = 10$$

when $\boxed{x_1 = 0}$

$$0 + 2x_2 = 10$$

$$\boxed{x_2 = 5}$$

So point $P_1(0, 5)$

when $\boxed{x_2 = 0}$

$$x_1 + 2 \times 0 = 10$$

$$x_1 = 10$$

point $P_2(10, 0)$

Then for equ^n (ii)

$$x_1 - x_2 = 8$$

when $x_1 = 0$

$x_2 = -8$

$P_1 (0, -8)$

when $x_2 = 0$

$x_1 - 0 = 8$

$x_1 = 8$

$P_2 (8, 0)$

$x_1 + 2x = 10$

$x_1 - x_2 \leq 8$

$3x_2 = 2$

$x_2 = \frac{2}{3}$

$x_1 = \frac{26}{3} = 8\frac{2}{3}$

$= 8.6667$

$Z_{max} = x_1 + 3x_2$

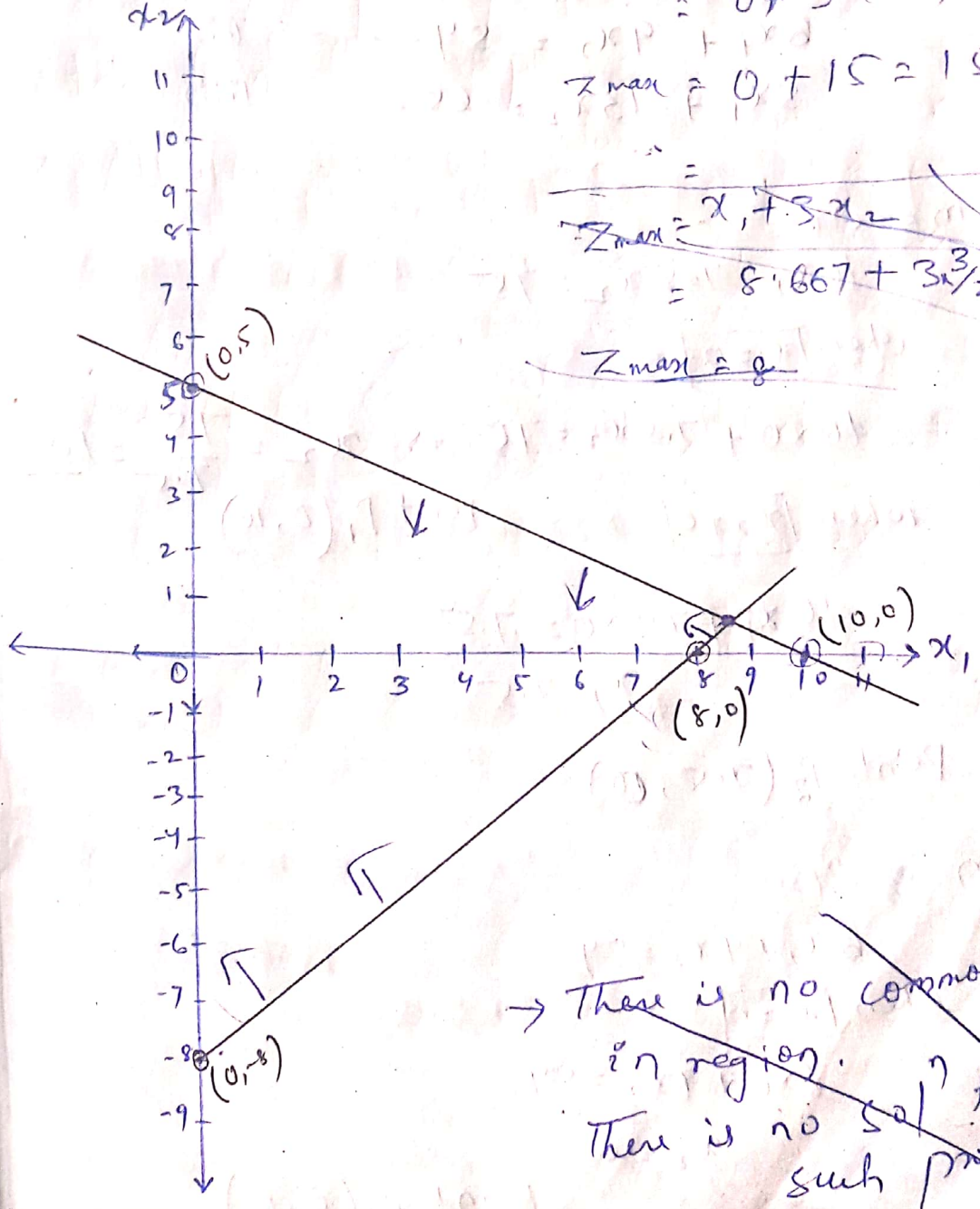
$= 0 + 3(-8) = -24$

$Z_{max} = 0 + 15 = 15$

$Z_{max} = x_1 + 3x_2$

$= 8.667 + 3 \times \frac{3}{2} = 13.167$

$Z_{max} = 8$



→ There is no common point in region. So, there is no solution to such problem.

(2)

Objective function

Max. $z = 60x_1 + 70x_2$

Constraints

$10x_1 + 7.5x_2 \leq 75$

$6x_1 + 9x_2 \leq 54$

$5x_1 + 13x_2 \leq 65$

and ~~$x_1, x_2 \geq 0$~~

Constraints in term of equation

$10x_1 + 7.5x_2 = 75$ ---- (i)

$6x_1 + 9x_2 = 54$ ---- (ii)

$5x_1 + 13x_2 = 65$ ---- (iii)

from equ^n (i)

$10x_1 + 7.5x_2 = 75$

when $\boxed{x_1 = 0}$

$10 \times 0 + 7.5x_2 = 75 \Rightarrow x_2 = \frac{75}{7.5} = 10$

when $\boxed{x_2 = 0}$ Point $P_1(0, 10)$

$10x_1 + 7.5 \times 0 = 75$

$x_1 = 7.5$

Point $P_2(7.5, 0)$

from equ^n (ii)

$6x_1 + 9x_2 = 54$

when $\boxed{x_1 = 0}$

$6 \times 0 + 9x_2 = 54$

$x_2 = 6$

Point $P_3(0, 6)$

when $x_2 = 0$

$6x_1 + 9 \times 0 = 54$

$x_1 = 9$

$P_2(9, 0)$

from equ^n (2)

$5x_1 + 13x_2 = 65$

when $x_1 = 0$

$5 \times 0 + 13x_2 = 65$

$x_2 = 5$

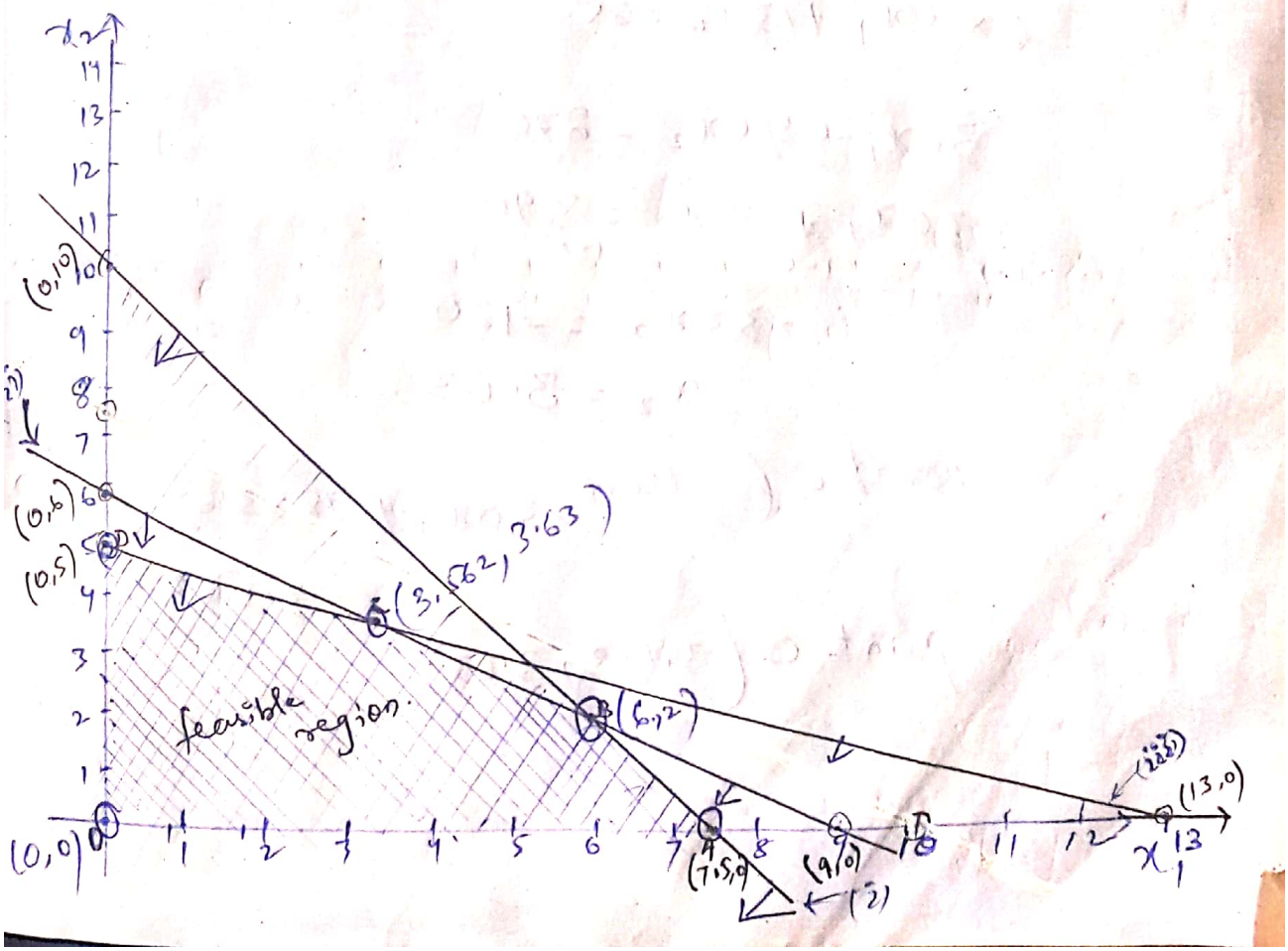
Point $P_1(0, 5)$

when $x_2 = 0$

$5x_1 + 13 \times 0 = 65$

$x_1 = 13$

point $P_2(13, 0)$



Point B is an intersection of constraints (i) & (ii)

So,

$6 \times 10x_1 + 7.5x_2 = 75$

$10 \times 6x_1 + 9x_2 = 54$

$$60x_1 + 45x_2 = 450$$
$$60x_1 + 90x_2 = 540$$
$$(-) \quad (-) \quad (-)$$
$$-45x_2 = -90 \Rightarrow x_2 = 2.$$

then

$$60x_1 + (45 \times 2) = 450$$
$$x_1 = \frac{360}{60} = 6$$

Point B (6, 2)

point C is an intersection of constraints (ii) & (iii)

$5 \times 6x_1 + 9x_2 = 54$

$6 \times 5x_1 + 13x_2 = 65$

$$30x_1 + 45x_2 = 270$$
$$30x_1 + 78x_2 = 390$$
$$(-) \quad (-) \quad (-)$$
$$-33x_2 = -120$$
$$x_2 = 3.63$$

point C then $30x_1 + 78 \times 3.63 = 390$

$x_1 = 3.562$

point C (3.562, 3.63)

Points	Co-ordinate	value of objective function $Z = 60x_1 + 70x_2$
O	(0, 0)	0
A	(7.5, 0)	450
B	(6, 2)	500
C	(3.562, 3.63)	467.82
D	(0, 5)	350

So,

$Z_B = Z_{max} = 500$, at $x_1 = 6$, $x_2 = 2$ } Ans

PERT & CPM :- PERT (Programme evaluation and review technique)
CPM (critical path method).

Terms related with CPM & PERT :-

Project :-

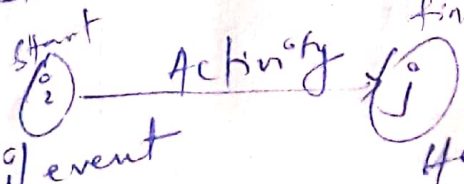
It is a group or combination of inter related activities that must be executed in a certain fixed order before the entire task is completed. Activities are inter related in a logical sequence in the same that some activity can only be started when all the activities earlier to it are completed.

Event :-

An event is a specific instant of time which indicates the beginning or end of the activity. Event is also known as a junction. It is represented by a circle and the event number is written within the circle. Unlike an activity, an event consumes neither time nor resources.

Activity :-

It is a recognisable part of a project which consume time & resources for its completion and it may involves physical and mental work. When all the activities are executed then a project only gets completed.



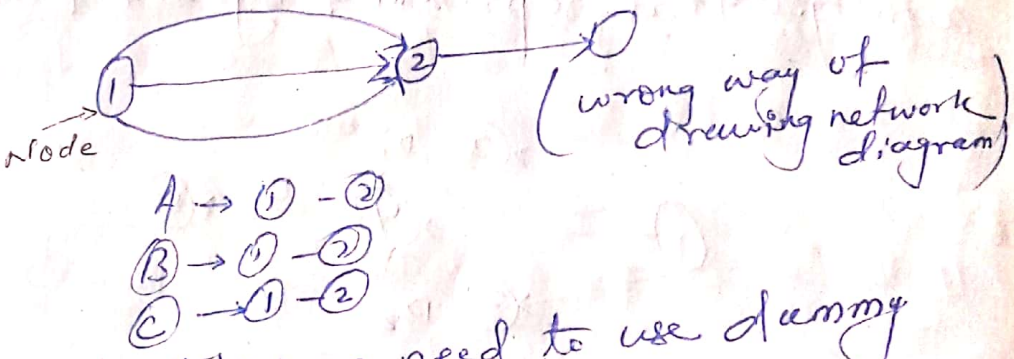
→ Every project consist of number of job operations or task which are called activities. An activity is any time or resources consuming part of the project which has definable start & finish.

Network diagram :-

It is a graphical representation of the logical sequence in which different activities are inter related to each other while completing a project.

Rules for Network construction :-

1. An activity can only be started when all the activities earlier to it are completed.
2. No two or more activities may have the same tail and head event.



A → (1) - (2)
B → (1) - (2)
C → (1) - (2)

In this condition we need to use dummy activity to represent same relation.

→ The length of the arrow doesn't indicate the time which the activity takes or the resources which the activity consumes.

→ The direction of the arrow indicates the direction of work flow.

→ No activity can be shown twice in the network unless it occur twices in the project. Normally in such cases it will bear a different activity identification.

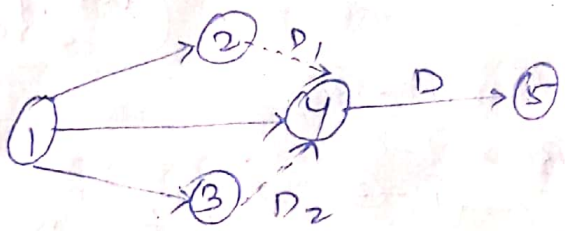
→ No two ~~activity~~ event will be directly connected by more than one activity.

Classification of activities :-

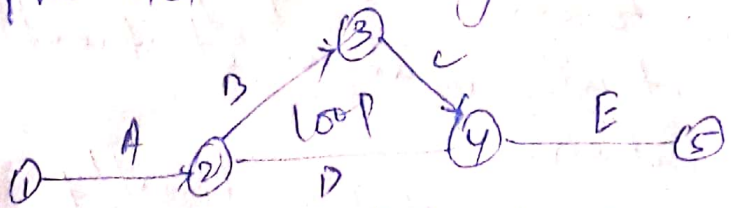
(a) Critical activities
(b) Non-critical activities
(c) Dummy activities.

Dummy activity :-

An activity which is used to show the logic, relationship, depending of one activity over the other but doesn't consume any time or resources for its completion is known as dummy activity. It is represented by dotted line arrow.

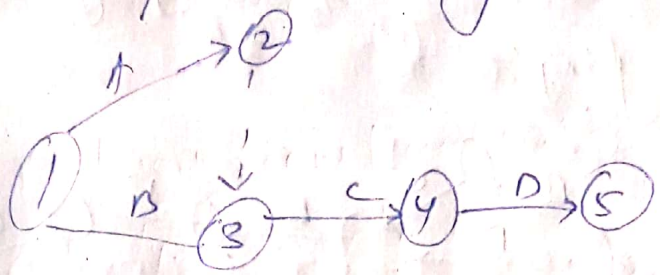


→ Dummy activity should only be used when it is very necessary, but there is no restriction on the no. of dummy activity used.
→ The length and direction of arrow is indicative only and time flow from left to right on the network diagram.
→ There should be no looping and dangling on the network diagram.



Non sol^n for looping.

* "When two activities start at the same instant of time like A and B, the head events are joined by dotted arrows and this is known as dummy activity."



The dummy activity is included in the network to show that the activity C cannot be started until activities A & B are completed.

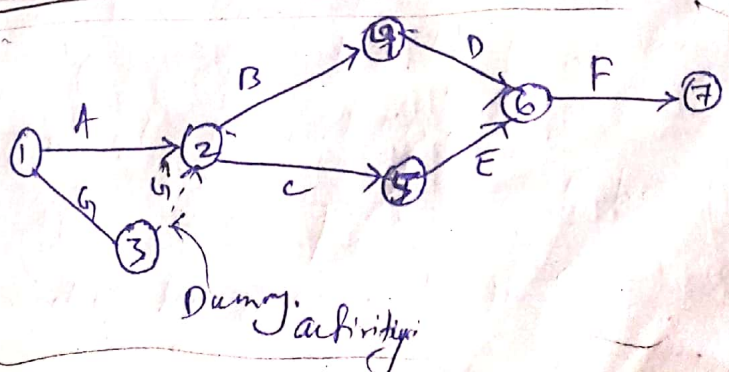
Critical activities :-

In a network diagram critical activities are those which if consume more than their estimated time, the project will be delayed.

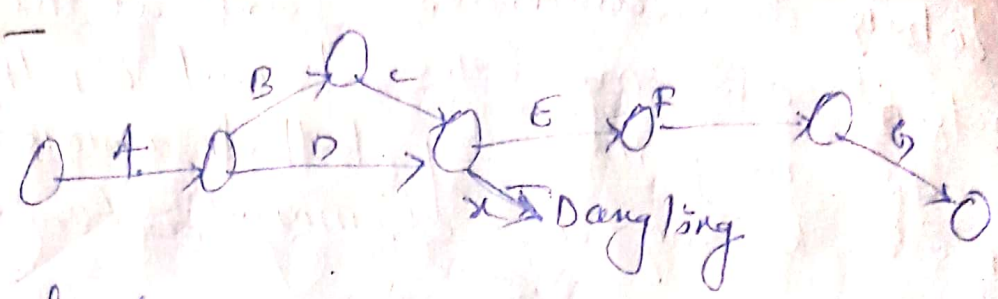
→ A critical activity is marked either by a thick arrow or a double line arrow to distinguish it from non critical activities.

Non critical activities :-

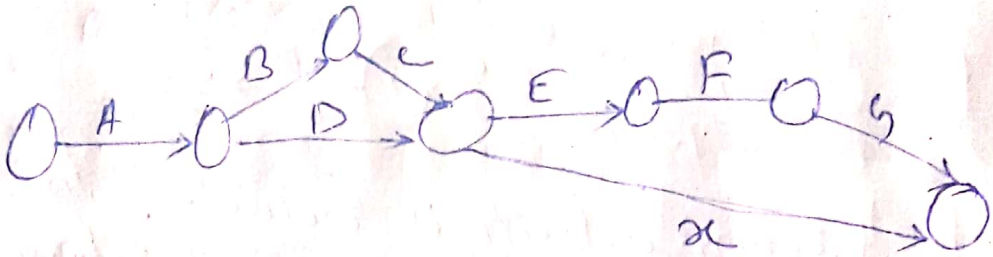
Such activities have a provision of float or slack so that, even if they consume a specified time over and above the estimate time, the project will not be delayed.



Dangling :-



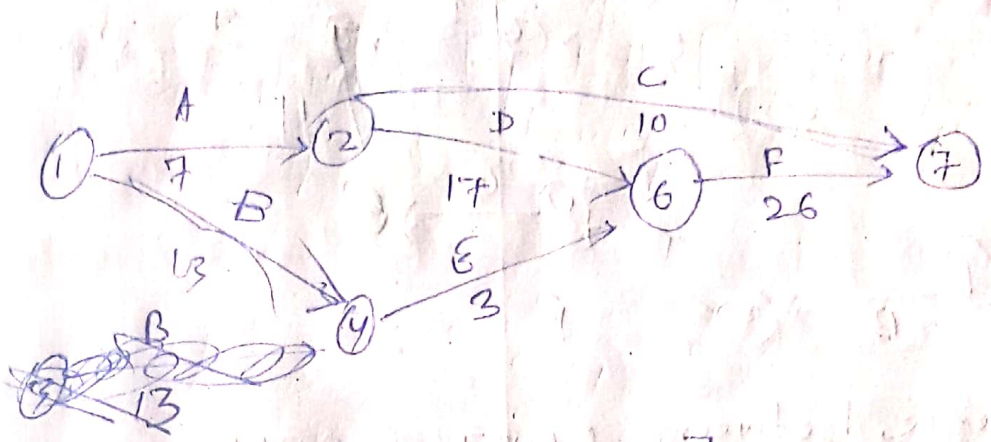
Soln to dangling :-



When activity other than the final activity does not have any successor activity then the situation is called as dangling. Such activity should be connected directly to the last event of the network diagram.

Q)

Activity	predecessor	Duration
A	—	7
B	—	13
C	A	10
D	A	17
E	B	3
F	D, E	26



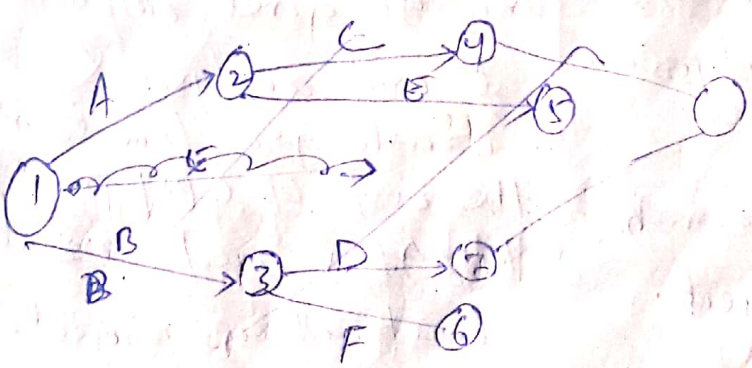
CPM — 1-2-6-7

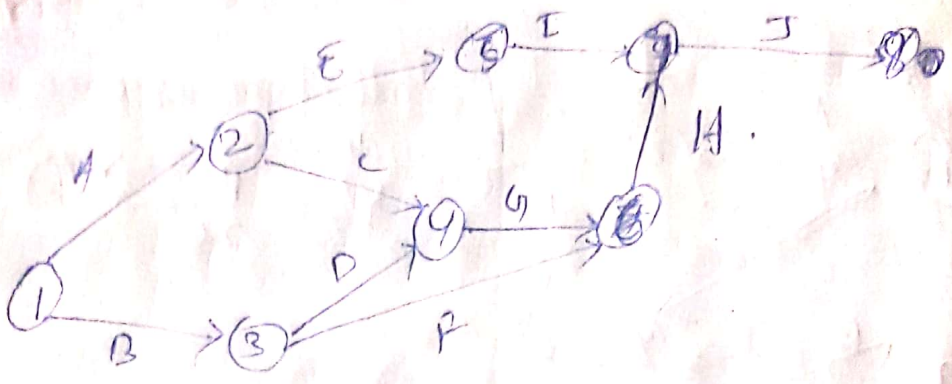
Project dur = 7+17+26 = 50

Activity - Predecessor

Activity	Predecessor
A	—
B	—
C	A
D	B
E	A
G	B
H	C, D
I	G, F
J	E
	H, I

Activity	Predecessor
A	—
B	—
C	A
D	B
E	A
F	B
G	C, D
H	G, F
I	E
J	H, I





Difference between PERT & CPM :-

PERT	CPM
i) Programme (project) evaluation and review technique.	i) Critical path method
ii) It is event oriented.	(ii) It is activity oriented.
(iii) Associated with probabilistic activities.	(iii) Associated with deterministic activities
iv) It is based upon 3 times estimate to complete an activity.	(iv) It is based upon single time to complete an activity.
v) It is used where time required for complete various activities is not certain.	(v) Used for repeatative job where one has prior experience of handling similar project.
vi) It usually doesnot consider cost analysis.	(vi) It gives importance to cost analysis & crashing is done to minimize the cost of CPM project.
vii) It is used for research & development project.	(vii) It is used mainly for construction project.

PERT:-

⇒ PERT and CPM are the scheduling techniques which are used to plan, schedule and control a project consisting of number of inter-related activities.

PERT:-

⇒ It is used for uncertain project & it is based upon 3 time estimate to complete an activity. These are.

1. Optimistic time (t_o or a):-
   It is the minimum time required to complete an activity when everything goes according to the plan.
2. Pessimistic time (t_p or b):-
   It is the minimum time reqd. to complete an activity when everything goes against the plan.
3. Most likely time (t_m or m):-
   It is time required to complete an activity when executed under normal working condition.

* The avg. or expected time to complete an activity is given by.

$$t_E = \frac{a+4m+b}{6} = \left(\frac{t_o+4t_m+t_p}{6}\right)$$

$$\sigma = \left(\frac{b-a}{6}\right) = \left(\frac{t_p-t_o}{6}\right)$$

$$\text{variance} = \sigma^2 = \left(\frac{b-a}{6}\right)^2 = \left(\frac{t_p-t_o}{6}\right)^2$$

$\pm 3\sigma$ limit - 99.7% $= 6\sigma$

$6\sigma = b-a \Rightarrow \sigma = \left(\frac{b-a}{6}\right)$

Earliest start time (EST)

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

⇒ Earliest Finish Time (EFT)

It is the earliest possible time at which an activity can finish.

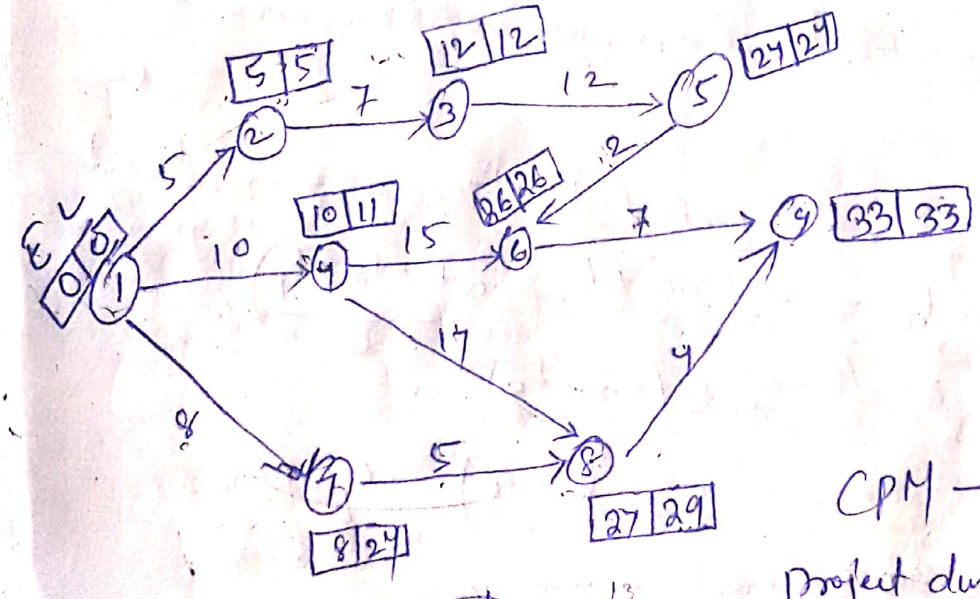
EFT = EST + duration of that activity.

Latest start time (LST)

It is the latest possible time by which an activity can start without delaying the date of completion of the project.

LST = LFT − duration of that activity.

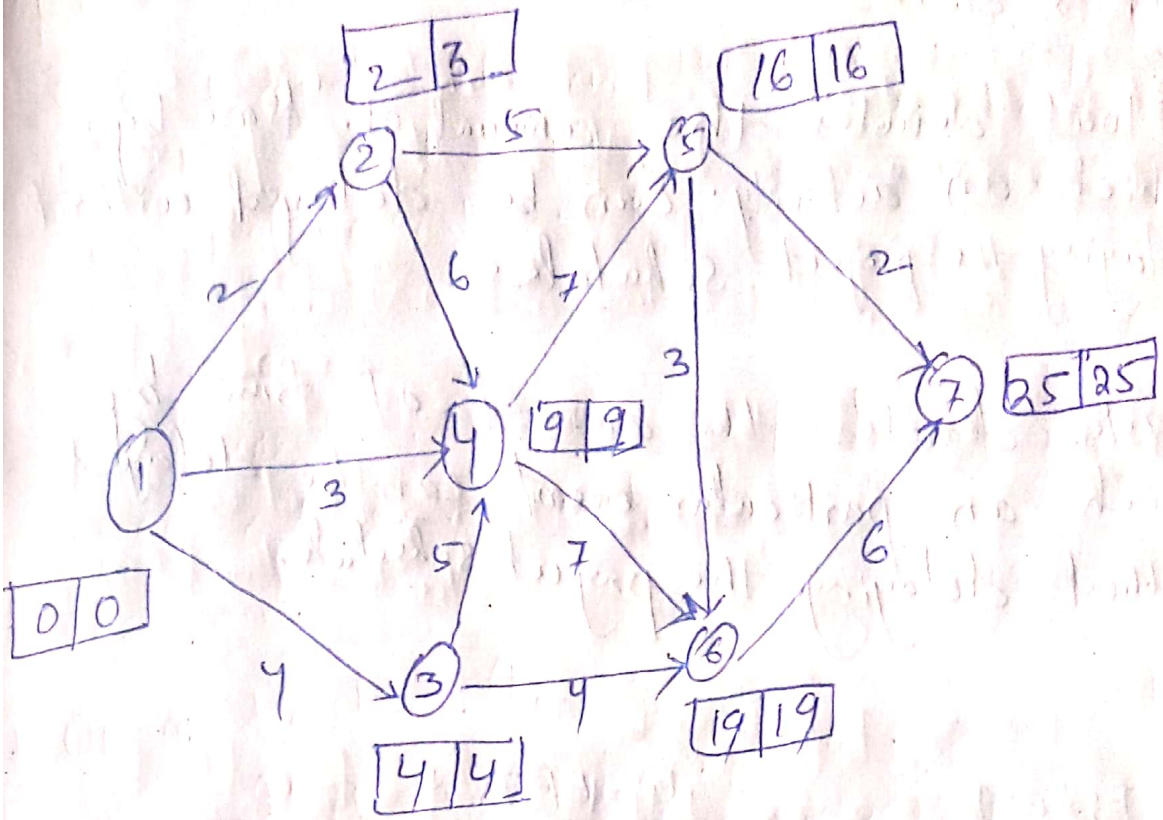
Calculate Earliest & Latest time.

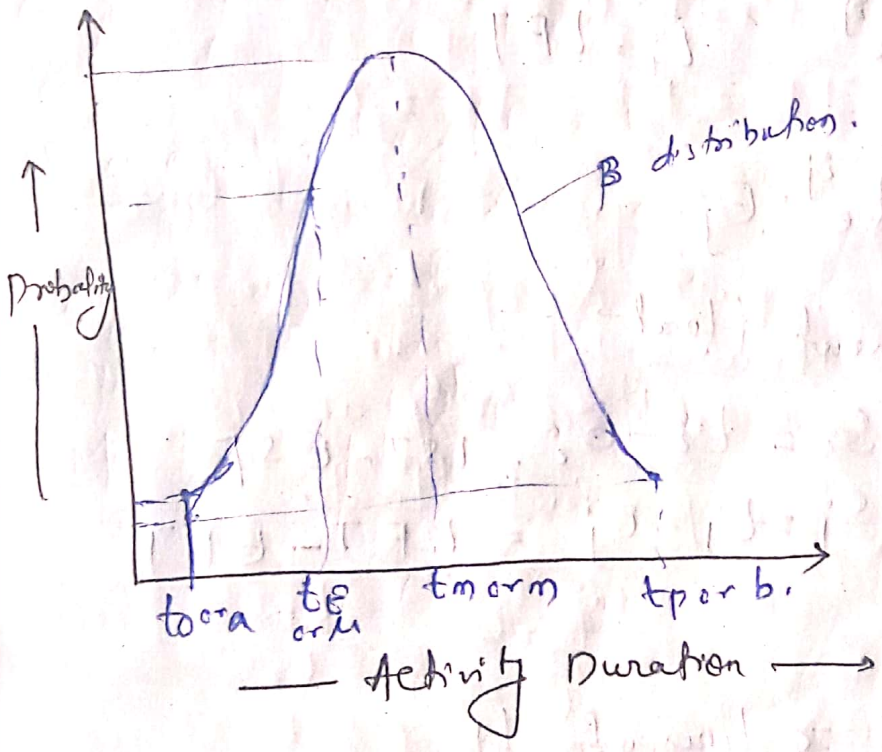


CPM − 1-2-3-5-6-9

Project duration = 33

CPM − 13 17





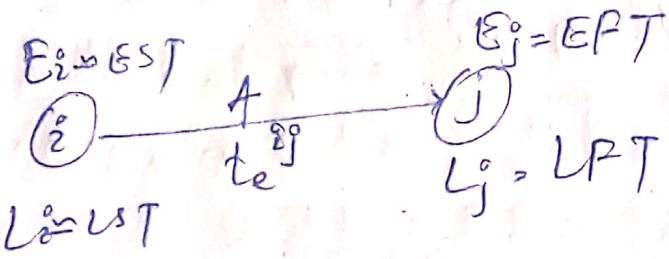
For single activity → β distribution curve is used

For set of activity or a project → normal distribution curve is used.

Float & Slack:-

⇒ Float denotes the amount of time by which an activity can be delayed without delaying the project schedule.

⇒ Slack denotes the amount of time by which an particular event can be delayed without delaying the project schedule.



$$E_i + t_e^{ij} = E_j$$

Slack or event float

$$S_i = L_i - E_i = LST - EST$$
$$S_j = L_j - E_j = LFT - EFT$$

Float:-

There are 3 types of float

(i) Total float.
(ii) free float
(iii) Independent float.

Total float :-

Total float denotes the amount of time by which can activity can be delayed without delaying the project schedule.

→ If total float value is

(i) positive → Resources are surplus & allocated for other activity.

(ii) Zero → Resources are just sufficient to complete activity on time.

(iii) Negative → Resources are not sufficient and activity may not complete on time.

Total float = LFT - EFT = LST - EST

~~The super critical parts~~

→ There are three type of path.

super critical path → highest negative total float

critical path → Total float value zero.

sub critical path → nexet positive total float value after critical path

Free float :-

It is that part of total float which can be used without effecting the float of succeeding activity.

Free float = Total float - head events slack.

Sy)

Independent float :

It is the amount of time which can be used without affecting either the head or the tail event.

Independent float = free float - tail event slack.

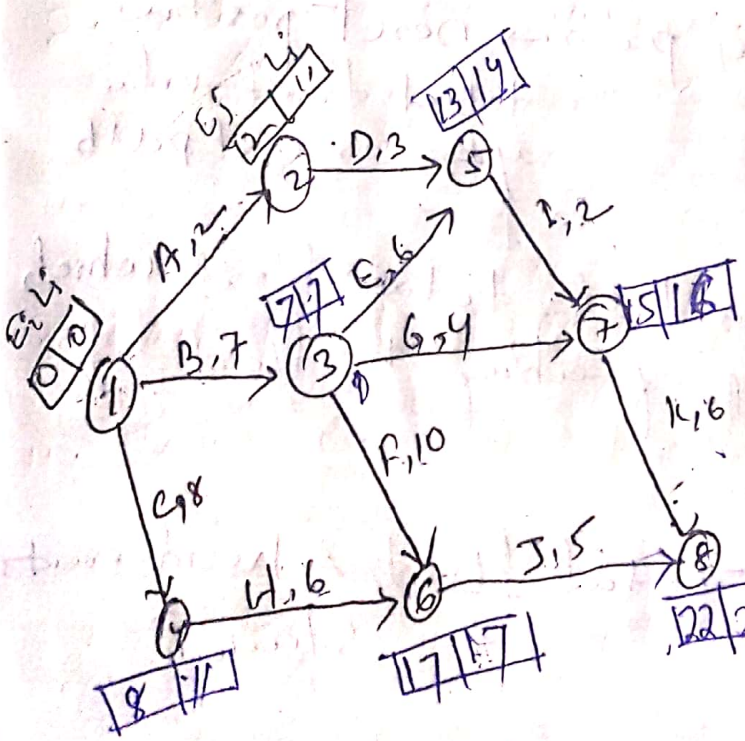
Independent float
= Total float - head event slack - tail event slack

TF > FF > IF

For critical path total float = free float = independent float. which is equal to zero.

TF = FF = IF = 0.

Q] For the network diagram shown below, find the critical path & expected project completion time. Draw a table showing the details for at each activity along with total, free & independent float.



$E_1 = 0$
$E_2 = 2$
$E_3 = 7$
$E_4 = 8$
$E_5 = 13$
$E_6 = 17$
$E_7 = 15$
$E_8 = 22$

$L_1 = 0$
$L_2 = 11$
$L_3 = 7$
$L_4 = 7$
$L_5 = 14$
$L_6 = 17$
$L_7 = 16$
$L_8 = 22$

project duration = 22.

For conventional:-

Activity i-j	t_E^{ij}	Earliest EST (E_i)	Earliest EFT (E_j)	Latest LST (L_i)	Latest LFT (L_j)	Float Total (LST-EST)	Float free (EFT-EST)	Float 2nd
A, 1-2	2	0	2	9	11	9	0	0
B, 1-3	7	0	7	0	7	0	0	0
C, 1-4	8	0	8	3	11	3	0	0
D, 2-5	3	2	5	11	14	9	8	(-1)* 0
E, 3-5	6	7	13	8	14	1	0	0
F, 3-6	10	7	17	7	17	0	0	0
G, 5-7	4	7	11	12	16	5	4	4
H, 4-6	6	8	14	11	17	3	3	0
I, 5-7	2	13	15	14	16	1	0	(-1)* 0
J, 6-8	5	17	22	17	22	0	0	0
K, 7-8	6	15	21	16	22	1	1	0

There is no meaning of -ve value, so take zero.

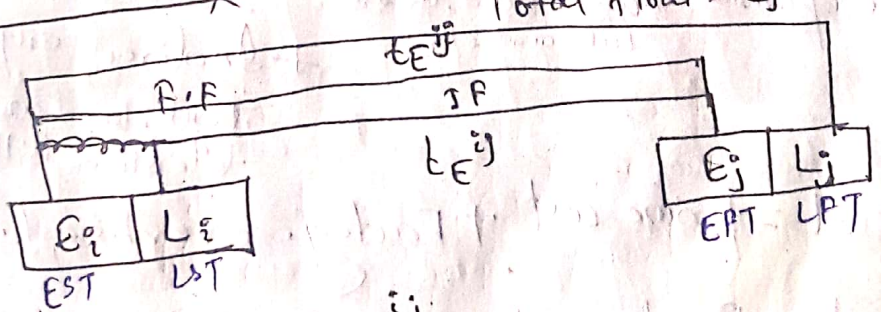
for any activity i-j

$TF = L_j - (E_i + t_E^{ij})$ or LST-EST

$FF = E_j - (E_i + t_E^{ij})$ ⟶ EST of head event − EST tail event − t_E^{ij}

$IF = E_j - (L_i + t_E^{ij})$

Total float $= L_j - E_i - t_E^{ij}$



$TF = L_j - E_i - t_E^{ij}$

$IF = E_j - L_i - t_E^{ij}$

$FF = E_j - E_i - t_E^{ij}$

2- $11 - (0 + 2)$ LFT − EST − T

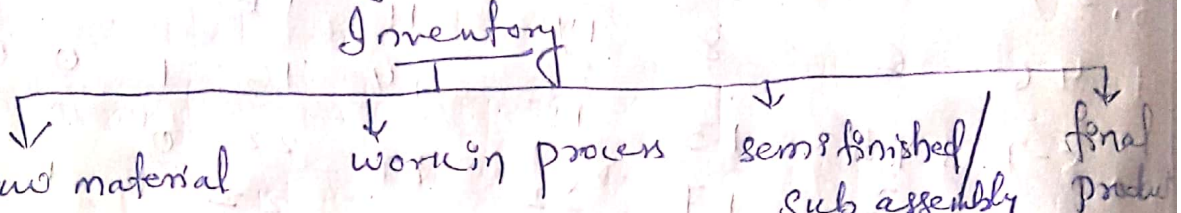
9 37

CH-3 INVENTORY CONTROL

Inventory :-

Inventory can be term as stock on hand at a given point of time which may be held for the purpose of later use or sale.

→ It has an economic value and it may include raw material, work in process, semi finished or sub assembly and final product.



→ Our aim is to manage inventory in such a way that day to day working run smoothly without any delay, but at the minimum of cost.

Cost in production :-

1. prime or direct cost = Direct material + Direct labour + Direct expenses (machinary, tool etc.)

2. Factory overhead or factory expenses = Indirect material (cutting fluid, Grease, lubricant etc.) + Indirect labour (watchman, supervisor) + Indirect expenses (Rent, land cost, telephone bills,

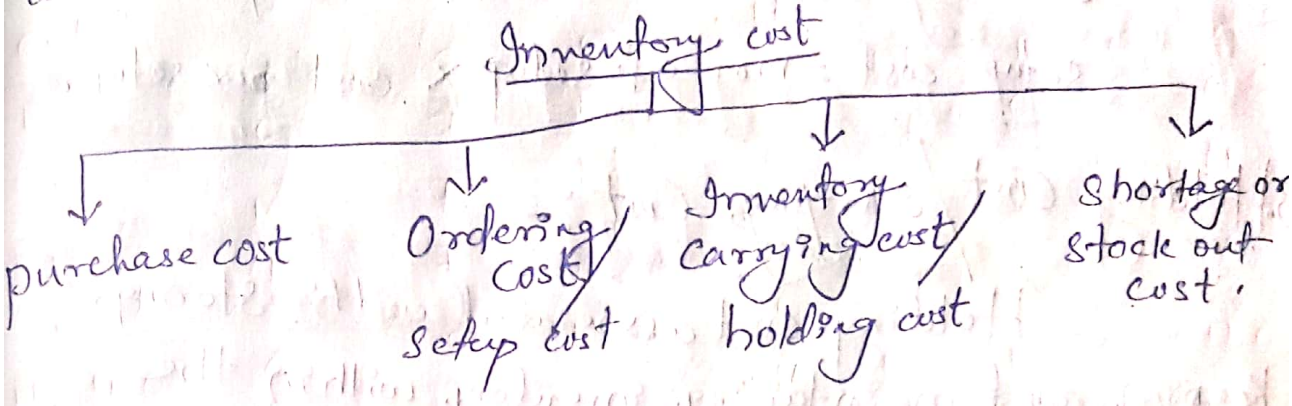
3. Factory cost = prime cost + Factory overhead.

4. Total cost : Factory cost + Marketing, Advertising cost + Taxes, Maintainance cost.

5. Selling cost : Total cost + profit.

Inventory Cost :- (costs associated with inventories)

The costs that are affected (i.e. increase or decrease) by the firm's decision to maintain a particular level of inventory are called cost associated with inventories or relevant inventory costs.



Total Inventory Cost :-

TIC = purchase cost + inventory carrying cost + ordering cost + shortage cost.

1. Purchase Cost :-

It is the cost of purchasing inventory and it depends up on quantity purchased.

purchase cost = No. of units × cost per unit.

2. Ordering Cost :-

When inventory is purchased from outside, the cost associated with bringing inventory within the production system is term as ordering cost.

→ It include cost of tender, processing cost, communication cost, inspection cost & transportation cost etc.

Setup cost :-

When inventory is produce internally, the cost associated with bringing shutdown production system again into starting condition.

is term as setup cost.

→ It include m/c maintainance cost, schedule chart preparation cost, arrangement of workers, tool & equipment etc.

Ordering cost = no. of order x cost per order

setup cost = no. of setup x cost per setup.

3. Holding cost/carrying Cost:-

Holding cost associated with storing, keeping and maintaining inventory within the production system. It include storage cost, handling cost, damage & depreciation cost, insurance, interest, etc.

Holding cost/carrying cost = Average inventory for a period x holding cost per unit time.

4. Shortage or stock out Cost:-

Shortage simply means absence of inventory & the loss associated with not serving the customer is term as shortage cost. It include potential profit loss, goodwill lost, lost of production hour, discount etc.

Shortage unit: Average no. of unit short x Shortage unit per unit time.

Inventory classification :-

(i) Transit or pipeline inventories.
(ii) Buffer or safety stock
(iii) Seasonal inventory
(iv) Anticipation inventory
(v) Decouple inventory.

Transit inventory :-

Inventory cannot provide service while in transportation and such inventories is known as transit inventory.

Buffer or safety stock :-

It is the reserved stock kept throughout a year. It is help for protecting against the fluctuation of the demand rate & lead time. It never required under normal working cond^n and used only in adverse cond^n to prevent stock out.

Seasonal inventory :-

The demand for the inventory item changes with seasonal variation.

Anticipation :-

The inventory are buildup to meet anticipated demand in future like selling forecast, government policy change, price hike, strike, shutdown etc.

Decouple :- This is extra inventory kept between different work station which work as reserve stock against breakdown or maintainance.

Note

Lead time:-

It is a time gap between placing an order and inventory on hand. So that it can used or consumed.

Adverse cond":-

→ when actual demand is greater than average demand.

→ when actual lead time is greater than average lead time.

INVENTORY FUNCTION :-

1. To ensure against delays in deliveries :- when an order is placed, the material are not immediately available but takes some time. This period between the time of placing the order and the time of arrival is often subjected to variation. A firm must therefore hold some reserve stock to allow production operation to continue if delay in procurement occurs.

2. To allow for possible increase in output :- Changes in the manufacturing programme may occur because of variation in the demand. To meet the increased demand for the finished goods the company should have enough stock of inventories so as to allow the production without interference.

3. Maintain smooth & efficient production flow :- when a company has little inventory and runs out of stock, stockout of essential materials means interruptions in production which raises cost of production.

4. To keep better customer relations :- Stock out means stoppage or interruption in production. Therefore it may delay the delivery of finished goods to the customers. After a few such delays even a most patient customer will start looking for a supplier who will give him better service.

5. To take advantages of quantity discount.

6. To utilize to advantage price fluctuations.

7. To have better utilization of men and machinery :- If there is a stock out of material the men & machinery will remain idle.

8. To protect against stock out.

Inventory Control :-

According to production handbook (edited by Gardon B. Carson), "Inventory control refers to the process where by the investment in material and parts carried in stock is regulated within predetermined limits set in accordance with the inventory policy established by management."

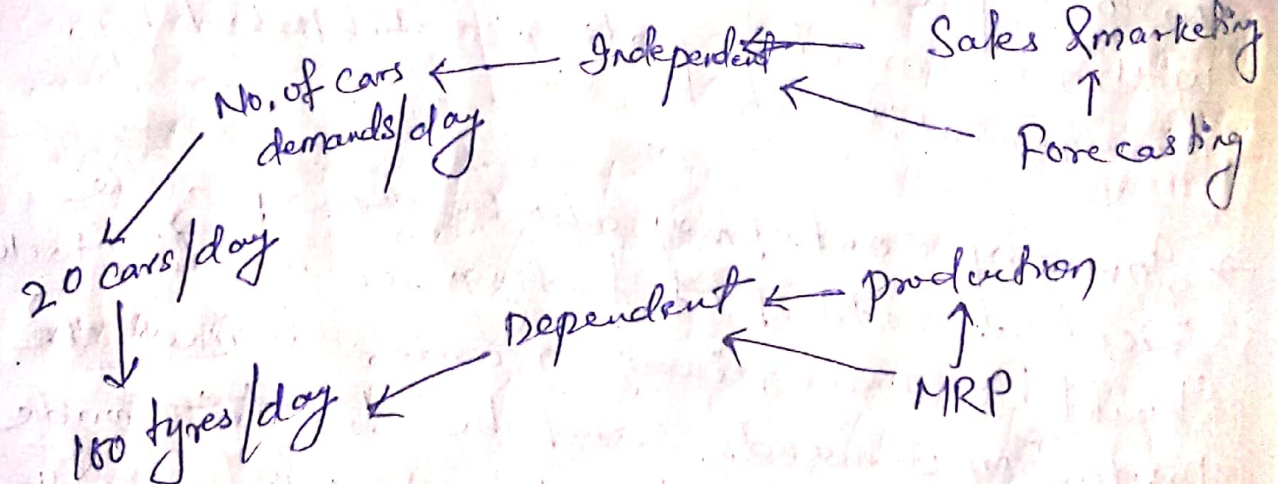
→ Inventory control may also be defined as the scientific method of finding how much stock should be maintained in order to meet the production demands and be able to provide right type of materials at right time in the right quantities and at competitive prices.

Objective of inventory control :-

* To supply the product in time.
* To give maximum clients service.
* To reduce or minimize investment in inventories.
* To avoid shortage of stock.
* To minimize the losses.
* To meet unforeseen future deemand.
* To minimize idle time by avoiding Stock outs & Shortages.
* To smoothen the production process.
* To meet the customer requirement timely, effectively, efficiently, smoothly & satisfactorily.

Characteristic of inventory model :-

1. Dependent & independent demand inventory :-



Dependent :-
Demand for these item, which is directly related or linked to any other item, usually of higher level of which it becomes a part.

Independent :-
The demand for these items is not directly or linked to any other item, it is difficult to compute & it is projected with the help of forecasting.

Inventory Review System :-

Q - system
or, fixed order system
or, Reorder level system
or, Two bin system.
bin-box
single order, single inventory

P - system
or, Fixed Period system.
or, Periodic Review system.
Perishable
Holding cost ↑
Rang ↑
safety stock ↑
single order & multiple inventory

combined
SS - system

optimum Replenishment Policy.
Fast - Q system ROL = 50 units
Slow - P system ROP = 15 days.

$d = 10$ units/day, $d' = 15$ units/day, $d'' = 9$ units/day
LT = 5 days, ROL = 50 units, Q = 500 units/order

450	50

Fixed Order system :-

In the system, as inventory decrease to reorder level a fresh order for fixed quantity is placed at that point. In this system size of order is fixed but time of order is variable.

Fixed period system :-

~~In the system as inventory decrease to reorder level a fresh order for fixe~~

In this system inventory is reviewed after a fixed period of time and a fresh order for variable quantity is placed at that point. In the system size of order is variable but time of order is fixed.

9. Deterministic & probabilistic model :-

Deterministic :-

In these model demand rate & lead time remain fixed & constant. Therefore we need not to carry safety stock.

probabilistic :-

These model represent the real world cond^n where there is uncertainity of demand rate and lead time. In these model we need to carry safety stock to prevent stock out during adverse cond^n.

Notation :-

D - Annual or yearly demand of inventory (units/year)

Q - Quantity to be ordered at each order point (unit/order)

N - No. of orders placed in a year (order/year)

$N = D/Q$ order/year.

T – Time length of one inventory cycle or time gap between 2 successive order (year/order)

$T = \frac{1}{N} \Rightarrow T \cdot N = 1$

C – Cost of purchasing one unit of inventory (Rs/unit)

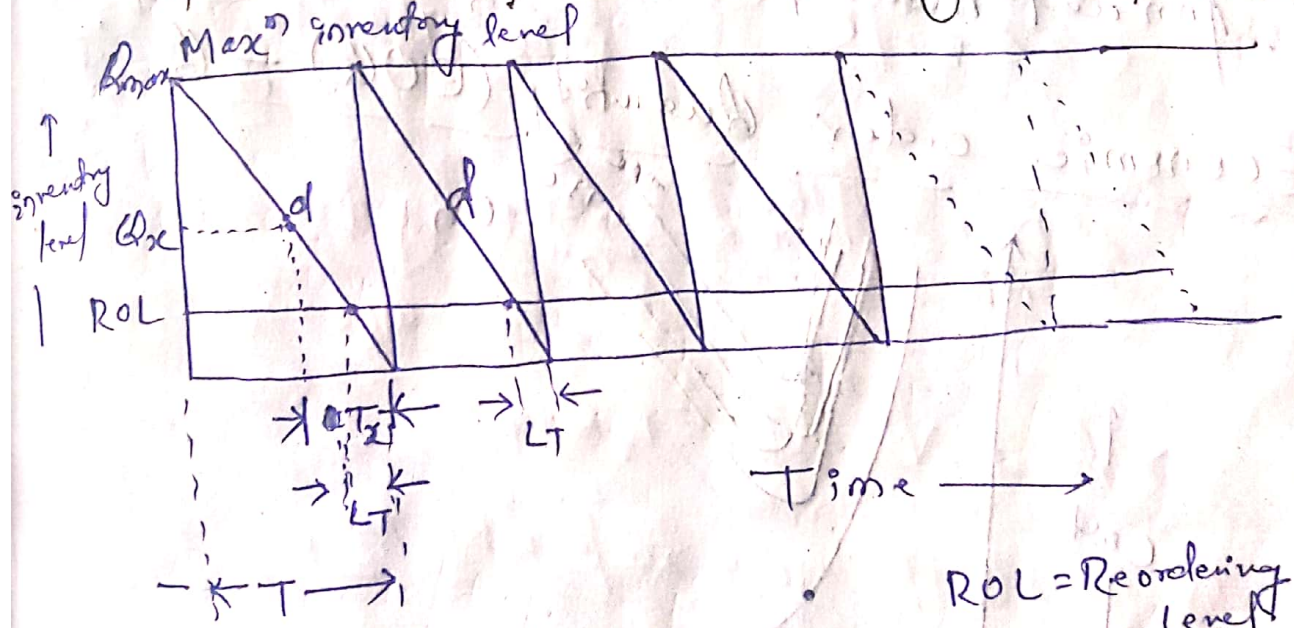
C_o – Cost of placing one order (Rs/order)

C_c/C_h – Cost of holding one unit inventory for on complete year (Rs/unit/year)

Deterministic Model :-

Economic order Quantity.

Harris Wilson model or Infinite replenishment model.



$ROL = LT \times d$

$Q_x = T_x \times d$

$Q = T \times d$

$d = \frac{Q_x}{T_x} = \frac{Q}{T} = \frac{ROL}{LT}$

ROL = Reordering level

d = demand rate.

LT = lead time.

N = number of order.

D = Annualy demand of inventory.

Total annual cost = purchase cost + ordering cost + holding
(TAC) (C) C_o C_c

Total inventory
(TIC)

$$TAC = D \times C + N \times C_o + \frac{Q}{2} \times C_h$$

$$\boxed{TAC = D \times C + \frac{D}{Q} \times C_o + \frac{Q}{2} \times C_h} \quad [\because N = \frac{D}{Q}$$

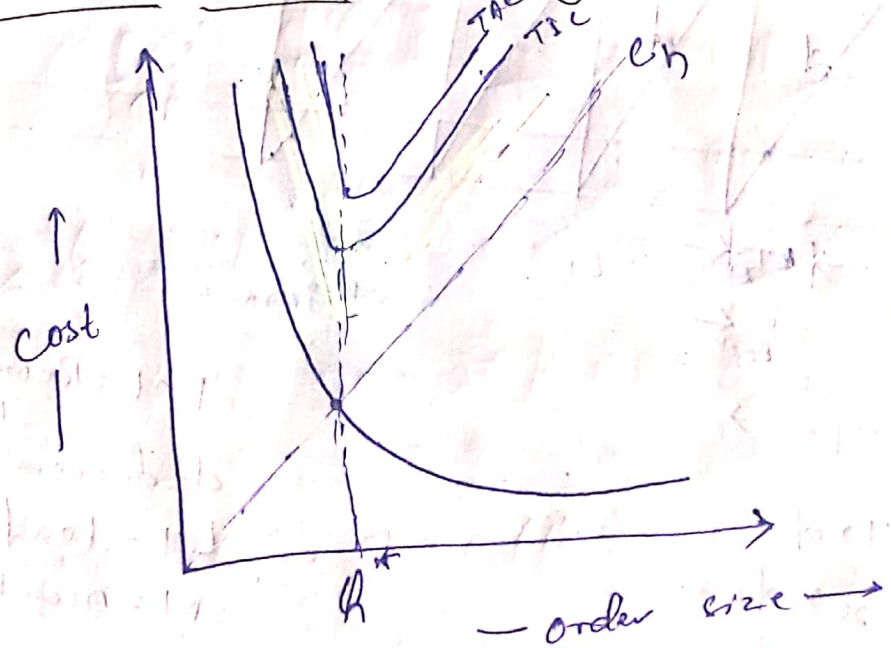
$$\boxed{TAC = D \times C + TIC}$$

$$\boxed{TIC = \frac{D}{Q} \times C_o + \frac{Q}{2} \times C_h}$$

Holding cost for period $T = \frac{Q}{2} \times C_h \times T$ (T in yea

Annual holding cost $= \frac{Q}{2} \times C_h$.

Economic order quantity (EOQ) $= Q^*$



At EOQ Holding cost = Ordering cost.

$$\frac{Q}{2} \times C_h = \frac{D}{Q} \times C_o$$

$$Q^2 = \frac{2DC_o}{C_h}$$

$$\boxed{Q = \sqrt{\frac{2DC_o}{C_h}} = Q^*}$$

$$\text{TIC at EOQ} = \frac{Q^*}{2} \times C_h + \frac{D}{Q^*} \times C_o \quad \left[\because \text{Holding cost} = \text{ordering cost}\right]$$

$$= 2\frac{Q^*}{2} \times C_h$$

$$= Q^* \times C_h = \frac{\sqrt{2DC_o}}{\sqrt{C_h}} \times C_h$$

$$\boxed{\text{TIC at EOQ} = \sqrt{2DC_oC_h}}$$

Note:-

Holding cost is when given in terms of interest or percentage; it always corresponds to unit price of inventory and interest rate should be always ~~ea~~ yearly.

C_h = i% of C

i% = 1.2 %/month

= 1.2 × 12 %/year

= 14.4 %/year.

[% given, calculation made on price p.u. R/m]

Q) Total inventory cost of the order size 400 units and 900 units are equal then determine the EOQ?

Sol)

$$TIC_{(Q)} = \frac{D}{Q} \times C_o + \frac{Q}{2} \times C_h$$

$$TIC(400) = TIC(900)$$

$$\Rightarrow \frac{D}{400} \times C_o + \frac{400}{2} \times C_h = \frac{D}{900} \times C_o + \frac{900}{2} \times C_h$$

$$\Rightarrow D C_o \left[\frac{1}{400} - \frac{1}{900}\right] = \frac{500}{2} \times C_h \quad \frac{1}{2}$$

$$\Rightarrow \frac{2DC_o}{C_h} = \left(500 \times \frac{1}{\frac{1}{400} - \frac{1}{900}}\right)$$

$$\Rightarrow Q^* = \sqrt{\frac{2DC_o}{C_h}} = \sqrt{500 \times \frac{900 \times 400}{500}}$$

$$Q^* = 30 \times 20 = 600 \text{ Ans}$$

$$TIC(Q_1) = TIC(Q_2)$$

$$Q^* = \sqrt{Q_1 Q_2}$$

Q) Determine EOQ value when annual demand is worth rupees 50000/-

C_o = 2% of order values

C_h = 10% of average inventory value.

$$Q^* = \sqrt{\frac{2DC_o}{C_h}}$$

$D_i = 50,000$

$C_o = 0.02Q$

$C_h = 0.1\,\frac{Q}{2}$

$D.C = 50000$

$C_o = 0.02 \times Q^*C$

$C_h = \frac{0.1 \times Q^* \cdot C}{2}$

$C_h = 0.1 \times C$

$$Q^* = \sqrt{\frac{2 \times 50000 \times 0.02 \times Q^* C}{0.1 \times C}}$$

$$Q^* = \sqrt{\frac{2 \times 50000 \times 0.02 \times Q^*}{0.1 \times C}}$$

$$\Rightarrow Q^* = \frac{2 \times 50000 \times 0.02 \cdot Q^*}{0.1 \times C}$$

$$Q^* \cdot C = \frac{2 \times 50000 \times \frac{2}{100}}{\frac{1}{10}}$$

$Q^* \cdot C = 20000/-$ (Ans)

Q) The demand of soap at a retailer is 40 kg/day. retailer purchase soap from a company at the rate rupess ₹50/kg. ordering cost 200/order holding 0.1 rupess per kg/day. lead time is 13 days and retailer current ordering policy is to order 200 kg. in every 5 day. Determine (i) EOQ

(ii) Amount of saving with EOQ compare to current policy. in 30 days

(iii) Reorder level corresponding to EOQ.

Sol? $D = 40 kg/day = 14600 kg/year$.

(i) $C_o = ₹200/order$.

$C = ₹50/kg$ $C_h = 0.1/kg/day = 36.5/kg$

$$Q^* = \sqrt{\frac{2 \times 14600 \times 200}{36.5}} = 400 kg$$ Ans

(ii) $D = 40 kg/day \times 30 day = 1200 kg$.

$C_h = 0.1/kg/day = ₹3/kg/month$.

Current policy $TIC = \frac{D}{Q} \times C_o + \frac{Q}{2} \times C_h$

$= \frac{1200}{200} \times 200 + \frac{200}{2} \times 3 = 1500$.

According to EOQ

$TIC = \frac{1200}{400} \times 200 + \frac{400}{2} \times 3 = 1200/-$

$TIC_{at\ 400}$

So Amount of saving / month

$= 1500 - 1200 = 300/-$ Rs

TDC D = 14600 kg/year.

$C_h = 0.1/kg/day = 0.1 \times 365 = Rs\ 36.5/kg/year.$

Annually $TIC_{at\ 200} = \frac{14600}{200} \times 200 + \frac{200}{2} \times 36.5$

$= Rs\ 18250/-$

Annually $TIC_{at\ 400} = \frac{14600}{400} \times 200 + \frac{400}{2} \times 36.5$

$= Rs\ 14600/-$

Annual saving $= TIC|_{at\ 200} - TIC|_{at\ 400}$

$= 18250 - 14600$

$= Rs\ 3650/-$ (Ans

(iii) ROL = d × LT

$= 40 \times 13 = 520\ kg.$

$T^* = \frac{Q^*}{d} = \frac{400}{40} = 10\ days$

LT = 13 days, $T^* = 10\ day$

ELT = 13 - 10 = 3 days.

ROL = 3 × 40 = 120 kg. Ans

ELT × D

Q] Calculate the EOQ from the following information. Also state the number of order to be placed in a year.

Consumption of material per Annum = 10,000 kg.

order placing cost per order - ₹50

(c) Cost per kg of raw material - ₹2

storage cost - 8% on average inventory.

Soln

$$EOQ = \sqrt{\frac{2DC_o}{C_h}}$$

D = Annually demand of inventory = 10,000 kg

C_o = Ordering cost per order = ₹50

C_h = holding cost one unit for one year = 8% × 2 = Rs 0.16

$$EOQ = \sqrt{\frac{2 \times 10000 \times 50}{0.16}}$$

EOQ = 2500 kg Ans

Number of order to be placed in a year.

$$= \frac{\text{Total consumption of material per Annum}}{EOQ}$$

$$= \frac{10,000}{2500} = 4 \text{ order per year}$$

Q) From the following information Calculate EOQ No. of order and time between two consecutive order's

consumption — 300 units per quarter.

cost per unit — Rs. 40

cost of processing an order — Rs. 600

Obsolescence — 15%

Insurance on Inventory — 25%

} 40%

Sol) D = 300 units × 4 = 1200 units per annum.

C = ₹40/unit C_h = 40 × 40% = ₹16

C_o = ₹600/order

a) $EOQ = \sqrt{\frac{2DC_o}{C_h}} = \sqrt{\frac{2 \times 1200 \times 600}{16}} = 300$ units. Ans

b) No. of order/year = $\frac{1200}{300}$ = 4 order/year Ans

c) Time between consecutive order = $\frac{12 \text{ month}}{\text{no. of order}}$

= $\frac{12}{4}$ = 3 month Ans

Q) From the following information calculate Re-order level, Minimum stock level & maximum stock level. Monthly demand - 1000 units, Annual carrying cost Rs. 15, cost of placing an order Rs 100, Normal usage 50 units per week, Maximum usage 75 units per week, Minimum usage 25 units per week & Re-order period 4 to 6 week. (1 year = 52 week)

Average (normal) re order period = $\frac{4+6}{2}$ = 5 week

Soln

$D = 1000 \times 12 = 12000$ units / year.

$C_h = Rs.15$, $C_o = Rs\ 100$

$$EOQ = \sqrt{\frac{2DC_o}{C_h}} = \sqrt{\frac{2 \times 12000 \times 100}{15}} = 400 \text{ units.}$$

(Re-ordering Qty)

(ii) Re-order level (ROL) = Maximum usage × Max. Re-order period

$= 75 \times 6 = 450$ units.

(iii) Minimum level = ROL − (Normal usage × Average re-order period)

$= 450 - (50 \times 5) = 200$ units.

(iv) Maximum level = ROL + Re-order Quantity − (Min. usage × min. re-order period)

$= 450 + 400 - (25 \times 4)$

$= 750$ units.

Q] Explain briefly about EOQ. Given that

Annual usage 'D' = 60 units.

procurement cost 'Co' = Rs 15/- per order.

cost purchase one unite 'C' = Rs 100/-

cost of carrying I, a percentage including Expenditure of obsolescense, taxes, Insurance, deterioration, etc = 10%.

Calculate EOQ:

Sol" $D = 60$ units.

C_o = Rs 15/- per order.

C = Rs 100/-

C_h = 0.1 × 100 = Rs 10/- per unit per year.

$$EOQ = \sqrt{\frac{2DC_o}{C_h}} = \sqrt{\frac{2 \times 60 \times 15}{10}} = 13.41 \text{ units}$$

No. of order per year = $\frac{60}{13.41} = 4.47$ say 5 order/year.

Time between consecutive order = $\frac{12 \text{ month}}{5}$

= 2.4 say 3.

4

Q) Calculate EOQ.

(i) Annual usage = 80 units.

(ii) Procurement cost = Rs 20/order.

(iii) Cost per 10 pieces = Rs 1000

(iv) Cost of carrying inventory = 16%.

What is cycle time?

Sol" $D = 80$ units

C_o = Rs 20 per order.

C = Rs $\frac{1000}{10}$ = Rs 100

$C_h = \frac{16}{100} \times 100$ = Rs 16/units/year.

$$EOQ = \sqrt{\frac{2DC_o}{C_h}} = \sqrt{\frac{2 \times 80 \times 20}{16}} = 14.14 \text{ units.}$$

No. of order per year = $\frac{80}{14.14} = 5.65$ say 6 order/year.

Cycle time or time between two consecutive order.

= $\frac{12 \text{ month}}{6}$ = 2 months.

Note

1. Lot for lot prodⁿ :-

In this method, lot size for a batch is selected to satisfy the requirement for a single period. This method is preffered where the setup cost is very less compared to holding cost.

2. Least cost technique :-

In this method we search out different combination in such a manner that summation of ordering and holding cost should be minimum.

3. Part period total cost Balancing :-

In this method H.C. and setup cost are balanced as closely as possible for each lot size. The target is to find out a lot size near to EOQ.

Inventory classification & control :-

1. ABC control or Always better control :-

(Pareto law or 80-20 law)

	Usage %	Item %
A	50-60%	10-20%
B	30-40%	30-40%
C	10-20%	50-60%

Usage value - purchase cost.

item	item%	Demand(D)	Unit price(c)	Usage value (Dc)	Usage %	Let usage %
1	10%	200	80	16000	$\left(\frac{16000}{\Sigma x}\right)\times 100$	32%
2	10%	70	60	4200	$\left(\frac{4200}{\Sigma x}\right)\times 100$	8%
3	10%	300	200	60,000	$\left(\frac{60}{\Sigma x}\right)\times 100$	60%
10	100%			Σx	100%	

A

B

C

Arrange this column % wise in descending order.

In ABC control inventory items are classified into A, B & C category depending upon their usage value. For A category items inventory is kept almost nil & frequent review is done. On the other hand for 'C' category items large amount of inventory is kept & it is reviewed after a long period.

A — safety stock — Low or very low S.S.

2. VED (Vital Essential and Desirable)
Raw material | Lubricating oil | stationary, cotton etc

Inventories are classified on basis of importance of inventory for the prod^n system.

3. HML (High medium Low) : C (Rs/unit)
Inventories are classified on the basis of unit price of inventorys.

4. SDE (scare difficult and Easy)
Inventories are classified on the basis of availability of inventory for the prod^n system.

5. XYZ Analysis :-
(Base on closing inventory value)

ABC Analysis :-
ABC Analysis divides inventories into three grouping in term of percentage of number of items and percentage of total value.

→ It is based on pareto Analysis.

→ In ABC analysis important item (high usage valued items) are grouped in 'A' while trivial item (low usage valued items) are grouped in 'C' & the remaining middle level items are considered 'B' items.

Category	% of item (approx.)	% value (approx.)
A	10%	70%
B	20%	20%
C	70%	10%

Q) Describe different types of overhead? / factory overhead / indirect cost?

Ans:- Overhead can be defined as the cost of indirect labour, indirect material and indirect expenses including services, It cannot be charged conveniently direct to cost of specific cost unit. This can be sub divided in to or classified in to five types.

(i) Production or Manufacturing overhead/ indirect cost
(ii) Administration overhead.
(iii) Selling overhead.
(iv) Distribution overhead.
(v) Reasearch & Development overhead.

(i) Production or Manufacturing overhead :- It includes the expenses from the receiving of order until its completion. like rent, insurance,

Ex:- (i) Building expanses.
lighting electricity.

(ii) Indirect labour :- i.e. Supervisour, expertise, Soft clerck or soft inspector, watchmen, maintanance staff.

(iii) Indirect material, i.e. water, fuel, Power,

(iv) Consumable atoms i.e Cotton waste, lubricant, (Grease)

(v) Depreciation, welfare, recreation and restrooms.

② Administration Overhead :-

It include expenses incurred in the direction control and administration of an enterprise.

Ex :- Salary and wages, legal cost, taxes, & bill (telephone bills, carrier bill etc), Bank charges, Audit fees,

③ Selling overhead :-

It include the expenses in order to maintain or increase the volume of sell.

Ex :- Advertisment, customer service, Service after sell, Salary or commision of agent, Sellsmen salary.

④ Distribution overhead :- It covers the expenses connected with transporting product to customer & storing them when required.

i.e. godown and ware house, cost of transporting goods, records keeping/maintaining.

⑤ Research & development overhead :-

It directly depends upon the employees effort.

Control can be defined as a process by means of which we observe that actual performance & compare it with some standard. If there is a deviation between the observed performance and the standard performance then it is necessary to take corrective action.

Inspection & Quality Control

Inspection :-

The act of checking weather a component or product perform certain required function or not is called inspection.

⇒ It checks the acceptability of the manufactured part or component.

⇒ It measures the quality of product or service in terms of predecided standard.

Quality :-

"Quality is a relative term, & it can explained with reference to the end users of the product."

"In general quality can be defined as the degree of customer satisfaction"

⇒ The quality depends on the perception of a person in a given situation.

Dimension of quality :- Quality depends upon these factors.

(i) performance
(ii) conformance
(iii) reliability - It should give efficient & consistent performance.
(iv) durability - It should have desired life.
(v) Aesthetic / outer looks - It should look attractive.
(vi) Special feature.
(vii) Maintainability.
(viii) Economical - It should have reasonable prices.
(ix) versatility - It should serve number of purpose.
(x) Grade.

Control :-

Control is a system for measuring and checking phenomenon / event. It suggest when to inspect how often to inspect and how much to inspect.

⇒ A feedback mechanism should be added which explore the cause of poor quality and takes corrective actions.

Types of Quality :- There are the three types of Quality
(i) Quality of Design.
(ii) Quality of conformance
(iii) Quality of performance.

(i) Quality of design :-
It means the intension of designer to include or exclude features in products or in services.
eg. Manufacturing sector - automobile,
Service sector - Railway, hotel, Banking.

(ii) Quality of conformance :-
It means how well the products or services meet the specification as determined by the designer.
eg. Manufacturing sector :- automobile features.
Service sector :- Hotel facility, Banking facilities.

(iii) Quality of performance :-
It is associated with reliability of product or services performing its needed under prescribed setup cond.
eg. Satisfy the product warranty, performance of all feature of product voltage stabiliser.

7) "The quality of performance is concerned with how well the manufactured product gives its performance. It depends up on
(a) Quality of Design (b) Quality of conform

Types of inspection :-

(i) Robing, process, patrolling or floor inspection, fixed inspection, key-point, final.

Robing inspection :-

⇒ The inspection officer walks around on the shop floor from m/c to m/c and check the work sample.

⇒ It helps in finding error during the process itself that is before the final product is ready to dispatch.

Fixed inspection :-

⇒ The work is brought at intervals for inspection officer to check.

⇒ It finds defects after the job has been completed

⇒ It is used when inspection equipments & tool cannot be brought on the shop floor.

⇒ It is a type of centralized inspection, the worker and inspection officer donot come in contact with each other, Thus it eliminates the chances of passing a doubtfull product.

Key point inspection :-

⇒ Every product has a key point in manufacturing process. (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 expenditure on poor or substandard parts which are likely to be rejected.

final inspection :-

Final inspection of the product may checks its appearance and performance.

→ Many destructive or and non-destructive inspection method are available for final inspection.

It may include Tensile testing, compressing testing, bending test, fatigue test, torsion test,

Non-destructive - Ultrasonic waves, magnetic flux test, X-ray.

Quality Control tools :-

These are used to improve the quality of product and improvement of service

H → Histogram

F → Flow chart

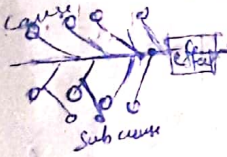
P → pareto chart. / 80-20 law.

C → Check sheet

S → Scattered diagram.

F → Fish bone diagram / cause effect diagram / Ishikawa diagram

used to find the root cause of problem



C → Control chart.

- Variable
- attribute.

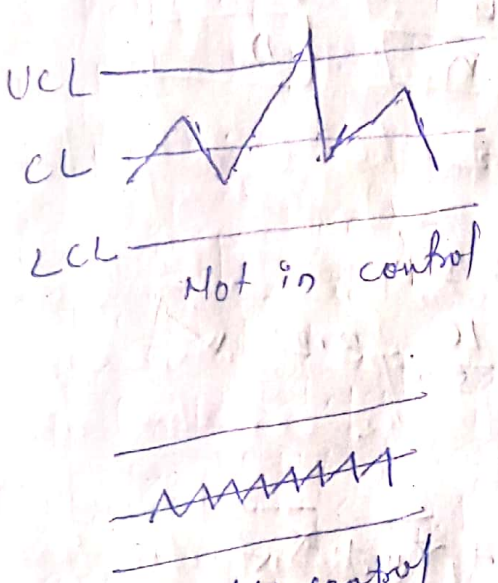
Control chart :-

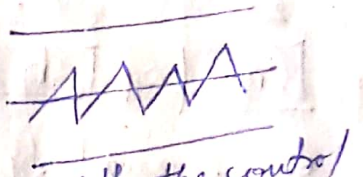
The primary purpose of the control chart is to predict expected product out come.

- out of control
- Upper CL
- control line (CL)
- LCL

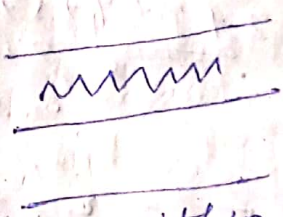
⇒ variable can be measured.
⇒ attribut can be counted.

Control chart graph are used to study how the process changes over time. Control chart variation can defined by normal distribution curve, Binomial distribution curve, poisson distribution curve.

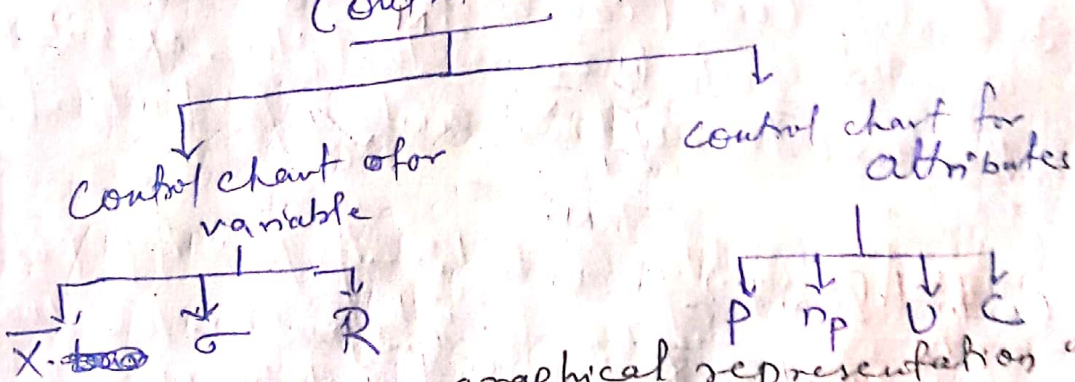



within the control centered stable

within the control centered more stable


within the control limit more stable but not centred.

Types of control chart:-



Note

A control chart is a graphical representation of the collected information. The information may pertain to measured quality characteristics or judge quality characteristic of samples. It detects the variation in processing and warns if there is any departure from specific tolerence limit.

$\bar{X}$ Chart :- / Mean chart

It shows the centering of process

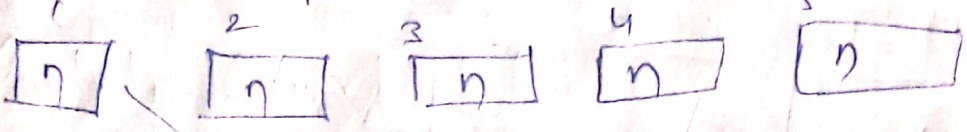
n = number of observation in each sample

$\bar{x}$ = Mean variation of each sample.

R = Range of variation of each sample.

$$R = Max - Min.$$

$\bar{\bar{X}}$ = Average of the averages.



n = 5 2, 3 4 5 2

$$R = 5 - 2 = 3$$

$$\bar{x}_1 = \frac{2+3+4+5+2}{5} = \frac{16}{5} = 3.2$$ ✓

$\bar{x}_2 =$

$$\bar{\bar{X}} = \frac{\bar{x}_1 + \bar{x}_2 + \bar{x}_3 + \bar{x}_4 + \bar{x}_5}{5}$$

$$\bar{\bar{X}} = \frac{\bar{x}_1 + \bar{x}_2 + \dots + \bar{x}_N}{N}$$

$$\bar{\bar{X}} = \frac{\sum_{i=1}^{N} \bar{x}_i}{N}$$ ✓

Control limits :-

$C.L = \bar{\bar{X}}$

for 3σ limit

$UCL = \bar{\bar{X}} + 3\sigma_{\bar{x}}$

$LCL = \bar{\bar{X}} - 3\sigma_{\bar{x}}$

for 2σ

$UCL = \bar{\bar{X}} + 2\frac{\sigma}{\sqrt{n}} = \bar{X} + 2\sigma_{\bar{x}}$

$LCL = \bar{\bar{X}} - 2\frac{\sigma}{\sqrt{n}} = \bar{X} - 2\sigma_{\bar{x}}$

~~For standard deviation.~~

σ = Universal standard deviation.

$\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}}$ = Control limits

$\sigma = \frac{\bar{R}}{d_2}$

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

[$\bar{x}$ = Average or mean chart
R = Range chart

$CL = \bar{\bar{x}}$

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

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

$\bar{R} = Max - Min$

$\bar{R} = \frac{R_1 + R_2 + \cdots + R_N}{N}$

2σ limit

$CL = \bar{\bar{x}}$

$UCL = \bar{\bar{x}} + 2\frac{\sigma}{\sqrt{n}}$

$LCL = \bar{\bar{x}} - 2\frac{\sigma}{\sqrt{n}}$

* A_1 & A_2 factor of $\bar{x}$ & R chart for LCL & UCL respectively.

Q) A drilling m/c has bore hole with mean diameter of 0.5230 cm & a standard deviation of 0.0031 cm. Calculate 2σ & 3σ limit for the mean sample of 4.

Soln $\bar{\bar{x}} = 0.5230$, $\sigma = 0.0031$, $n = 4$

For 2σ limit

$UCL = \bar{\bar{x}} + 2\frac{\sigma}{\sqrt{n}}$

$= 0.5230 + 2 \times \frac{0.0031}{\sqrt{4}}$

$= 0.5261$

$LCL = \bar{\bar{x}} - 2\frac{\sigma}{\sqrt{n}}$

$= 0.5230 - \frac{2 \times 0.0031}{\sqrt{4}} = 0.5199$

for 3σ limit

$$UCL = \bar{\bar{X}} + 3\sigma_{\bar{x}} = \bar{\bar{X}} + 3\frac{\sigma}{\sqrt{n}} = 0.5230 + 3\times\frac{0.003}{\sqrt{n}}$$

$$= 0.52765 \text{ A}$$

$$LCL = \bar{\bar{X}} - 3\times\frac{\sigma}{\sqrt{n}}$$

$$= 0.5230 - \frac{3\times 0.0031}{\sqrt{n}} = 0.51835 \text{ A}$$

Quality Control defination:-

The term quality Control has variety of meaning.

1. Quality Control is the process through which we measure the actual quality performance, compare it with the standards and take corrective action if there is a deviation.
2. It is a systematic control of various factors that affect the quality of the product. It depends on material, tools, machines, type of labour, working conditions, measuring instruments etc.
3. Quality Control can be defined as the entire collection of activities which ensures that the operation will produce the optimum quality products at minimum cost.

Total Quality Control:- As per AV Feigenbaum, An effective system for integrating the quality development, quality maintenance and quality improvement efforts of the various group in an organization, so as to enable production & services at the most economical levels which allow full customer satisfaction.

8) Calculate the control limit for $\bar{x}$ & R chart of the following data. Total no. of sample 10. $A = 1.342$, $A_1 = 1.596$, $A_2 = 0.577$, $D_1 = 0$, $D_2 = 4.928$, $D_3 = 0$, $D_4 = 2.115$.

SAMPLE NO	$\bar{x}$	R
01.	3290	560
02.	3180	410
03.	3350	200
04.	3470	300
05.	3080	90
06.	3240	650
07.	3260	890
08.	3310	410
09.	3640	1120
10.	4110	520
	$\bar{x} = 33930$	$R = 5150$

Sol?

$$CL = \bar{\bar{x}} = \frac{\Sigma \bar{x}}{N} = 3393.$$

~~$UCL = \bar{\bar{x}} + A_2 \bar{R}$~~

$$CL = \bar{R} = \frac{\Sigma R}{N} = 515.$$

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

$$= 3393 + (0.577 \times 515) = 3690.153.$$

$$LCL = \bar{\bar{x}} - A_1 \bar{R}$$

$$= 3393 - (1.596 \times 515) = 2571.06.$$

Control limit for R chart.

$CL = \bar{R} = 515$

$UCL = D_4 \times \bar{R} = 2.115 \times 515 = 1089.225$

$LCL = D_3 \times \bar{R} = 0 \times 515 = 0.$

'R chart (Range chart) :-

The R chart is used as a measure of sub group dispersion. The important of R chart depends on the type of production process.

→ The purpose of R chart & σ chart is the same but generally R chart is used instead of σ chart because of R is easier to compute, and R is easier to understand.

$R_1 = x_1^{max} - x_1^{min}$

= Range of variation of sample 1.

$R_2 = x_2^{max} - x_2^{min}$

= Range of variation of sample 2.

$R_N = x_N^{max} - x_N^{min}$

= Range of variation of sample N.

$$\bar{R} = \frac{R_1 + R_2 + \cdots + R_N}{N}$$

$CL = \bar{R}$

$UCL = D_4 \bar{R}$

$LCL = D_3 \bar{R}$

* D_3 & D_4 factor of R chart for LCL & UCL respectively.

D_3 & D_4 are constant & only depend on sample size.

Calculation procedure:-

1. Calculating the average $\bar{x}$ and range R for each of sub group.

If a sample contains 5 items whose dimensions are x_1, x_2, x_3, x_4 & x_5, the sample average

$$\bar{x} = \frac{x_1 + x_2 + x_3 + x_4 + x_5}{5}.$$

* The Range is computed by substracting the lowest value from the highest value.

[R = High value - Small value].

2. Calculating the grand average $\bar{\bar{x}}$ and average rang $\bar{R}$.

$\bar{\bar{x}}$ is the average of the $\bar{x}$ value for each sub-group or average of average.

$$\bar{\bar{x}} = \frac{\Sigma \bar{x}}{N}.$$

$$\bar{R} = \frac{\Sigma R}{N}.$$

3. Calculation of 3 sigma limits on control chart for $\bar{x}$ chart.

Table B, C, D and E of Appendix may be used to obtain the relevant factor like A, A_1, A_2, D_1, D_2, D_3 and D_4 for a particular sample size, According to the method used.

If Table B is to be used, the next step is to estimate σ'. For table B, find the value of factor D_2 for a particular sample size, then

$$\sigma' = \frac{\bar{R}}{d_2} \quad = d_2 = 2.059 \text{ for subgroup of 4 part}$$

Now, $3\sigma_{\bar{x}}$ can be calculated from the relationship

$$\sigma_{\bar{x}} = \frac{\sigma'}{\sqrt{n}}$$

$$UCL = \bar{\bar{X}} + 3\sigma_{\bar{x}}$$

$$LCL = \bar{\bar{X}} - 3\sigma_{\bar{x}}$$

The formulas for 3 sigma control limit on chart for $\bar{x}$ then become.

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

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

$$\bar{\sigma} = \frac{\Sigma\sigma}{M}$$

The formulas for 3-sigma control limit using factor A_1 are

$$UCL = \bar{\bar{X}} + A_1\bar{\sigma}$$

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

$UCL_{\bar{x}} = \bar{\bar{x}} + A\sigma'$

$LCL_{\bar{x}} = \bar{\bar{x}} - A\sigma'$

1. Calculate the control limit for R chart :-

$UCL_R = D_4 \bar{R}$ | $UCL_R = D_2 \sigma''$

$LCL_R = D_3 \bar{R}$ | $LCL_R = D_1 \sigma'$

P-chart :-

⇒ P chart is an attribute control chart.

P-chart is use for fraction defective.

⇒ Fraction defective may be defined as the ratio of the no. of defective article or no. of defect in any inspection to the total no. of article or sample size actually inspected. It is always express in decimal fraction.

⇒ The cost of colleting the data for P chart is less than the cost of colleting the data for $\bar{x}$ and R chart.

⇒ P chart is best suited in cases where inspection is carried out with a view to classifying an article as accepted or rejected. $\bar{x}$ & R chart does best suited for critical dimension.

Control limit (3σ limit) on P chart :-

Sample	n	d	P
1	n_1	d_1	$P_1 = \frac{d_1}{n_1}$
2	n_2	d_2	$P_2 = \frac{d_2}{n_2}$
⋮	⋮	⋮	⋮
N	n_N	d_N	$P_N = \frac{d_N}{n_N}$

n = size of sample

d = no. of defect or no. of defect unit

p = fraction defective.

$$\bar{p} = \frac{p_1 + p_2 + p_3 + \cdots + p_N}{N}$$

Sample is not same $n_1 \neq n_2 \neq n_3 \neq \cdots$ in p chart.

$$UCL = \bar{p} + 3\sigma_{\bar{p}}$$

$$LCL = \bar{p} - 3\sigma_{\bar{p}}$$

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

$$\bar{n} = \frac{n_1 + n_2 + n_3 + \cdots + n_N}{N}$$

$\bar{n}$ = Average of sample size.

np chart :-

It is the special case of p-chart where the sample size is constant.

3σ limit :-

$$\bar{p} = \frac{\sum np}{\sum n}$$

$$CL = \overline{np} = \bar{n}\bar{p} = n\bar{p}$$

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

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

2σ limit

$$CL = \overline{np} = \bar{n}\bar{p} = n\bar{p}$$

$$UCL = n\bar{p} + 2\sqrt{n\bar{p}(1-\bar{p})}$$

$$LCL = n\bar{p} - 2\sqrt{n\bar{p}(1-\bar{p})}$$

$$\sigma = \sqrt{np(1-p)}$$

p. fraction defective for each subgroup.

$$p = \frac{\text{Number of defective in subgroup}}{\text{Number inspected in subgroup}}$$

$$p = \frac{np}{n}$$

A manufacturer find on his experiment that on an average 1 out of 10 items produce by a m/c is defective on a particular day. He select a lot of 100 & find them 18 of them are defective. Find the control limit for p-chart & find weather the process is within the control limit or not?

$$\bar{p} = \frac{d}{n} = \frac{1}{10} = 0.1$$

$$\bar{p} = \frac{d}{n} = \frac{1}{10} = 0.1$$

avg of sample size $= \bar{n} = 100$

control limit $= \bar{p} = 0.1$

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

$$= 0.1 + 3\sqrt{\frac{0.1(1-0.1)}{100}} = 0.19$$

$$LCL = \bar{p} - 3\sigma_{\bar{p}}$$

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

$$= 0.1 - 3\sqrt{\frac{0.1(1-0.1)}{100}} = 0.01$$

C- chart :-

It follows the Poisson distribution it used to compute or calculate number of defects.

Control limit :-

$$\left.\begin{aligned} C.L &= \bar{c} \\ UCL &= \bar{c} + 3\sqrt{\bar{c}} \\ LCL &= \bar{c} - 3\sqrt{\bar{c}} \end{aligned}\right\} 3\sigma$$

$$\left.\begin{aligned} C.L &= \bar{c} \\ UCL &= \bar{c} + 2\sqrt{\bar{c}} \\ LCL &= \bar{c} - 2\sqrt{\bar{c}} \end{aligned}\right\} 2\sigma.$$

$\bar{c}$ = centre line = $\frac{\text{Number of defect in all sample}}{\text{Total number of sample}}$

Sampling :-

It is a technique in which a sample is drawn at random & on the basis of this random sample, it is decided to accept or reject, the lot.

There are mainly two types of inspection
(i) 100% inspection (ii) Sampling inspection

100% inspection :-

In 100% inspection all the parts or products are subjected to inspection.

→ Generally if is expensive & can't used when the product is destroyed when inspection. (destructive testing method)

sample inspection :-

whereas in sampling inspection only a sample is drawn from the lot and inspected.

→ A sample may be defined as the number of items drawn from a lot, batch or population for inspection purpose.

N = lot size, n = sample size

c = acceptance number, d = no. of defect.

If $d \leq c$ accept the lot

If $d > c$ reject the lot.

Sampling plan :-

The most important element of acceptance sampling is choosing a appropriate sampling plan that is specify lot size, sample size, number of sample, & acceptance & rejection criteria.

Types

1. Single sampling plan
2. Double sampling plan
3. Multiple sampling plan.

Single sampling plan :-

When a decision on acceptance or rejection of the lot is made on the basis of only one sample, the acceptance plan is known as a single sampling plan.

Inspect a sample of n pieces.

↓

If number of defective.

↳ $d \leq c$ → Accept the lot

↳ $d > c$ → Reject the lot.

Double sampling plan :-

In double sampling plan the decision on acceptance or rejection of the lot is based on two sample. A lot may be accepted at once if the first sample is good enough or rejected at once if the first sample is bad enough. If the first sample is neither good enough nor bad enough, the decision is based on the evidence of first and second sample combined.

N = lot size.

n_1 = number of piece in the first sample

n_2 = " " " second sample.

$n_1 + n_2$ = number of pieces in the two sample combined.

d_1 = number of defect in 1st sample

d_2 = " " in 2nd sample.

$d_1 \leq c_1$ accept the lot

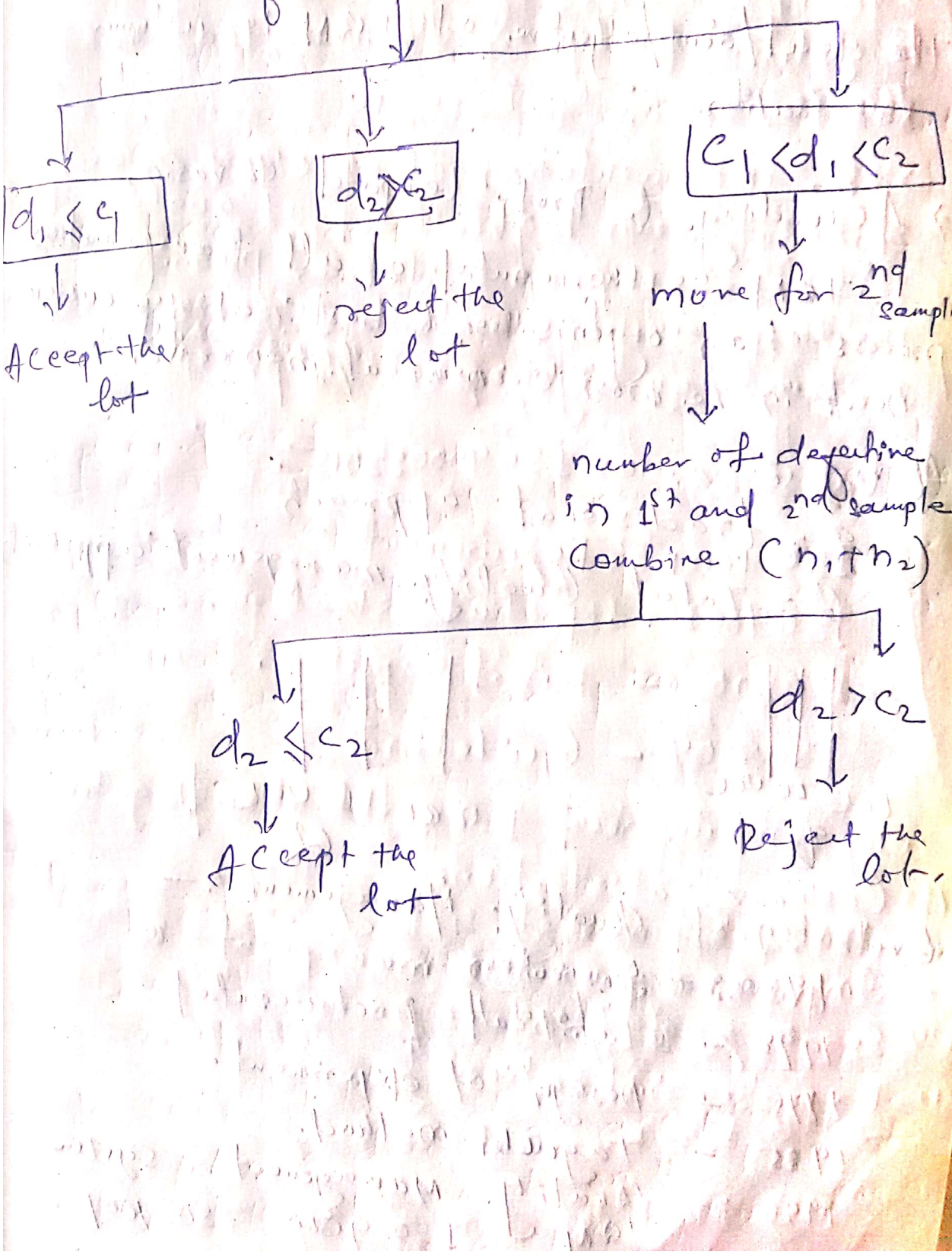
$d_2 > c_2$ reject the lot.

c_1 = acceptance number for the 1st sample
c_2 = acceptance number for the two sample combined.

Inspect n_1 pieces (N)

↓

If the number of defective (n_1)



Quality Management system

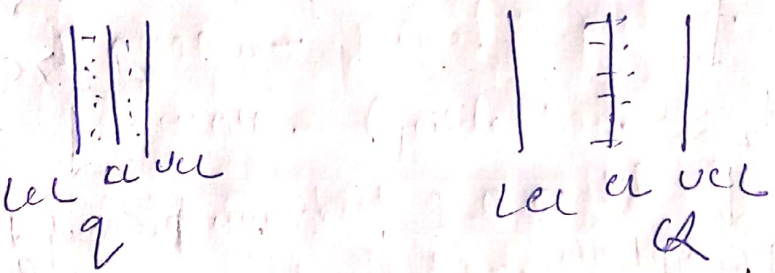
Ch-6

Total Quality Management (TQM) :-

TQM is a culture not a programme. It is not the collection of tools & technique The goal/aim/objective of TQM is customer satisfaction.

→ According to Prof Leopald S. Vasin,
"TQM is the control of all transformation process of an organisation to best satisfy customer needs in the most economical manner."

Q vs Q :
Q = traditional approach
Q = Total Quality management approach



Evaluation of Quality Management :-
1930 :- Inspection
1940 - statistical process control
1975 - Design of experiment.
1985 - Taguchi method.
1995 :- Quality Management System TQM ISO 9000, ISO 9001
2000 :- Six sigma (σ)

principle of TQM :-

(i) Leadership
(ii) Customer focused organisation.
(iii) Involvement of peoples.
(iv) Process improvement.
(v) System approach to management.
(vi) Continious improvement, Kaizen
(vii) Factual approach to decision making.
(viii) Mutually benificial supplier relation-ship.

ISO (International Standard organisation) :-

It is founded in 23rd feb 1947, headquater Genera, Switzerland. The main objative of ISO is to acheive, to maintain and continiously improve the product quality & also improve the quality of operation.

What is of ISO Certificate?

(i) First party :- A firm can audit itself.
(ii) Second party :- A customer can audit.
(iii) Third party :- A certifying agency can audit.

ISO 9000 Series:—

It is series of quality management

1979 → BSI → proposal

In 1987 first edition of ISO 9000 was published based on UK and canadian standard. It is a management methodology adopted by a company to deliver product & services that need the customer satisfaction.

→ The implementation of ISO 9000 award doesnot mean higher level of quality but it forces a company to deliver product as per the required standard. ISO 9000 series are based on eight quality management pricple.

→ Latest version ISO 9000 : 2015.

ISO 9001 — Requirement

ISO 9002 :- product standard.

ISO 9003 — Final inspection.

ISO 9004 — Guideline.

Why company need ISO certification & Registration

(i) Customer satisfaction.

(ii) Interglobal market.

(iii) Improve organisation management

(iv) Service quality of the product.

(v) Exporting internationally.

This ISO 9000 series are based on eight quality management principles (QMP).

1. Customer focus :-
Organization depend on their customers and therefore should understand current and future customer needs, should meet customer requirement & strive to exceed customer expectations.

2. Leadership :-
Organizations succeed when leaders establish and maintain the internal environment in which employees can become fully involved in achieving the organization's unified objectives.

3. Engagement of people :-
People at all levels are the essence of an organization and their full involvement enables their abilities to be used for the organization's benefit.

4. Process Approach :-
A desired result is achieved more efficiently when activities and related resources are managed as a process.

5. Improvement :-
Improvement of the organization's overall performance should be a permanent objective of the organization.

6. Evidence based decision making :-
Effective decisions are based on the analysis of data & information.

7. Relationship management :-
Develop mutually beneficial relationships with suppliers.

(2) System approach to management :-

Organization sustain success when process are managed as one coherent quality management system.

ISO 14000 :-

ISO 14000 is defined as a series of international environmental management standards, guides, and technical report. The standards policy specify requirements for establishing an environmental management policy, determining environmental impact of products or services.

→ The primary objective of the ISO 14000 series of standards is to promote effective environmental management system in organizations.

→ ISO 14000 certification is optional, not required.

→ In 1996, the international organization for standardization (ISO) created the ISO 14000 family of standards.

→ ISO 14000 - based on British Standard instituted in 1992

→ ISO 14000 deal with how a company manage the environment inside the facility & immediate outside the facility or company.

→ ISO 14001 revised in 2004.

→ ~~ISO 14001~~ The current version of ISO 14001 Published in 2015.

TQM (Total Quality Management)

In order to make business excellency in the present scenario, it calls for continuously changing process/method/procedure that makes the goods/services delighting to customers. TQM is that management philosophy which create such organization. Total Quality Control (TQC) is only limited to manufacturing department.

Definition

TQM is an integrated organizational approach in delighting customers (both external and internal) by meeting their expectation on a continuous basis through everyone involved with the organization working on continuous improvement basis in all products/processed along with proper problem-solving methodology. In other words, TQM means activities involving everyone (management persons & workers) in a totally integrated effort towards improving performance at every level. Improved performance means: Quality, cost, manpower development, quality of work life etc. It leads to increased customer and employee satisfaction. In short, the definition implies – continuously meeting customers requirement at the lowest cost by utilizing the potential of all employees. Hence TQM can also be called as = Continuous Quality Improvement (CQI).

Why TQM?

The reasons are:

1. Commitment to customers.
2. Improved productivity and quality.
3. Reduced cost.
4. Improved company's image.
5. Increased employees participation.

Principles of TQM

1. Agree with customers requirement.
2. Understand customers/suppliers.
3. Do the right things.
4. Do things right first time.
5. Various measures/action for success.
6. Continuous improvement is the goal.
7. Training is essential.
8. Better communication skills.

TQM should become a way of life. Once started, it is never ending. Continuous improvement is the goal. The top management should demonstrate their commitment to the subordinate consistently so that remaining members of the organization can

follow it. Total means really total. TQM is a process of habitual improvement, where control is embedded within and is driven by the culture of organization.

Where applicable?

TQM is applicable to all functions/organization

Sl. no	TQM approach	Traditional approach
1	No workers, no managers, only facilitators and team members	Blue collar employees – workers white collar employees– managers
2	Employees can voluntarily participate to look after various problems and take the pride of solving the problems.	Workers participation is legislated and take part at the time of bargaining (for money & other facilities).
3	Employee mostly focuses of organizational needs especially meeting the customers requirements.	Workers/managers focuses mostly on their needs.
4	Integrated co-operative (family like) working culture.	Conflict, win/loss style.
5	Open-ness, trust and respect is observed.	Secretive, distrust and hatred culture.
6	Here everyone is given importance	Here only top managers (decision makers) are given importance.

TQM philosophy was implemented in every organization after 1970. From this time the boss & servant culture has been changed to friendly (family like) working environment.

Just in Time (JIT)

The Just In Time production concept was first implemented in Japan around 1970's to eliminate waste of

- Materials
- Capital
- Manpower
- Inventory

Throughout manufacturing system

The JIT concept has the following objectives

- Receives raw materials just in time to be used.
- Produce part just in time to be used in subassemblies.
- Produce subassemblies just in time to be assembled into finished products.
- Produce and deliver finished products just in time to be sold.

In order to achieve these objectives, every point in the organization, where buffer stocks normally occur are identified. Then critical examination of the reason for such stocks are made.

A set of possible reasons for maintaining high stock is listed below.

- Unreliable/unpredicted deliveries.
- Poor qualities from suppliers.
- Increased varieties of materials.
- Machine break down.
- Labour absenteeism.
- Frequent machine setting.
- Variation in operators' capabilities.
- Schedule changes.
- Changing product modification.

In traditional manufacturing, the parts are made in batches, placed in the stock of finished product and used whenever necessary. This approach is known as "push system". Which means that parts are made according to schedule and are kept in inventory to be used as and when they are needed.

In contrast, Just in Time is a "pull system" which means that parts are produced in accordance with the order. It means the rate at which the products come out at the end of final assembly matches with the order quantity for that product. There no stock piles within the production process. This is also called zero inventory, stockless production, demand scheduling. Moreover, parts are inspected by the workers as they are manufactured. And this process of inspection takes a very short period. As a result of which workers can maintain continuous production control immediately identifying defective parts and reducing process variation. Therefore, the JIT system ensures quality products. Extra work involved in stockpiling parts are eliminated.

Advantages of JIT: -

1. Exact delivery schedule is possible with JT practices.
2. Quality of product is improved.
3. Lower defect rate = lower inspection cost.
4. Lower – raw material inventory - In process inventory - Finished product inventory Resulting lower product cost.
5. Satisfy customer without delay in delivery.
6. JIT helps in effective communication and reduce waste.
7. Less shop floor space in required.
8. Employees morale is high due to effective working environment.
9. JIT reduces scrap.
10. JIT reduces rework.

ISO

International Organisation for Standardisation

It is founded in 23rd Feb, 1947

Headquarter :- Geneva, Switzerland

National member : 162

Main objective : The main objective of ISO is to achieve, to maintain and continuously improve the product quality and also improve the quality of operation.

ISO has 3 types of membership category.

1. Member body :—

Member body are the national body ~~can represents~~ consider the most representative body in each country. These are the only member of ISO that have voting rights.

2. Correspondent member :—

Correspondent member are the country that do not have their own standard organisation. These member are informed about the ISO work but do not part in the standard changes.

3. Subscriber member :—

Subscriber member are the country with ~~soon~~ small economy. They pay reduced membership fee but can follow the development of standards.

→ India is member body ~~now~~ of ISO.

Parties of ISO Certificate :-

1. 1st party - A firm itself can audit
2. 2nd party - A customer can audit
3. 3rd party - A certifying agency ~~to~~ serve as auditar

ISO 9000 Series :-

- ISO 9000 series of quality management.
- In 1979 (BSI)
  - ↓
  - British Standard Institute → Submit a formal proposal to I.S.O.
  - 1987: First edition of ISO 9000 was published
    - ↓
    - Based on U.K. & ~~Canad~~ Canadian standard.

↗ It is a management methodology adopted by a company to deliver product & services that meet the customer satisfaction.

↗ The implementation of ISO 9000 award does not mean higher level of quality but it forces a company to deliver product as per the requirement.

Why Company need ISO registration ?

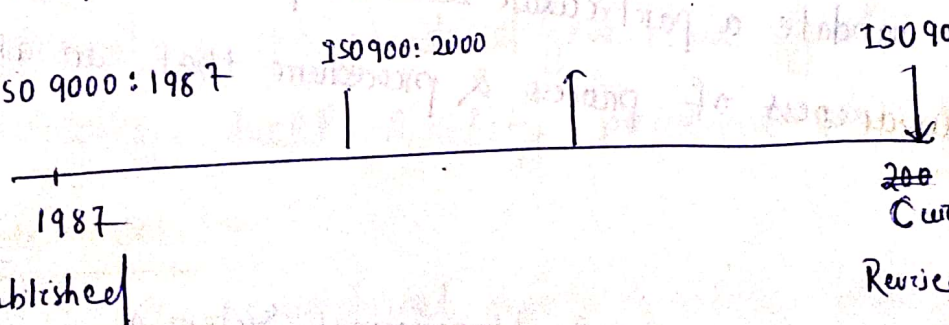
i) Customer satisfaction.
ii) Enter global market
iii) Improved organisation management
iv) Product service quality
v) Exporting internationally

Note :-

ISO 9000 series are based on eight quality management principle.

Current version of ISO 9000 :-

ISO 9000 : 2015.



ISO 9001 → Requirement → Current version :- ISO 9001 : 2015
ISO 9002 → Product standard ↓ Published sept. 2015
ISO 9003 → Final inspection
ISO 9004 → Guideline

ISO 14000 :-

Series of Environmental Management.

ISO 9000 - Quality
ISO 14000 - Environment

↗ ISO 14000 provide standard in 3 major areas.

1. Management system :-
System development and integration of environmental responsibility into the business planning.

2. Operation system :-
It is about consumption natural resources and energy.

3. Environmental System :-
It is about measuring and managing emission and other wastage.

ISO 14000 :- based on british standard
↓
Instituted in 1992

↗ ISO 14000 deal with how a company manage the environment inside the facility and immediate outside the facility or company.

↗ ISO 14000 do not mandate a particular level of pollution or performance but forces on the awareness of process & procedure that can affect the environment.

ISO 14001

It is about EMS (Environmental Management System)

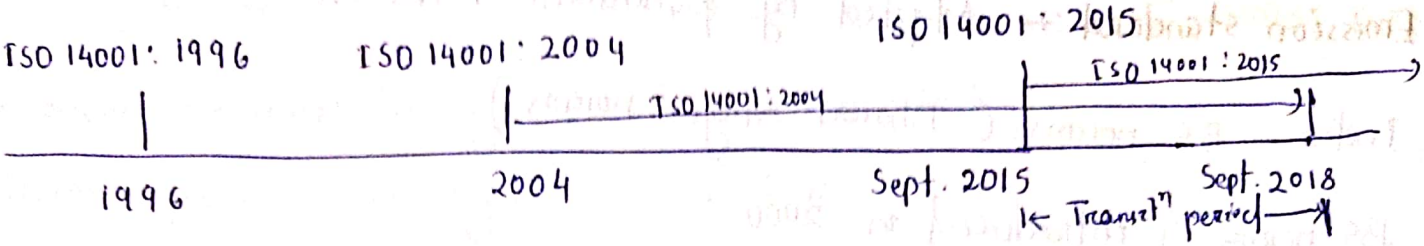
. It is main std. of 14000 series..

» It is first ~~launched~~ ~~lunch~~ published in 1996.

In 2016 - 20 year completion

Current version of ISO 14001 :—

ISO 14001 : 2015



ISO 14001 : 2004 is valid up to 2018

» Key changes in ISO 14001 : 2015 :~

» Digital documentation.
- Greater focus on leadership.
- Better communication.
- Better environmental performance

ISO 14004 → Guide line — 1st march 2016

↳ Current version : ISO 14004 : 2016

Six Sigma (6σ)

- It is a methodology & symbol of quality.
- It is a quality philosophy and the way of improving performance and by knowing where you are and where you can be.
- It is a purely scientific method used for process improvement and this method is known as DMAIC (Define Measure Analyse Improve Control).
- Main focus in quality improvement and reduction of defect, it's target to bring down the error rate to 3.4 DPMO (Defect Per Million Opportunities) or 3.4 EPMO (Error Per Million Opportunities).

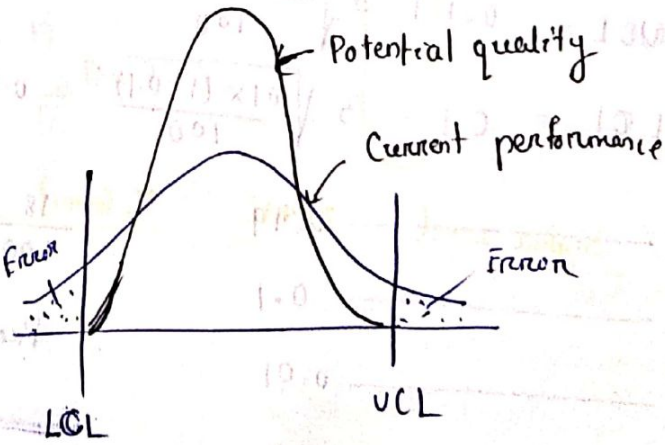
DPMO – For manufacturing sector
EPMO – For service providing sector.

Quality

Potential quality (PQ)
Or
Maxm quality
Or
Where you can be

$x \rightarrow \frac{y}{o/p}$.

Actual quality (AQ)
Or
Current performance
Or
Where you are



PQ - AQ = Defect or Error
⇓
Waste
⇓
To reduce waste
⇓
Six sigma

Six Sigma

Father of six sigma "Bill Smith".
⇓
An engineer in motorola company

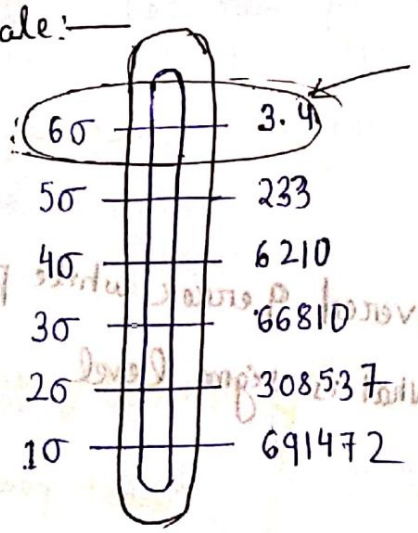
- In 1970 motorola started experimenting with problem solving through statistical analysis.
- In 1987 Motorola officially launch '6σ' programme and due to this motorola known worldwide as quality leader and profit leader.
- In 1988 Motorola won "Malcolm Baldrige National Quality Award" [MBNQA]. (Award of U.S.)
- 1991 :— Motorola certified it first Black belt.
- 1995 :— Six sigma (6σ) became well known after Mr. Jack Welch (CEO of G.E.) Manager of Century

Why sigma?

Sigma (σ) measures, how for a given process deviate from perfection.

Higher sigma capability, better performance

Sigma scale:—

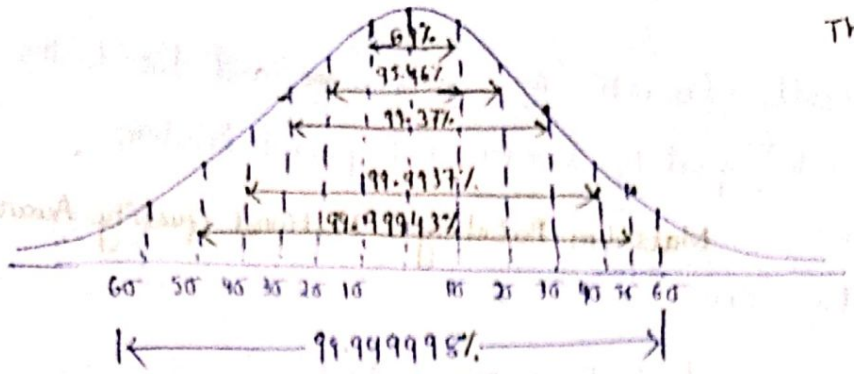


Sigma Level	DPMO	% Good
6σ	3.4	99.9997%
5σ	233	99.98%
4σ	6210	99.38%
3σ	66810	93.37%
2σ	308537	69%
1σ	691472	31%

% Good computation:

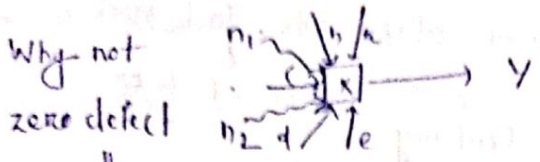
For 6σ.

$$\frac{1\times10^6 - 3.4}{1\times10^6}\times10^2$$



These % are from normal distribution curve func^n.

n = noise factor



noise factor which can't on very very difficult to handle.

Going for 7σ - huge task, more money investment

so 6σ is enough for profit & customer satisfaction.

$$DPMO = \frac{\text{no. of defect}}{\text{no of units produced}} \times 10^6$$

$$EPMO = \frac{\text{no. of error}}{\text{no. of customer served}} \times 10^6$$

Q/ In PNB during the last month discovered 9 error while processing 2000 statement. i) What is EPMO. ii) What is sigma level.

Ans:- $EPMO = \frac{9}{2000} \times 10^6 = 4500$

Sigma level → In between 4σ and 5σ

Do not scaling for 4500. It doesn't obey linear scale. It can be computed from normal distribution curve func^n.

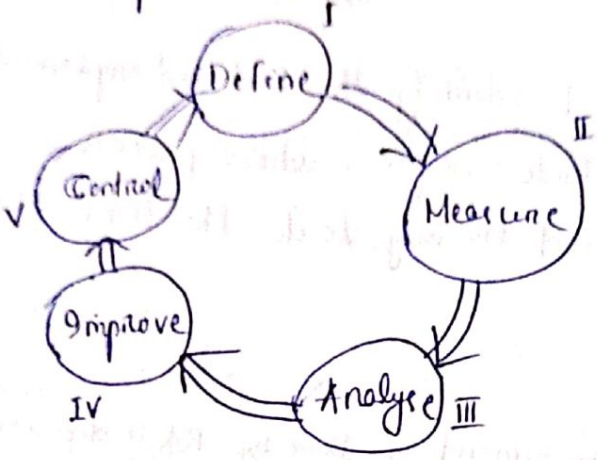
Six sigma Methodology:

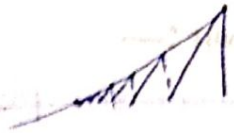
DMAIC:- (Define Measure Analyse Improve Control)

- It is a process improvement methodology.

It is used for the improvement of exiting process.

- It is used for improving, optimizing and stabilizing business process and design.
- It is a core tool which is used to drive '6σ' project.
- It is a logical & structured approach for problem solving and process improvement.
- It is a five step iterative process





DMAAV - For new process.

Define phase:- ——defined by VOC——→ VOC ——→ CTQ

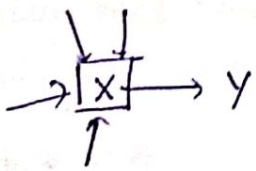
Target, goal — Voice of customer — Critical to Quality

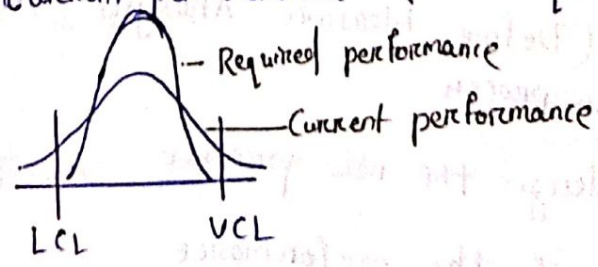
Project, project scope

Measure Phase:-

In this phase existing system or process is measured.

Identify the gap between current performance & the reqd. performance.

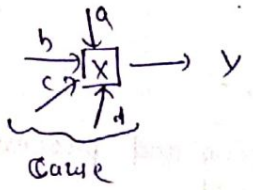


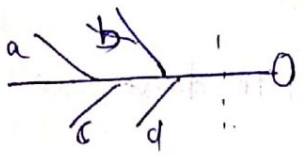


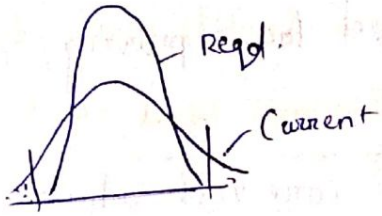
Analyse Phase:-

In this phase system is analysed to identify the way to eliminate the gap between current performance & required performance.

We use Fishbone diagram here.







* Fishbone diagram must be used in this phase
~> The main focus on the factor which has more effect on O/P.

Improve phase:—

The purpose of this phase is to identify the best and implement a solution to the problem whether in a factor or in a whole process.
On this phase team try to find the way to do the things cheaper, better and faster.

Tools: { Brainstorming
Six thinking hat -
DOE - Design of Experiment — Done by R&D department

Six thinking hat → White hat
↓
Six division
① White hat
② Red "
③ Black "
④ Yellow "
⑤ Green "
⑥ Blue "

Team name →

Control phase:—

The purpose of this phase is to control or sustain the ~~game~~ gain.

DMADV:~ (Define Measure Analysis Design Verify)

Used for new process

Design :— design the new process.

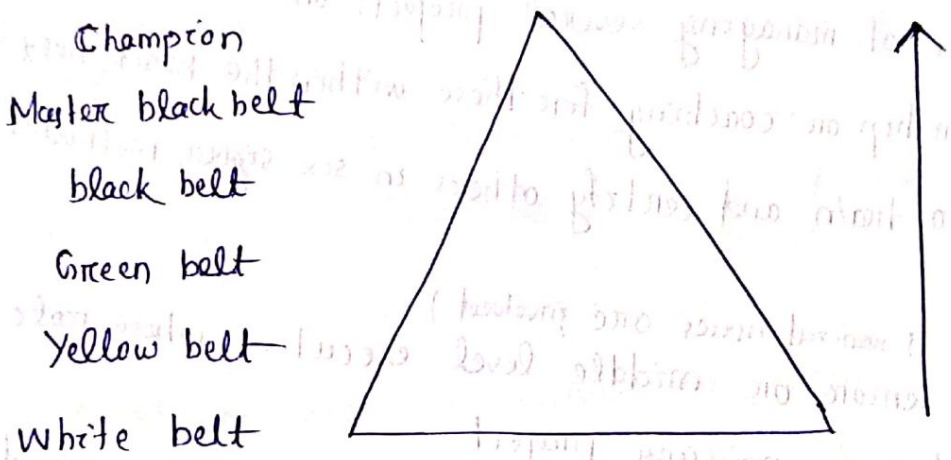
Verify :- Verify the performance.

It is used when we need to replace by new process rather simplifying the existing process.

Six Sigma Certification Program

Or, Different Level in Six Sigma :—

- Six sigma training and certificate levels are organised into a hierarchy of individual can achieve in six sigma.
- It is important for each certified six sigma proffessional to know his or her role and responsibility within an organisation.
- Lower level individual will report to higher level individual with their problem and higher level individual are responsible for monitoring the lower level individuals.



White belt :—

Yellow belt serve as a trainer on the basic overview of the six sigma.

Note :-

White belt is not fully recognised by the entire '6σ' community. Many consider yellow belt to be the lowest.

Yellow belt :—

- Having basic knowledge of '6σ' but does not lead any project on their own.
- Responsible for development of process map.
- Responsible for running small process improvement project using PDCA methodology.

Green belt :—

- Having enhanced problem solving skill on the DMAIC model.
- They can lead small scale improvement project with their respective area.
- They can be the project team member.

Black belt :—

- Having knowledge of '6σ' philosophy and principle.
- They have complex understanding of DMAIC and DMADV
- They can be the project team leader.

Master Black belt :—

- Having experience of managing several projects on 6σ.
- Offering mentorship or coaching for those within the black belt.
- They are able to train and certify others in six sigma methodology.

Champions :— (Financial issues are involved)

- Champions are senior or middle level executive whose role is choosing ~~of~~ and sponsoring any project.
- Champion is a person on the team who know the business inside & outside.

Dabbawala :— Indian Company.

- NMTBSA — Nutan Mumbai Tiffin Box Supplier Association.

2 lakh/day - pick. 60 Km. 3 hr. ₹200/- only per month

4 lakh/day - Transaction. 5000 employee. Use local train

8th grade employee company. independent of distance & size of lunch box

- Started in 1880
- 1956 — Registered as charitable trust
- Having world record in best time management
- Having name in Guiness ~~of~~ Book of World Record.
- 1 error in 16 million transaction
- Current President : Raghunath Medge
- Started by : Havaji Bachche

7S QUALITY SYSTEM

WHAT IS 5S?

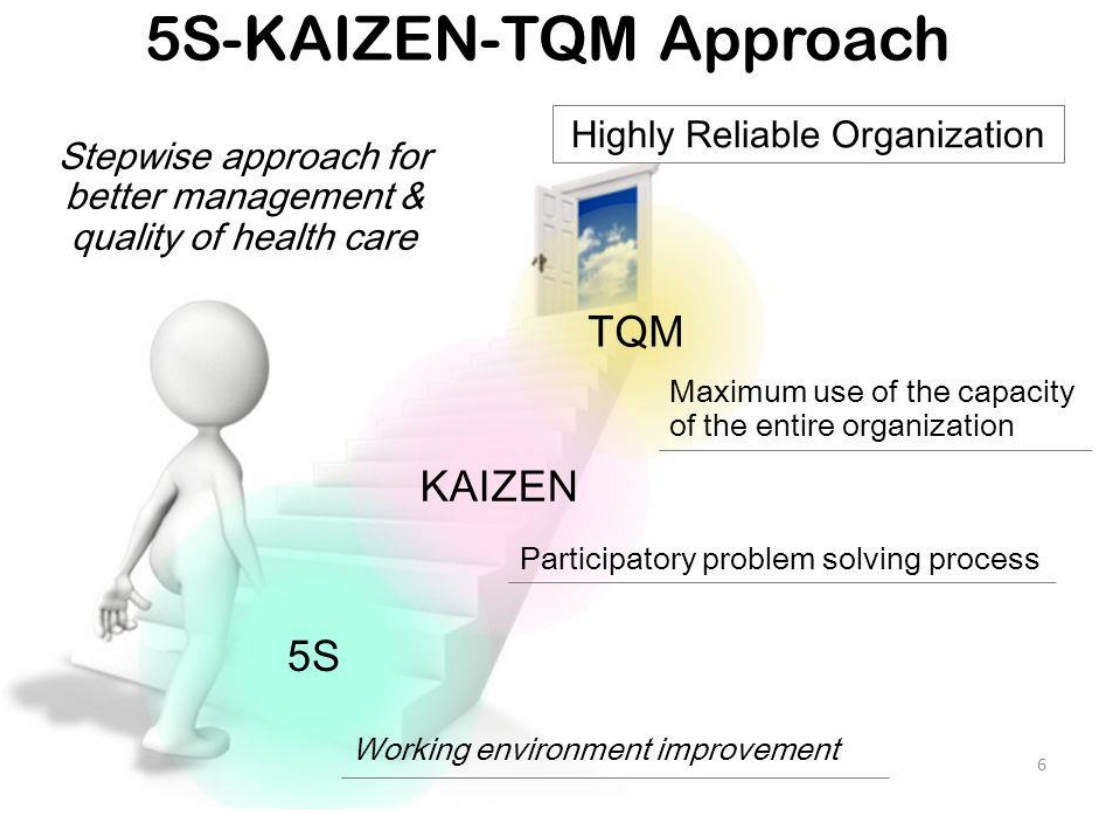
5S is a system for organizing spaces so work can be performed efficiently, effectively, and safely. This system focuses on putting everything where it belongs and keeping the workplace clean, which makes it easier for people to do their jobs without wasting time or risking injury.

It is one of the important tools of lean manufacturing.

The term 5S comes from 5 Japanese words which are translated into English.

BENEFITS OF 5S: -

- Reduced costs
- Higher quality
- Increased productivity
- Greater employee satisfaction
- A safer work environment



7S QUALITY: -

It is the extension of 5S model with the additional 2S i.e. Safety and Spirit.

Seven S (7S) methodology adopted for the workplace organization by eliminating or reducing Muda (Waste), Mura (Inconsistency) and Muri (Physical strain). The 7S implementation consists of seven phases i.e. Sort, set in order, Shine, Standardize, Sustain or Self Discipline, Safety and Spirit.

WARNING: - DO NOT MIX THE CONCEPT OF 7S QUALITY SYSTEM WITH McKinsey 7S Framework.

1. **Sort: -**

   This means distinguishing or sort out between wanted (Value Added) and unwanted (Non-Value Added) items at place of work and removal of unwanted (NVA) items.

   Outcomes-

   - Increase in floor space utilization.
   - Searching time of tools, materials, and papers is reduced.
   - Better flow of work.
   - Inventory cost of unnecessary items is reduced.

2. **Set in order: -**

   Arranging and labelling items in such a manner that they are easy to find and use.

   Outcomes-

   - Take things out and keep things back easily.
   - Make lesser mistakes.
   - Reduce searching time.
   - Work environment becomes safe.

3. **Shine: -**

   This means removing dirt, strain, filth, soot and dust from the work area. This includes cleaning and care for equipment and facilities and also inspecting them for abnormalities. In a way it also includes primary maintenance of equipment.

   Outcomes-

   - Work place becomes free of dirt and stains which is the starting point for quality.
   - Equipment lifespan will be prolonged and breakdowns will be less.
   - Creates a pleasant environment.
   - Prevents accidents.

4. **Standardise: -**

   This call for systematizing the above practices. This means ensuring that whatever cleanliness and orderliness is achieved should be maintained. This should develop a work structure that will support the new practices and turn them into habits.

The purpose of standardization is to make sure that everyone in the company follows the same procedure, the same names of items, the same size of signalization/floor marking, shapes, colours, etc. Standardize also helps to do the right thing the right way every time.

Outcomes-

- Activities will be simplified.
- Consistency in the work practices.
- Avoid mistakes.
- Better visual and transparency management work efficiency will improve.

5. Sustain or Self Discipline: -

Sustain also means ‘Discipline’. It denotes commitment to maintain orderliness and to practice first 3S as a way of life.

Outcomes-

- Promotes habit for complying with workplace rules and procedures.
- Creates healthy atmosphere and a good work place.
- Helps you to develop team work.
- Provides you with data for improving 5S.

6. Safety: -

Safety is the condition of being protected against physical, social, spiritual, financial, political, emotional, occupational, psychological, educational, or other types or consequences of failure, damage, error, accident, harm, or any other event that could be considered non-desirable.

Outcomes-

- Avoid errors or mistakes.
- Reduces accidents.
- Safer working environment.

7. Spirit(Team Spirit): -

Team spirit is a willingness to cooperate as part of a team.

Outcomes-

- Better communication.
- Higher confidence to do work.
- Better Understanding & Analysis on problems.
- Creates healthy working environment.
- Reduces boredom approach toward the job.

BENEFITS: -

• Workplace becomes cleaner, safer, well-organized and more pleasant;

• Floor space utilization is improved;

• Workflow becomes smoother and more systematic and non-value-added activities are reduced;

• Time for searching tools, materials and document is minimized;

• Machine breakdowns are reduced since clean and well-maintained equipment breaks down less frequently and it also becomes easier to diagnose and repair before breakdowns occur, therefore extending equipment life;

• Errors are minimized leading to making defect-free products;

• Consumables and material wastage are minimized;

• Morale and satisfaction of employees improve;

• Productivity of the organization improves together with the quality of products and services.

DISCUSSION: -

The general concept of the 7S is that they are intended to eliminate Muda (waste). The Lean Manufacturing (LM) focuses on the reduction of the wastages and the foundation tool of LM is Workplace organization. Working in disorder is neither productive, nor safe. 7S is a simple and practical method to build a quality culture at the work place. It is relatively easy to undertake, and requires minimal additional resources. The first and small investment made in time and effort pays off in a much bigger manner when the results are realized and maintained.

Only implementation of the 7S is not sufficient. Continuous monitoring and controlling the all 7S activities are also important and it can be monitored by conducting the questionnaire survey at regular interval. If the responses by the respondents are poor then it reflects the degradation of the workplace organization; then it should be improved. **7S** improves the organisation performance in terms of higher productivity, better quality, less accidents, clean, safe and healthier working environment.

LEAN MANUFACTURING

WHAT IS LEAN?

Lean is defined as a set of management practices to improve efficiency and effectiveness by eliminating waste. The core principle of lean is to reduce and eliminate non-value adding activities and waste.

WHAT IS WASTE?

Waste is defined as any activity that does not add value from the customer's perspective. According to research conducted by the Lean Enterprise Research Centre (LERC), fully 60% of production activities in a typical manufacturing operation are waste – they add no value at all for the customer.

Waste, or *Muda* in Japanese, is defined as the performance of unnecessary work as a result of errors, poor organization, or communication.

Quality professionals often debate whether or not there are seven or eight wastes of lean. The eighth waste of lean is unique from the original seven because its elimination can directly benefit the employees, as well as the employer.

The eight lean manufacturing Mudas can be remembered using the acronym **DOWNTIME**.

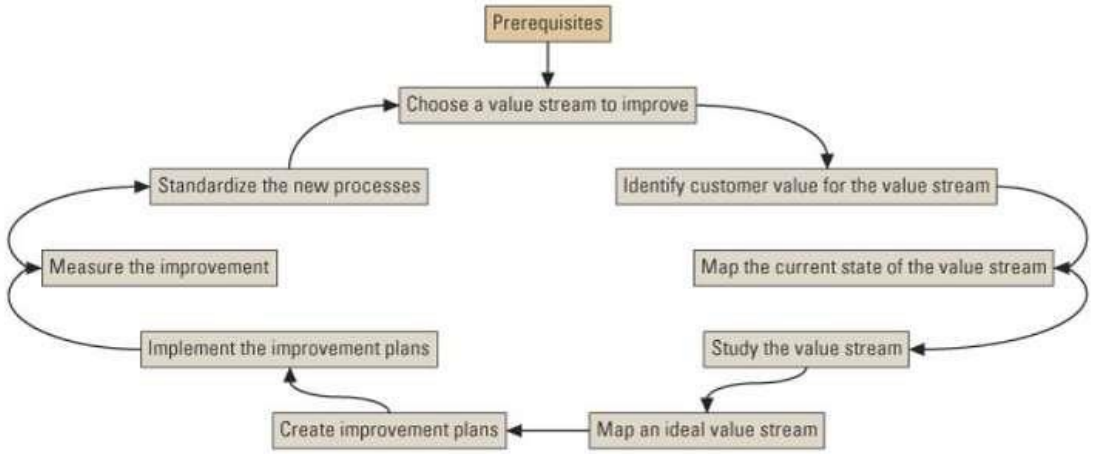
1. **D**efects
2. **O**verproduction
3. **W**aiting
4. **N**on-utilized talent
5. **T**ransportation
6. **I**nventory
7. **M**otion
8. **E**xtra-processing

But the good news is that just about every company has a tremendous opportunity to improve, using **Lean manufacturing** techniques and other manufacturing best practices. Techniques that enable you to deliver higher quality products at significantly lower costs.

WHAT IS LEAN MANUFACTURING?

Lean manufacturing, or lean production, is a system of techniques and activities for running a manufacturing or service operation which eliminates all of the non-value-adding activities and waste from the business.

IMPLEMENTING LEAN EXAMPLE



KEY PRINCIPLES

Womack and Jones define Lean as "...a way to do more and more with less and less - less human effort, less equipment, less time, and less space - while coming closer and closer to providing customers exactly what they want" and then translate this into five key principles:

1. Value - Specify the value desired by the customer. "Form a team for each product to stick with that product during its entire production cycle", "Enter into a dialogue with the customer" (e.g. Voice of the customer)
2. The Value Stream - Identify the value stream for each product providing that value and challenge all of the wasted steps (generally nine out of ten) currently necessary to provide it
3. Flow - Make the product flow continuously through the remaining value-added steps
4. Pull - Introduce pull between all steps where continuous flow is possible
5. Perfection - Manage toward perfection so that the number of steps and the amount of time and information needed to serve the customer continually falls.

Lean is founded on the concept of continuous and incremental improvements on product and process while eliminating redundant activities. "The value of adding activities are simply only those things the customer is willing to pay for, everything else is waste, and should be eliminated, simplified, reduced, or integrated"

OR

Core idea of lean manufacturing is relentlessly work on eliminating waste from the manufacturing process.

Plant Maintenance.

Plant :-

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

Maintenance :-

Maintenance is a set of organised activities that are carried out in order to keep an item in its best operational condition with minimum cost acquired.

Objectives of plant maintenance :-

(i) The objective of plant maintenance is to achieve minimum breakdown and to keep the plant in good working cond'at the lowest possible cost.

(ii) Machines and other facilities should be kept in such a condition which permits them to be used at their optimum (profit making) capacity without any interruption or hindrance.

(iii) Maintenance division of the factory ensures the availability of the m/c, buildings, and services required by other sections of the factory for the performance of their functions at optimum return on investment whether this investment to be in material, machinery or personnel.

Duties, functions and Responsibilities of plant maintenance Engineering Department :-

(i) Depending upon the size of the maintenance department, it has a wide variety of duties or function to perform.

The work is under the control of plant engineer or maintenance engineer who normally reports to the works manager.

(ii) The different duties, functions and responsibilities of the maintenance department are as follows.

(1) Inspection :-

(i) Inspection is concerned with the routine schedule checks of the plant facilities to examine their condition & to check for needed repairs.

(ii) Inspections ensure the safe and efficient operation of equipment and machinery.

(iii) Frequency of inspections depends upon the intensity of the use of the equipment. For example, belts in a m/c may be checked every week; furnace equipment every month; an overhead bridge crane every four months and so on.

(iv) Inspection section makes certain that every working equipment receives proper attention.

(v) Maintenance items received from vendors are inspected for their fitness.

(2) Engineering :-

i) Engineering involves alterations and improvement in existing equipments and building to minimize breakdowns.

(ii) Maintenance department also undertakes engineering and supervision of construction projects that will eventually become part of the plant.

(iii) Engineering and consulting services to production supervision are also the responsibilities of maintenance department.

(3) Maintenance (including Preventive Maintenance) :-

1) Maintenance of existing plant equipment.

2) Maintenance of existing plant building, and other service facilities such as yards, central stores, roadways, sewers etc.

3) Engineering and execution of planned maintenance, minor installations of equipment, building & replacements.
4) preventive maintenance, i.e. preventing breakdown (before it occurs) by well conceived plan of inspection, lubrication, adjustments, repair & overhaul.

(D) Repair :-
(i) Maintenance department carried out corrective repairs to alleviate unsatisfactory conditions found during preventive maintenance inspection.
2) Such a repair is an unscheduled work often of an emergency nature, and is necessary to correct breakdowns and it include trouble calls.

(E) Overhaul :-
(i) Overhaul is a planned, scheduled reconditioning of plant facilities such as machinery etc.
(ii) Overhaul involves replacement, reconditioning, reassembly, etc.

(F) Construction :-
(i) In some organization, maintenance department is provided with equipment and personnel and it takes up construction job also.
(ii) Maintenance department handles construction of wood, brick and steel structures, cement, and asphalt paving, electrical installations, etc.

(G) Salvage :-
(i) Maintenance department may also handle disposition of scrap or surplus materials.
(ii) This function involves,
- segregation, reclamation & disposition of production scrap and
- The collection and disposition of surplus equipments, materials & supplies.

(H) clerical jobs :-

(i) Maintenance department keeps records
- of costs
- of time progress on jobs,
- pertaining to important feature of building and production equipment ; electrical installation water, steam, air & oil lines ; transportation facilities (such as elevators, conveyors, powered trucks, crane etc). etc.

(:) Generation & distribution of power and other utilities.

(J) Administration and supervision of labour force.

K) providing plant protection, including fire protection.

L) Insurance administration.

M) Establishing & maintaining a suitable store of maintenance materials.

N) Janitorial service.

O) Housekeeping.

P) pollution & noise abatement.

Types of maintenance :—

Maintenance may be classified into following categories.

(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. e.g. an electric motor will not start, a belt is broken etc.

→ Under such condition, production department calls on the maintenance department to rectify the defect. The maintenance department checks into the difficultly & makes the neccessary repairs.

=> After removing the fault, maintenance engineers do not attend the equipment again until another failure or breakdown occurs.

Limitation :—

(i) Breakdown generally occurs at inopportune times.
(ii) Reduction of O/P.
(iii) Faster plant detertion.
(iv) More spoilt material
(v) Direct loss of profit.

(b) Scheduled maintenance :-

* Scheduled maintenance is a stich in time procedure aimed at avoiding breakdown.
* Breakdown can be dangerous to life and as far as possible should be minimized.
* Scheduled maintenance practise incorporate inspection, lubrication, repair and overhaul of certain equipment which if neglected can result in breakdown.
* Scheduled maintenance practise is generally followed for overhauling of m/c, cleaning of water and other tanks, while washing of building etc.

(c) Preventive maintenance :- (PM)

* A system of scheduled, planned or preventive maintenance tries to minimize the problem of breakdown maintenance.
* It is a stich in time procedure.
* It locates weak spots in all equipments provides them regular inspection & minor repairs thereby reducing the danger of unanticipated breakdown.

The underlying principle of preventive maintenance is that prevention is better than cure.

* PM may be taken care by
(a) productive department.
(b) Maintenance department.
(c) A separate division of inspection, crafts and supervisors.

(d) Predictive Maintenance :-

* It is comparatively a newer maintenance technique.
* It make use of human senses or other sensitive instrument such as.
- Audio gauge.
- vibration analyzes
- Amplitude meters. etc.
to predict troubles before the equipment fails.

→ In predictive maintenance, equipment condition are measured periodically on a continous basis and this enable maintenance men to take a timely action such as equipment adjustments, repairs or overhaul.