RK INSTITUTE OF ENGINEERING & TECHNOLOGY

Approved by AICTE, New Delhi
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LECTURER NOTE

INDUSTRIAL ENGINEERING AND MANAGEMENT

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Diploma in Mechanical Engineering
Semester: 5TH
Academic Session: 2026-27 (WINTER)

Shaping Engineers, Building Tomorrow

CHAPTER -01 PLANT ENGINEERING

Plant: Plant is a place where men ,material ,money ,equipment ,machinery etc are utilized properly for manufacturing useful products.

Factors Affecting/Governing Plant Location: Plant location must be selected properly by entrepreneurs while planning to set up their business units. While taking such a decision, they must consider some important factors.

In practice, the choice of plant location should be based on following considerations

1. nearness to Raw material:

- An ideal location is one where the main raw-material required to manufacture the product is adequately available. This will ensure regular supply of the material and will also reduce the transportation costs.
- The technical and delivery problems associated with raw-material can be reviewed and discussed from time to time. Alternately, the per unit cost of raw-material should come out to be minimum at the ideal plant location.

2. Nearness to the potential market:

- Marketing of its product efficiently is also an important function of an enterprise. If the plant is located near the market, then the management can keep close touch with the changes in market environment and formulate its production policies accordingly. But with expansion of markets both on national and international levels this aspect has now become of secondary importance. But the reduction in marketing costs still remains an important consideration for location to be near the market.
- The transportation and other overheads are likely to increase with distance between plant and the market. Also, in case of factory being nearer to the market the risk of damage in transportation, loss of demand due to change in fashions etc. is also reduced. Glass and chemical factories are mainly affected by this consideration.

3. Availability of Fuel and Power:

- In some industries continuous and adequate supply of power is of great significance e.g. nylon fibber plant.

- There are some industries for which cheap electricity may be more important. In such situation location of the plant near to hydro-power stations will provide cheap electricity e.g. paper and pulp mills, flour mills etc.

4. Availability of labour:

- Labour is one of the most important inputs in an industrial enterprise.
- Stable labour force of right kind of adequate size and at reasonable rates with its proper attitude towards work are a few factors which h affect plant location.
- The purpose of management is to face less boycotts ,strikes and to achieve lower labour costs per unit of production.

5. Transport and Communication facilities :

- Transport is very important for bringing raw materials, fuel from different places. Also transport is required to supply the finished products to markets. The region well connected with Rail, Road, Water and Air transport system is considered to be more appropriate for the location of plants.
- Similarly good communication facilities viz. Postal and Telecommunication links are of great significance towards the success of an enterprise. Regions with good communication system should be given priority for the selection of sites. Similarly, Industries producing goods for export may be located near ports or airports.

6. Availability of Water : Water is used for processing as in paper and chemical industry and is also required for drinking and sanitation purpose. Depending upon the nature of plant , water should be available in adequate quantity **.**

7. Integration with other group of companies : New enterprise owned or operated by a single group of companies should be so located that its work can be integrated with the work of the associated establishments.

8. Suitability of land and climate : Sub-soil of the location should be able to support the load likely to be placed on it. Similarly, the climatic conditions viz, humidity, temperature and other atmospheric conditions should be favourable for the plant e.g. damp climate is favourable for textile and cotton industries. These conditions also determine heating and ventilating requirements.

9. Availability of housing, amenities and other services: Good housing facility, adequate number of shops, theatres, cinemas, restaurants, local passenger transport and rail services and sufficient availability of gas, water supply, drainage, disposal of waste, firefighting services can easily attract goods toff.

10. Local building and planning regulations: Proposed location should not infringe local regulations and bye-laws. A discussion with the survey department of the local authority is most desirable. Laws for the construction of buildings, local taxes etc should be taken into consideration for the selection of site.

11. Safety requirements: industries like nuclear power stations, explosive in nature, chemical process likely to pollute the atmosphere should be located in remote areas. Safety from enemy during the war periods also affects location decision.

1.2 PLANT LAYOUT

DEFINATION: Plant layout means the disposition of the various facilities (equipment's, material, manpower etc.) within the areas of the site selected. Plant layout begins with the design of the factory building and goes up to the location and movement of work. All the facilities like equipment, raw material, machinery, tools, fixtures, workers etc. are given a proper place.

1.3 OBJECTIVES OF PLANTLAYOUT:

The principal objective of a proper plant layout is to maximize the production at the minimum of the costs. This objective should be kept in mind while designing a layout for a new plant as well as while making the necessary changes in the exiting layout in response to change in management policies and processes and techniques of production with the production system, i.e. workers, supervisors and managers.

If a layout is to fulfil this goal, it should be planned with the following clear objectives in mind.

There is the proper utilization of cubic (i.e. length, width and height). Maximum use of volume available should be made. For example, conveyors can be run above head height and used as moving work in progress or tools and equipment's can be suspended from the ceiling. The principle is particularly true

in stores where goods can be stored at considerable height without inconvenience.

1. Waiting time of the semi-finished products is minimized.
2. Working conditions are safer, better (well ventilated rooms etc.) and improved
3. Material handling and transportation is minimized and efficiently controlled.
4. The movements made by the worker are minimized.
5. Suitable spaces are allocated to production centres and service centres.
6. Plant maintenance is simpler.
7. There is increased flexibility for changes in product design and for future expansion.
8. A good layout permits material to move through the plant at the desired speed with the lowest cost.
9. There is increased productivity and better product quality with reduced capital cost.
10. Boosting up employee morale by providing employee comforts and satisfaction.
11. There is utilization of cubic space(length,width and height)
12. Bottlenecks and point of congestions are eliminated so that the raw material and semifinished product move fast from one work station to other.

1.3 PRINCIPLES OF PLANTLAYOUT: While designing the layout of a plant, the following principles should be kept in mind:

(i) Principle of minimum movement. As far as possible materials and labour should be moved over minimum distances.

(ii) Principle of flow. The work areas should be arranged according to the sequence of operations so that there is a continuous flow of materials without backtracking or congestion. The layout should allow for easy movement of materials without interruptions or delays. As far as possible movement of materials should be continuous.

(iii) Principle of space. All available cubic space should be effectively used both horizontally and vertically.

(iv) Principle of safety. Due consideration should be given to the safety and convenience of workers. There should be built-in provision for the safety and comfort of employees.

(v) Principle of flexibility. Layout should be so designed that production facilities can easily be rearranged when it becomes necessary in future on account of expansion or technological changes.

(vi) Principle of integration. All the plant facilities and services should be fully integrated into a single operating unit so as to maximize efficiency and minimize costs of production.

(vii) Principle of minimum investment. The layout should yield savings in fixed capital investment through optimum utilization of available facilities.

1.4 TYPES OF PLANT LAYOUT:

There are three main types of plant layout:

1) Functional or Process layout

2) Product or Line Layout,

(3) Combination Layout

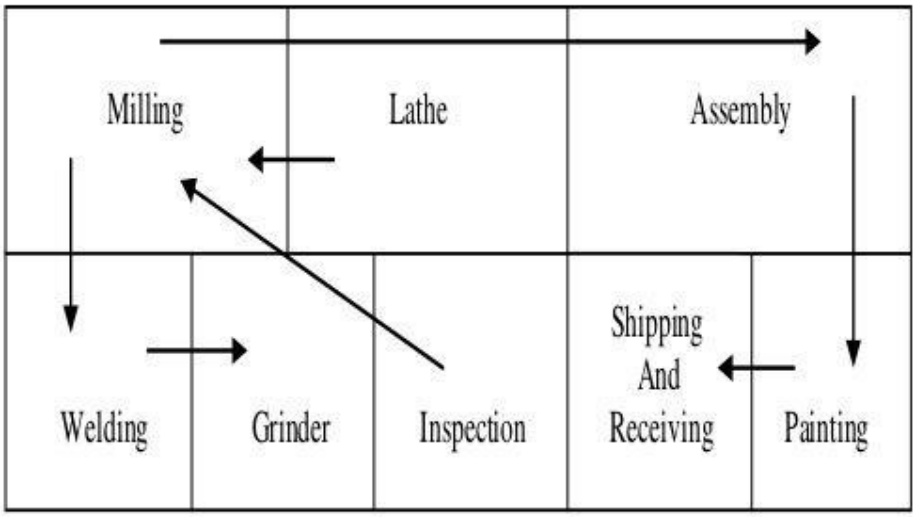
However, the choice of one or the other type of layout depends upon the machines and techniques used in the production.

(1) Process Layout:

Process layout is a design for the floor plan of a plant which aims to improve efficiency by arranging equipment according to its function. It is also known as the functional layout and is characterized by keeping similar machines or similar operations at one location (place). In other words, separate departments are establishing for each specializes operation of production and machines relating to that functions are assembled there.

PROCESS LAYOUT (CONT.)

- Process layout is shown in the following diagram:



Advantages of Process Layout:

The following advantages of Process Layout below are;

a) Wide flexibility exists as regards allotment of work to equipment and workers.
b) Better utilization of the available equipments.
c) Variety of jobs, coming as different job orders make the work more interesting for workers.
d) Workers in one section do not affect by the nature of operations carried out in another section. e.g. a lathe operator does not affect by the rays of welding as the two sections are quite separate.
e) The breakdown of one machine does not interrupt the entire production flow.

f) Capital investment is reduced because comparatively less number of machines are needed.
g) Under process layout, better and efficient supervision is possible because of specialization in operation.

Disadvantages of Process Layout:

The following disadvantages of Process Layout below are;

a) Automatic material handling is extremely difficult because fixed material handling equipment like conveyor belt cannot be possible to use.
b) Completion of the same product takes more time.
c) Raw material has to travel larger distances for getting processed to finished goods. This increases material handling and associated costs.
d) For the same amount of production ,process layout needs more space.
e) Completion of same product takes more time.
f) Work in process inventory is large.
g) Production control becomes difficult.
h) It needs more inspections and efficient coordination.

PRODUCT LAYOUT

It is known as line layout.it implies that various operations on raw material are performed in a sequence and the machines are placed along the product flow line.machines are arranged in the sequence in which the raw material will be operated upon.this type of layout is preferred for continuous production.

Advantages-

1. less space required for same volume of production.
2. automatic material handling can be done.
3. less in-process inventory.
4. product completes in lesser time.
5. better co-ordination and simple production planning and control.
6. smooth and continuous work flow.
7. Less skilled workers may serve the purpose.

Disadvantages-

1. layout flexibility is considerably reduced because a change in product involves major changes in layout.
2. excessive idle time for other machines if the production line is not balanced.
3. it involves higher capital investment,because if one machine in the line fails ,it may lead to shut down of the complete production line.
4. difficulty in inspection.
5. it is difficult to increase the production beyond the capacities of the production line.

COMBINATION LAYOUT-

- In combination layout the advantages of both process and product layout are combined.
- A combination layout is possible where an item is being made in different types and sizes.
- In such cases machinery is arranged in a sequence to manufacture various types and sizes of products.
- Examples-files, hacksaws, wood saws,circular metal saws are manufactured in combination type layout.

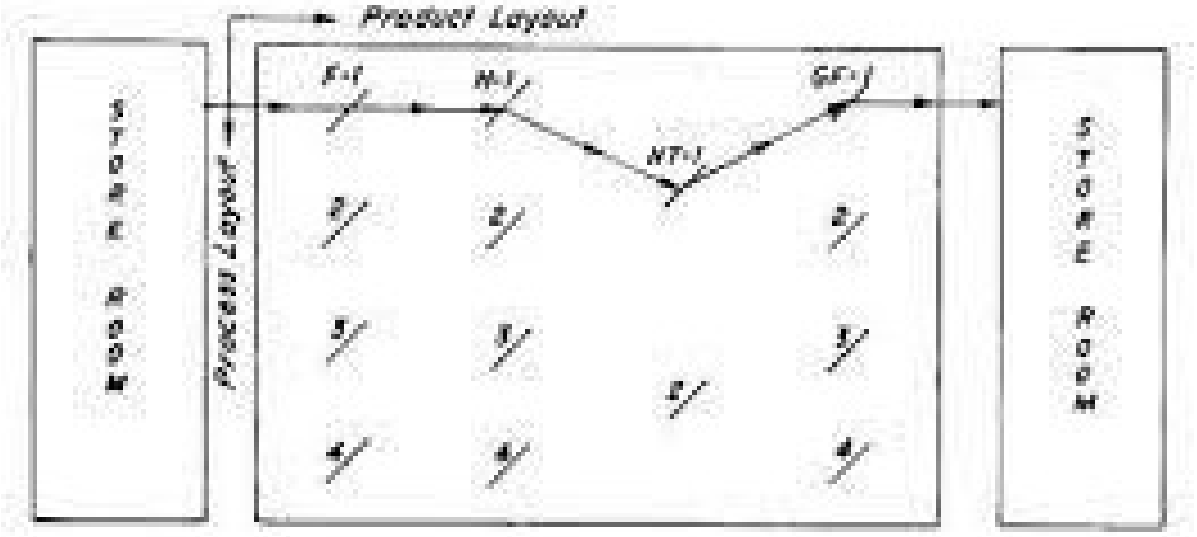


Fig. 4.3. A combination layout for making different types and sizes of gears.

F = Blank forging hammers.
H = Hobbing machines for cutting gear teeth.
HT = Heat treatment furnaces.
GF = Gear finishing machines.

PLANT MAINTENANCE-

Objectives-

- To achieve minimum breakdown and to keep the plant in good working condition at the lowest possible cost.
- Machines and other facilities should be kept in such a condition that they will permit them to be used at their optimum capacity .
- Maintenance division ensures the availability of the machines, buildings and service required by other sections of the factory.

Types of maintenance-

1.breakdown maintenance
2.preventive maintenance
3.scheduled maintenance

1.breakdown maintenance-

- In breakdown maintenance the repair work is done after the equipment is out of orderand it cannot perform its normal function any longer.example-electric motor will not start.
- Under such condition production department calls on the maintenance department to rectify the defect.
- After removing the fault ,maintenance engineers do not attend the equipment again until another failure takes place.
- This maintenance is economical for those equipments whose repair costs are less.
- This type of maintenance involves little administrative work,few records and small staff.

Causes of breakdown maintenance-

1.failure to replace worn out parts.
2.lack of lubrication.
3.neglected cooling system.
4.indifference towards minor faults.
5.too low or too high line voltage,wrong fuel etc.
6.indifference towards equipment vibration,unusual sounds,heating up of equipment.

Disadvantages of breakdown maintenance-

- ✓ Delay in production
- ✓ Reduction of output
- ✓ Faster plant detoriation.
- ✓ Increased chances of accidents.
- ✓ More spoilt material.
- ✓ Cannot be applied for lifts,hoists and pressure vessel.

2.SCHEDULED MAINTENANCE-

- It is a stich-in-time procedure aimed at avoiding breakdown.
- Breakdown should be minimized becasuse it is dangerous to life.
- In scheduled maintenance inspection,lubrication,repair and overhaul of certain equipments.
- Scheduled maintenance practice is generally followed for overhauling of machines,cleaning of waterand other tanks,white washing of building.

PREVENTIVE MAINTENANCE-

- It is stich –in-time procedure.
- It locates weak spots in all equipments, provides them regular inspection and minor repairs thereby reducing the danger of unanticipated breakdown.

Objectives of preventive maintenance-

1.

Chapter-2 / Sushree priyadarshini

OPERATION RESEARCH

Introduction -

→ Operation research (OR) is an analytical method of problem-solving and decision making that is useful in the management of organisation.

→ The concepts of operation research arose during world war II by military planners. After that the techniques used in operation research were applied to addressing problems in business, the government and society.

→ In operation research, the problems are broken down into basic components and then solved in defined steps by mathematical analysis.

→ The process of operation research can be broadly broken down into following steps.

① Identifying a problem that needs to be solved.

② Constructing the model around the problem.

③ Using model to derive solutions to the problem.

④ Testing each solution on the model and analyzing its success.

⑤ Implementing the solution to the actual problem.

Characteristics of operation research

① optimization
② Simulation
③ probability

The following methods are used to solve operation research problems.

① linear programming
② Transportation problem.
③ Queing theory.
④ Game theory
⑤ simulation technique
⑥ dynamic programming

2.2 Linear programming

Define Linear programming problems

→ It is a mathematical model in which a linear function is maximized or minimized when subjected to various constraints.

→ Linear programming may be defined as the problem of maximizing or minimizing a linear function which is subjected to linear constraints.

→ The constraints may be equalities or inequalities.

→ The optimization problem involves the calculation of profit and loss.

→ Linear programming problem helps to find the feasible region and optimize the solution in order to have the highest or lowest value of the function.

Components of Linear programming

1. Decision variable
2. Constraints
3. Data
4. objective function.

① Decision variable :- For any problem, the first step is to identify the decision variable. The decision variable will decide the output. It gives the ultimate solution of the problem.

② Constraints :- The limitations should be expressed in mathematical form.

③ objective function :- objective function should be specified in a quantitative way.

Standard form of Linear programming problem :-

Let $x_1, x_2, x_3 \ldots x_n$ are the decision variables

$Z = c_1x_1 + c_2x_2 + \ldots + c_nx_n$

Subjected to constraints

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

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

$a_{m_1}x_1 + a_{m_2}x_2 + \ldots a_{m_n}x_n \leq b_n$.

$x_1, x_2 \ldots x_n \geq 0$ (non negative).

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

a_{ij} $(i = 1, 2 \ldots n, j = 1, 2 \ldots n)$ are structural coefficients

$b_1, b_2 \ldots b_n$ are availability.

LPP can be solved by two methods.

1. Graphical Method
2. Simplex method.

Formulation of L.P problem :-

1. From the given problem, identify the key decision to be made.
2. Identify the decision variable, whose values give the solutions to the problem.

③ Write the objective in the quantitative terms, and express it as a function of linear variables.

④. Study the constraints and express them as a linear equations.

Q.1 A firm can produce three types of cloth say A, B and C. Three kinds wool are required for it say red wool, green wool and blue wool. One unit length of type A cloth needs 2 yards of red wool and 3 yards of blue wool. One unit length of type B cloth needs 3 yards of red wool, 2 yards of green wool and 2 yards of blue wool and one unit length of type 'C' cloth needs 5 yards of green and 4 yards of blue wool. The company has a stock of 8 yards of red, 10 yards of green and 15 yards of blue wool. The profit from sale of type 'A' cloth is Rs 10, type B cloth is Rs. 8 and type 'C' is Rs. 5.

Determine how the firm should use the available material to maximize the profit.

formulate the linear programming problem.

Solution

① objective is to maximize the profit by selling three types of clothes 'A', 'B' and 'C'.

② x_1, x_2 and x_3 be the number of units of type 'A', type 'B' and type 'C' clothes.

③. profit equation is written as

$$\boxed{Z = 10x_1 + 8x_2 + 5x_3}$$

Clothes

Requirement of wool	A	B	C	Availability of wool
(1) Red wool	2	3	–	8
(2) green wool	–	2	5	10
(3) Blue wool	3	2	4	15

These can be expressed as linear equations

$$2x_1 + 3x_2 \leq 8$$

$$2x_2 + 5x_3 \leq 10$$

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

Standard form

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

Subject to $2x_1 + 3x_2 \leq 8$

$2x_2 + 5x_3 \leq 10$

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

2.3 Solution of LPP by graphical Method

step 1 → State the problem in mathematical form

step 2 → plot the problem constraints on a graph by temporarily ignoring the inequality sign. Indicate the area of the feasible solution by shaded area.

step-3 :- Determine the coordinates of all points at the corner of the feasible solution.

step-4 :- Find out the value of the objective function corresponding to all the solution points determined in step-3

step-5 :- Determine the feasible solution which optimizes the value of the objective function

Question

Maximize $Z = 5x_1 + 3x_2$

Subjected to constraints

$2x_1 + x_2 \leq 1000$ —— (1)

$x_1 \leq 400$ —— (2)

$x_2 \leq 700$ —— (3).

$x_1, x_2 \geq 0$.

Step-1

Find out points by ignoring inequalities of constraints.

(1) $2x_1 + x_2 = 1000$ —— (1).

$x_1 = 0$	$x_2 = 0$
$x_2 = 1000$	$x_1 = 500$

(2) $x_1 = 400$.

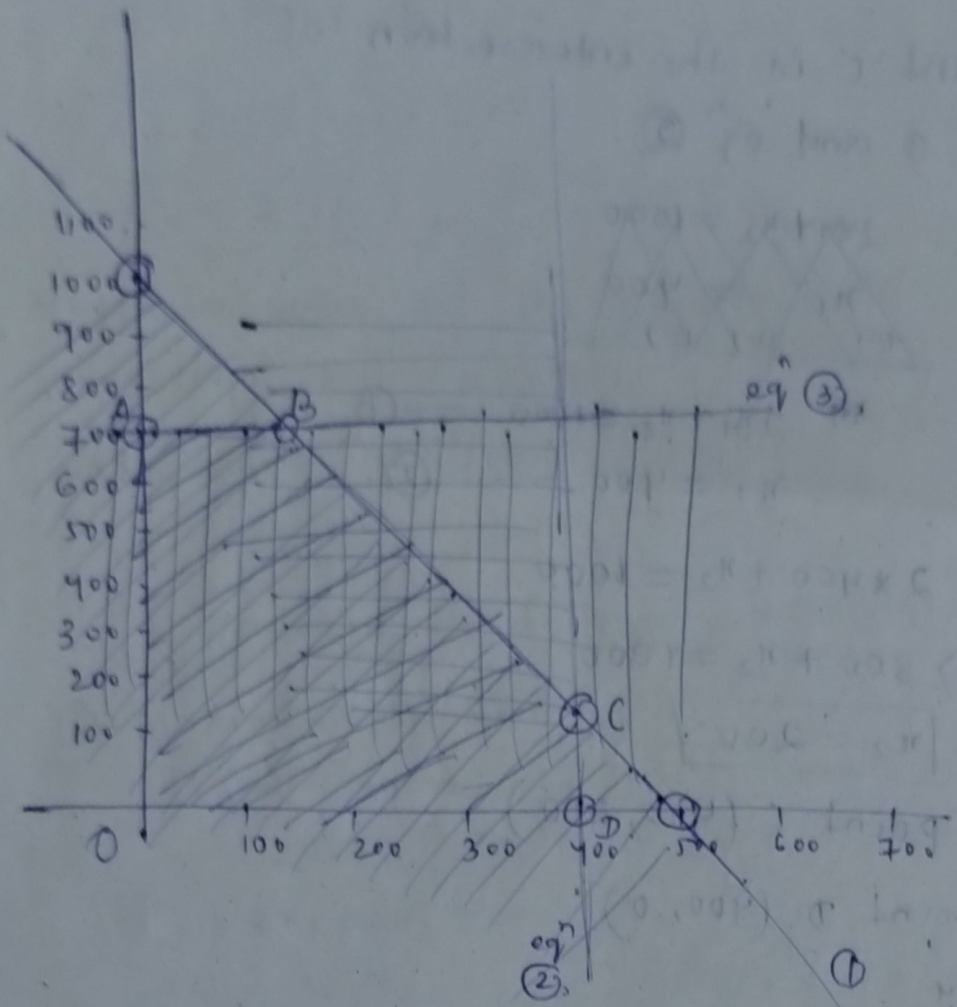
point $(400, 0)$

(3) $x_2 = 700$.

point $(0, 700)$.

Step-2

Now plot the points on the graph and find the feasible region.



The corner points in the shaded regions are 0, A, B, C, D.

Step-3 ~~point~~ (0)

Find the coordinates of the corner points of feasible region.

point 0 (0, 0).

point A (0, 700).

point B is the intersection point of eqn (1) and eqn (3).

$2x_1 + x_2 = 1000$

$x_2 = 700.$

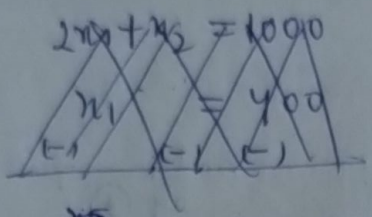
(-) (-)

$2x_1 = 300$

$\Rightarrow \boxed{x_1 = 150.}$

point B (150, 700).

point 'C' is the intersection of eq^n ① and eq^n ②.



$2x_1 + x_2 = 1000$ ——— ①

$x_1 = 400$ ——— ②

$2 \times 400 + x_2 = 1000$

$\Rightarrow 800 + x_2 = 1000$

$\Rightarrow \boxed{x_2 = 200}$

point C (400, 200)

point D (400, 0).

step-4

put the above points in the objective function.

$Z = 5x_1 + 3x_2$

At point 'O' (0,0)

$Z = 5 \times 0 + 3 \times 0 = 0.$

At point A (0, 700)

$Z = 5 \times 0 + 3 \times 700 = 2100.$

At point B (150, 700)

$Z = 5 \times 150 + 3 \times 700$

$= 750 + 2100 = 2850$

At point C (400, 200)

$Z = 5 \times 400 + 3 \times 200.$

$= 2000 + 600 = 2600.$

At point 'D'

$Z = 5 \times 400 + 3 \times 0$

$\boxed{Z = 2000}$

Maximum value of the objective function is $\boxed{Z = 2850}$ at point (150, 700). (Ans)

— o —

Practice the following problems

① Maximize $Z = 3x_1 + x_2$

subjected to

$2x_1 + x_2 \leq 1$

$3x_1 + 4x_2 \geq 4$

$x_1, x_2 \geq 0$.

(Ans $x_1 = 0$.
$x_2 = 1$
$Z = 2$)

② Minimize $Z = 600x_1 + 500x_2$

subjected to

$3000x_1 + 1000x_2 \geq 24000$

$1000x_1 + 1000x_2 \geq 16000$

$2000x_1 + 6000x_2 \geq 48000$.

$x_1, x_2 \geq 0$.

— o —

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2.4 Evaluation of project completion time using PERT & CPM

Objectives of Network Analysis

1. A powerful coordinating tool for planning, scheduling and controlling of projects.
2. Minimisation of total project cost and time.
3. Effective utilization of resources and minimization of effective resources.
4. Minimization of delays and interruption during implementation of the project.

Application of Network Analysis :- (PERT & CPM)

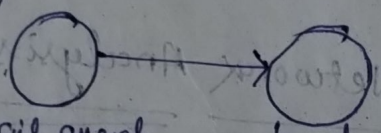
1. Research and development projects.
2. Equipment maintenance and overhauling.
3. Construction projects.
4. Setting up new industries.
5. Planning and launching of new products.
6. Design of plants, machine and systems.
7. Shifting of manufacturing location from one location to another.
8. Control of production in large job shops.
9. Conference.

Basic Concepts in Network

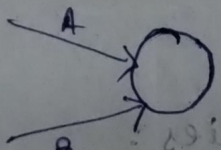
① **Network**:- It is a graphical representation of the project and it consists of series of activities arranged in a logical sequence.

② **Activities**:- An activity is a physically identifiable part of the project, which consumes time and resources. Activity is represented by an (→).

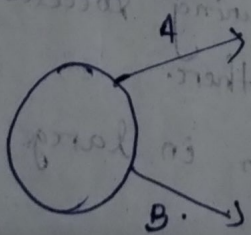
③ **event**:- An event represents the start or the completion of an activity. The beginning and end points of an activity are events.



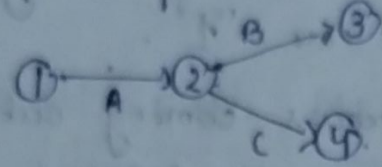
④ **Merge event**:- If number of activities terminate into a single node, that is called as merge event.



⑤ **Burst event**:- If number of activities start from a single node, that is called as burst event.

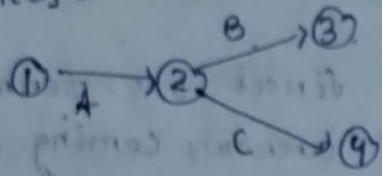


(6) Predecessor Activity :- All those activities which must be completed before starting the activity under consideration are called as predecessor activities.



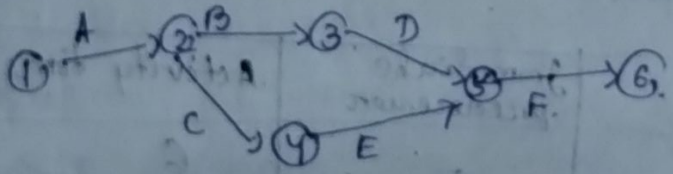
Here A is the predecessor for B and C.

(7) Succesor Activities :- All the activities which have to follow the activity under consideration are called as succesors activities.



Here B and C are succesors to 'A'.

(8) path :- An unbroken chain of activities between two events is called as path.



A - B - D - F → path - 1

A - C - E - F → path - 2

(9) Dummy Activity :- It does not consume time and resources. It is used to maintain the logical sequence. It is indicated by a dotted line.

Numbering of Events (Fulkerson's Rule)

Steps

(1) The initial event which has all outgoing arrows with no incoming arrow is numbered as '1'.

(2) Delete all the arrows coming out from node '1'. This will convert some more nodes into initial events. Number these events as 2, 3 etc.

(3) Delete all the arrows going out from these numbered events to create more initial events.

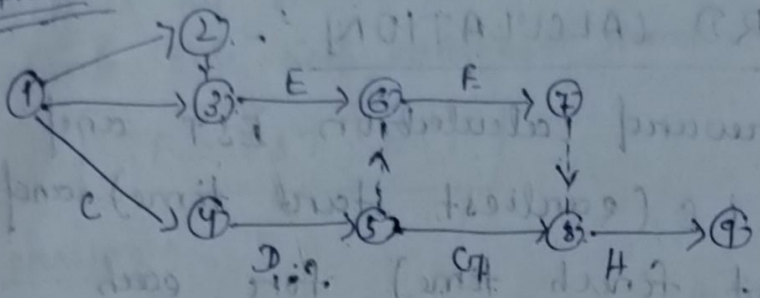
(4) Continue until the final or terminal node which has all arrows coming in.

problem - 1

Construct the network from the given data.

Activity	Immediate predecessor	Activity time.
A	–	6
B	–	10
C	–	14
D	C	6
E	A, B	14
F	E, D	6
G	D	4
H	F, G	4

Answer



Critical path Method

→ The path with the longest duration is called as critical path.

→ In critical path method, the activity times are known with certainity.

→ For each activity, earliest start time (EST) and latest start time (LST) are computed.

→ The length of the critical path determines the time in which the project can be completed.

→ The activities on the critical path are called as critical activities.

→ Objectives of time analysis are given below

① To determine completion time of project.

② To calculate earliest time when each activity can start.

③ latest time when each activity can start.

④ to determine float for each activity

⑤ Identification of the critical activities and critical path.

* FORWARD CALCULATION :-

→ In forward calculation EST and EFT i.e (earliest start time) and (earliest finish time) for each activity is calculated.

→ This calculation starts from the first node to the end node.

→ Earliest start time (EST)

EST is the earliest event time of the tail event.

→ Earliest Finish time (EFT).

EFT = EST + Activity duration

* BACKWARD CALCULATION :-

→ This calculation starts from the last node to first node.

LST = LFT - duration

Total Float

It is defined as the amount of time by which the completion of an activity can be delayed beyond earliest expected completion time without affecting overall project duration.

→ It is the difference between latest start time and earliest start time.

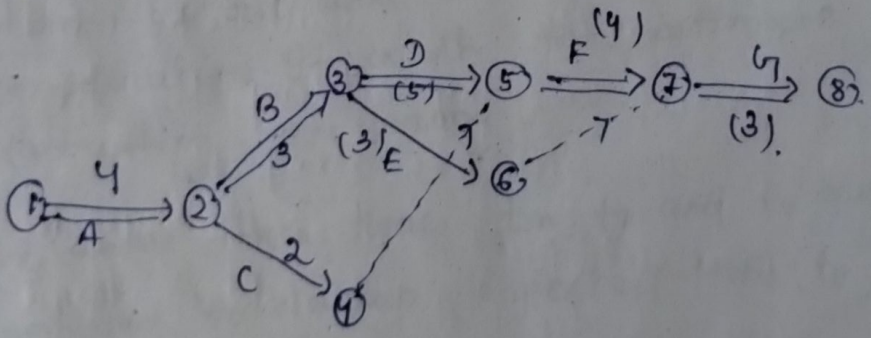
$$TF = LST - EST$$

problem:

Activity	preceleceesor	Activity time
A	–	4
B	A	3
C	A	2
D	B	5
E	B	3
F	C, D	4
G	E, F	3

① Draw the Network.

② Find EST, EFT, LST, LFT and total float for each activity.



Network diagram

No. of paths

A – B – D – E – G = 4 + 3 + 5 + 4 + 3 = 19

A – C – F – G = 4 + 2 + 4 + 3 = 13

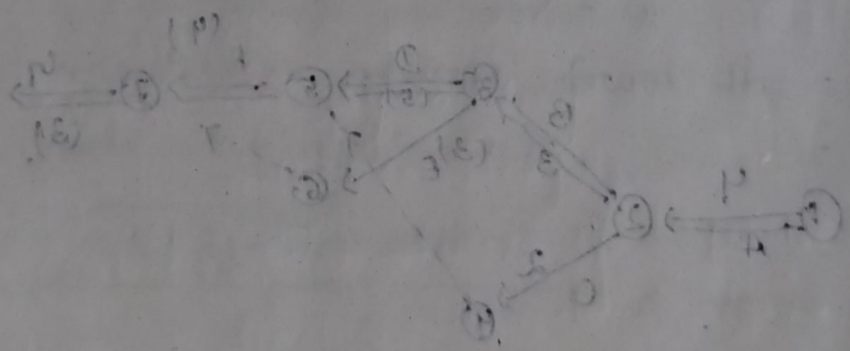
A – B – E – G = 4 + 3 + 3 + 3 = 13

Critical path = A – B – D – E – G.

Activity	Duration	EST	EFT	LST	LFT	Total float
A	4	0	4	0	4	0
B	3	4	7	4	7	0
C	2	4	6	10	12	6
D	5	7	12	7	12	0
E	3	7	10	9	12	2
F	4	12	16	12	16	0
G	3	1'	19.	16	19	0

The critical Activities are
A, B, D, F, G.

The critical activities will have "zero" total float values.



PORGRAMME EVALUATION AND REVIEW TECHNIQUE (PERT)

PERT makes use of three estimates of time.

① Optimistic time (to)

② Most likely time (tm)

③ pessimistic time (tp).

① Optimistic time (to) :- It is the shortest possible time, if everything goes perfectly without any complications.

② Most likely time (tm) :- It is the best estimate of activity time. This lies between optimistic and pessimistic time.

③ pessimistic time (tp) :- It is the longest time of all odds will be taken into consideration. It is the time estimate if everything goes wrong.

The above three times tm, tp and to are combined to develop expected time (te) for an activity.

The expected time (te) is given by

$$t_e = \frac{t_o + 4t_m + t_p}{6}$$

The standard deviation of the time required to complete each activity

$$\sigma = \frac{t_p - t_o}{6}$$

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

Probability of completion of the project within a scheduled time :-

* probability distribution is assumed to be normal distribution.

The following steps are followed to compute the probability

step-1 :- calculate the critical path duration.

step-2 :- calculate the variance of the event time by adding the times of the activities along the critical path. Take the square root to find the standard deviation.

step-3 :- Compute $Z = \frac{T_s - T_e}{\sigma}$

where T_s = The date

T_e = critical path duration

σ = standard deviation

from the table of normal curve, the value corresponding to z will give the required probability value.

problem:-

Activity	to	tm	tl	~~te~~	σ² var
1-2	1	1.5	5		
2-3	1	2	3		
2-4	1	3	5		
3-5	3	4	5		
4-5	2	3	4		
4-6	3	5	7		
5-7	4	5	6		
6-7	6	7	8		
7-8	2	4	6		
7-9	5	6	8		
8-10	1	2	3		
9-10	3	5	7		

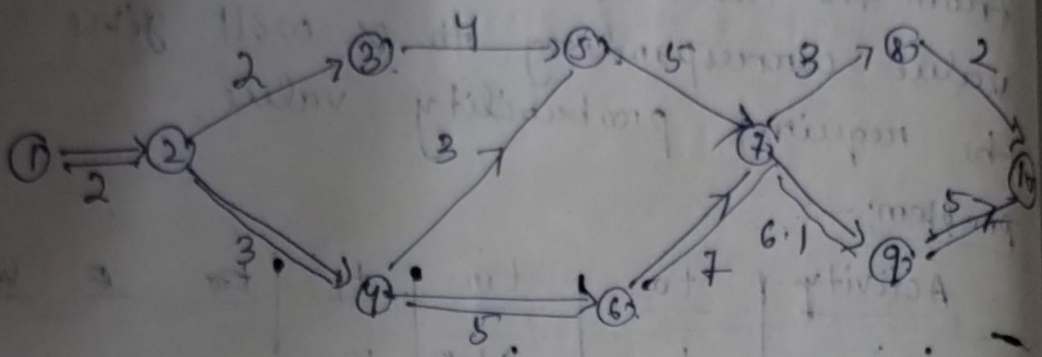
① Construct the network.

② Find the critical path duration.

③ Find the due date at 95% probability.

at 95% probability

$$z = 0.8229$$



Activity	to	tm	tp	te	σ	var
1-2	1	1.5	5	2	2/3	4/9
2-3	1	2	3	2	1/3	1/9
2-4	1	3	5	3	2/3	4/9
3-5	3	4	5	4	1/3	1/9
4-5	2	3	4	3	1/3	1/9
4-6	3	5	7	5	2/3	4/9
5-7	4	5	6	5	1/3	1/9
6-7	6	7	8	7	1/3	1/9
7-8	2	4	6	3	2/3	4/9
7-9	5	6	8	6.1	1/2	1/4
8-10	1	2	3	2	1/3	1/9
9-10	3	5	7	5	2/3	4/9

No. of paths in the above network

1-2-3-5-7-8-10 = 18

1-2-3-5-7-9-10 = 24.1

1-2-4-5-7-8-10 = 18

1-2-4-5-7-9-10 = 24.1

1-2-4-6-7-8-10 = 22

1-2-4-6-7-9-10 = 28.1

The critical path

1-2-4-6-7-9-10

critical path duration = 28.1 days.

$$Z = \frac{\text{due date} - \text{expected time}}{\sigma}$$

variance of critical path

$$= \frac{4}{9} + \frac{4}{9} + \frac{4}{9} + \frac{1}{9} + \frac{1}{4} + \frac{4}{9}$$

$$= \frac{16 + 16 + 16 + 4 + 9 + 16}{36}$$

$$= \frac{77}{36}$$

as given in the question for 95% probability 95% $Z = 0.8229$

$$Z = \frac{\text{Due date} - 28.1}{\sigma}$$

$$\sigma = \sqrt{\text{variance}}$$

$$= \sqrt{77/36}$$

$$\therefore 0.8229 = \frac{\text{Due date} - 28.1}{\sqrt{77/36}}$$

$$\Rightarrow \boxed{\text{Due date} = 29.6 \text{ days.}}$$ Ans

2.5 Explain distinct features of PERT with respect to CPM

PERT	CPM
① A probabilistic model with respect to uncertainity in activity duration.	① A deterministic model with well-known activity duration.
② An event-oriented approach.	② An activity-oriented approach.
③ In this approach probability of completion of project is computed.	→ In this approach critical path duration is computed.
④ Slack is considered.	④ Total float is considered.
⑤ Suitable for defence projects and R & D.	⑤ Suitable for problems in industrial setting, plant maintenance, civil construction projects etc.

———— o ————

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Chapter-3

3.1 Classification of Inventory :-

→ Inventory generally refers to the materials in stock.

→ Inventory might be either raw materials or semifinished products or finished items.

→ Types of Inventory :-

① Raw materials :- Raw materials are those basic unfabricated materials which have not gone any operation since they are received from the supplier.

② Brough out parts :- These parts refer to those finished parts, which are purchased from outside as per company's specification.

③ Work in process inventory :- These refer to those materials which are in partially completed condition.

④ Finished inventory :- These refer to the completed product ready for dispatch.

(5) Maintenance, repair and operating stores

These inventories refer to those items which are not part of the final product but are consumed in the production process.

Example → spare parts
oil
grease.

(6) Tool inventory :- These type of inventories include both standard tools and special tools.

3.2 :- Objectives of Inventory Control :-

(1) To ensure adequate supply of products to customers and to avoid shortage.

(2) To minimize financial investments in inventories.

(3) Efficient purchasing, storing, consumption and accounting for materials.

(4) To maintain timely record of inventories of all the items.

(5) To ensure timely action for replenishments.

(6) To provide a reserve stock for variations in lead time of delivery of materials.

(7) To provide a scientific base for both short term and long term planning of materials.

3.3 :- Benefits of Inventory control

(1) Improvement in customer relationship because of timely delivery of goods and services.

(2) Smooth and uninterrupted production and hence no stock out.

(3) Efficient utilization of working capital.

(4) Helps in minimizing loss.

(5) Economy in purchasing.

(6) eliminates the possibility of duplicate ordering.

3.4 :- Costs Associated with inventory :-

(1) Purchase Cost :-

The value of an item is its unit purchasing cost.

② Capital cost :- It is the total cost needed to bring a project to a commercially operable status.

③ Ordering Cost →

* It is also called as procurement cost or replenishment cost.

two types of costs.

① Fixed cost

② Variable cost.

* fixed costs do not depend on the number of orders whereas variable costs change with respect to the number of orders placed.

④ Inventory carrying cost :-

The inventory cost includes

① Storage cost

② Handling cost.

③ Tax and insurance.

④ costs of record keeping

⑤ product obsolescence.

⑥ Any kind of loss due to breakage.

2.5 Inventory control - Terminology

① **Demand** :- It is the number of items required per unit time.

② **Order cycle** :- The time period between two successive orders is called order cycle.

③ **Lead time** :- The length of time between placing an order and receipt of items is called lead time.

④ **Safety stock** :- It is also called as buffer stock or minimum stock.

⑤ **Re order Level (ROL)** → It is the point at which replenishment action is initiated.

⑥ **Re order quantity** :- This is the quantity of material to be ordered at the reorder level.

~~EOQ~~

3.7 :- Explain Economic Order Quantity for basic model :-

Assumptions :-

1. Demand is deterministic.
2. stock replenishment is instantaneous.
3. price of the material is fixed.
4. ordering cost does not vary with order quantity.

Let :-

D = Annual Demand.

C_o = ordering cost

C_h = Inventory carrying cost

C_p = price per unit.

Q = order quantity.

Q^* = Economic Order quantity

N = Number of orders placed per annum.

T_c = Total cost. per annum.

(1) Total Ordering cost =

No. of orders x Ordering cost/order

$$= \frac{D}{Q} \times C_o.$$

$$\text{Number of orders} = \frac{\text{Annual demand}}{\text{order quantity}}$$

② Annual inventory carrying cost =

Average inventory × inventory carrying cost

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

If the inventory carrying cost is expressed as a % of annual avg. inventory investment

$$C_h = C_p \times I$$

C_p = price per unit

I = percentage of inventory carrying cost.

③ Total cost = Annual ordering cost + Annual inventory cost

$$T_C = \frac{D}{Q} \times C_o + \frac{Q}{2} \times C_p \times I$$

To determine EOQ, differentiate total cost with respect to Q, and set the derivative equal to zero.

$$\frac{dT_C}{dQ} = 0$$

$$\Rightarrow \frac{d}{dQ}\left[\frac{QD}{Q} C_o + \frac{Q}{2} C_p \times I\right] = 0$$

$$\Rightarrow \frac{-DC_o}{Q^2} + \frac{C_p}{2} I = 0.$$

$$\Rightarrow \frac{DC_o}{Q^2} = \frac{C_p I}{2}$$

$$\Rightarrow \boxed{Q^* = \sqrt{\frac{2DC_o}{C_p \times I}}} = EOQ$$

Total cost based on EOQ

$$T_c = \frac{D}{Q^*} \times C_o + \frac{Q^*}{2} \times C_p \times I$$

$$= \frac{D}{\sqrt{\frac{2DC_o}{C_p \times I}}} C_o + \frac{\sqrt{\frac{2DC_o}{C_p \times I}}}{2} \times C_p \times I$$

$$\boxed{T_c = \sqrt{2DC_o C_p \times I}}$$

Optimum number of orders placed per annum

$$N^* = \frac{\text{Annual demand}}{EOQ}$$

$$\boxed{N^* = \frac{D}{Q^*}}$$

problem :-

A manufacturer has to supply his customers 3600 units of his product per year. Inventory carrying cost is Rs. 1.2 ~~unit~~ per unit per annum. The ordering cost is Rs. 80 per order. Find

① EOQ
② Annual total cost
③ optimum number of orders per annum.

Answer

$D = 3600$

$C_h = ₹1.2$

$C_0 = 80$ /~~per~~order.

① $EOQ = \sqrt{\frac{2DC_0}{C_h}}$

$= \sqrt{\frac{2 \times 3600 \times 80}{1.2}}$

$= 693$

② $T_C = \sqrt{2DC_0 \times C_h}$

$= \sqrt{2 \times 3600 \times 80 \times 1.2}$

$= 831.38$

③ $N^* = \frac{D}{Q^*} = \frac{D}{EOQ}$

$= \frac{3600}{693} = 5$ orders.

Answer

(8) $D = 10,000$

$C_p = 2$ RS.

$C_o = $ R36 / order

$I = 9\%$

Find

① EOQ

② optimum number of orders.

③ Minimum total Annual cost.

Answer :-

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

$$= \sqrt{\frac{2 \times D \times C_o}{C_p \times I}}$$

$$= \sqrt{\frac{2 \times 10,000 \times 36}{2 \times \frac{9}{100}}}$$

$$= 2000.$$

$$N^* = \frac{D}{EOQ} = \frac{10,000}{2000} = 5.$$

$$T_{Cm} = \sqrt{2 \times D \times C_o \times C_p \times I}$$

$$= \sqrt{2 \times 10,000 \times 36 \times 2 \times \frac{9}{100}}$$

$$= \sqrt{4 \times 100 \times 36 \times 9}$$

$$= 2 \times 10 \times 6 \times 3 = 360. \text{ RS / annum}$$

Answer

ABC Analysis :

→ In ABC analysis, items are segregated into three categories A, B and C on the basis of their annual usage.

→ This categorization is made to pay right attention and control demanded by items.

① A class item :- These items constitute 5-10% of the total items and account for 70-75% of the total money spent on inventories.

② B class item :- These items constitute 10-15% of the total item and represent 10-15% of the total expenditure on materials. These are the intermediate items.

③ C class item :- These are about 70-80% of the total item and constitute 5-10% of the total expenditure on materials.

Advantages of ABC analysis :-

① This approach helps the manager to give attention only on selective materials.

② The material manager is able to show the results within a short period of time.

③ It reduces clerical cost, saves time and effort and increases inventory turnover.

→ ABC analysis is considered as effective management control tool.

A class item	B class item	C class item
① Tight control on stock levels.	① Moderate control.	① Less control.
② Low safety stock.	② Medium safety stock.	② Large safety stock.
③ ordered frequently.	③ less frequently.	③ Bulk ordering.
④ continuous checking.	④ Broad check.	④ Hardly checking.
⑤ Weekly control statements.	⑤ Monthly control statements.	⑤ Quarterly control statements.
⑥ Minimize waste.	⑥ Quarterly control over waste.	⑥ Annual review regarding waste.
⑦ Continuous effort to reduce lead time.	⑦ Moderate effort.	⑦ ~~Annual review regarding w~~ ⑦ Minimum effort.

—o—

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Inspection & Quality Control

Content

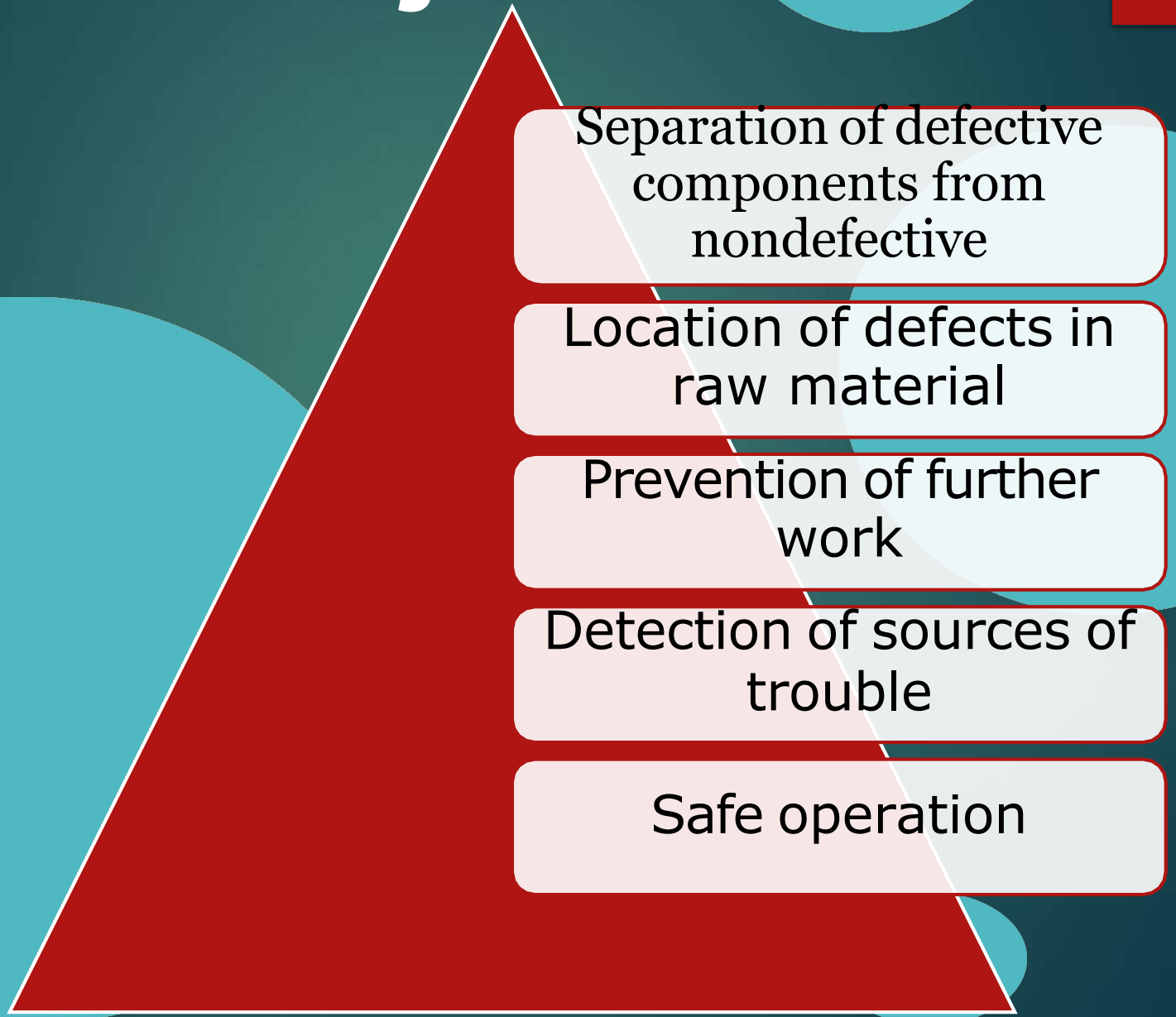
Definition

Inspection means checking the acceptability of manufactured products.

The act of checking whether the component is actually performing its function or not is called inspection

Inspection measures the quality of product or service in terms of predecided standards.

objective



- Separation of defective components from nondefective
- Location of defects in raw material
- Prevention of further work
- Detection of sources of trouble
- Safe operation

Types of inspection

Roving inspection

Fixed inspection

Key point inspection

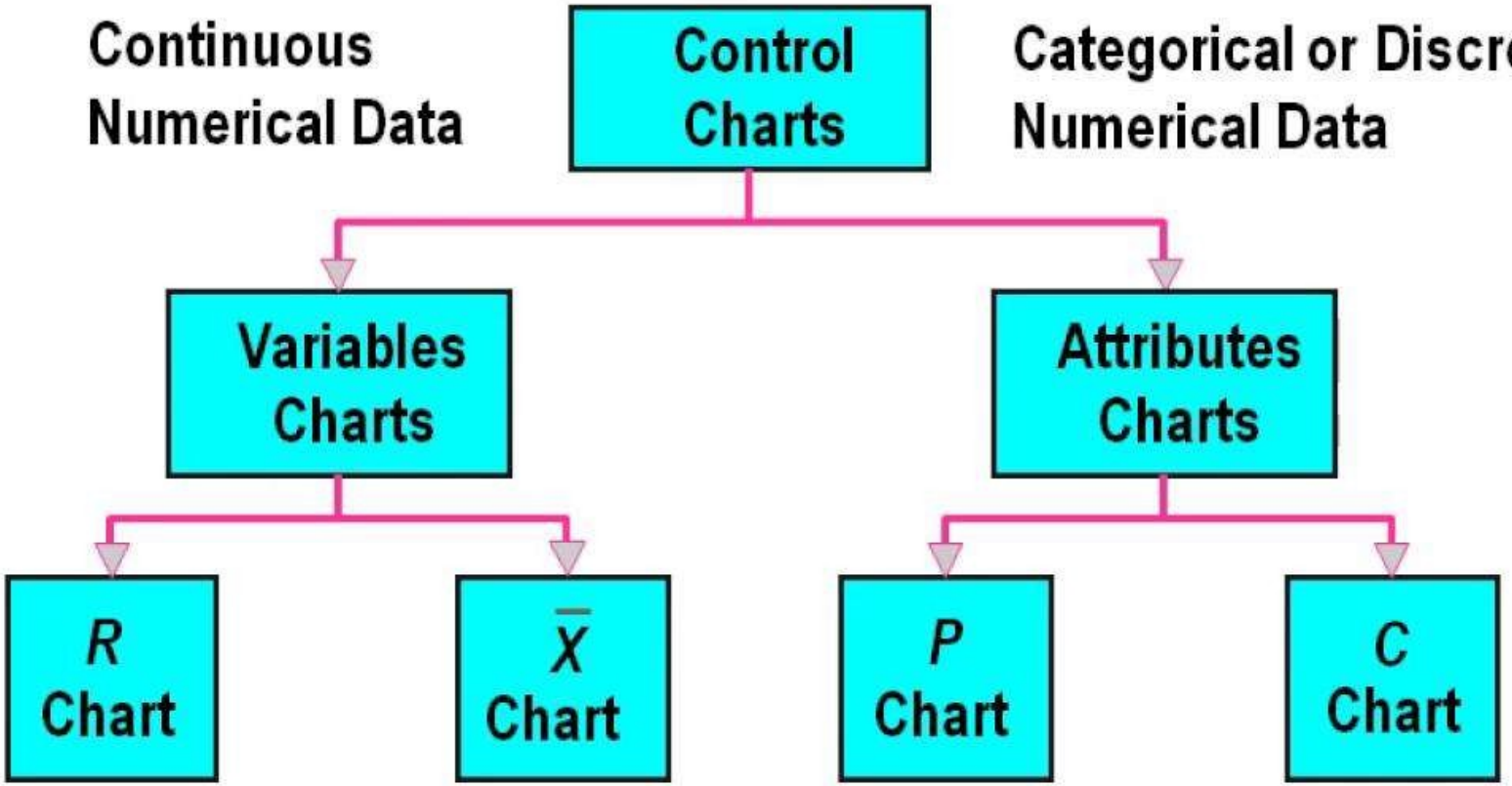
Final inspection

Control chart

- Control charts are based on statistical sampling theory according to which an adequate sized sample drawn at random from a lot.
- Control chart is graphical representation of the collected information.
- Control chart detects the variations in the processing.

TYPES

Control Chart Types



$\overline{X}$ CHART

It shows changes in process average and is affected by changes in process variability.

- It detects steady progress changes.

It is a chart for the measure of central tendency.

- It is the most common used variable chart.

$\bar{X}$ Chart Control Limits

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

Value depends upon sample size

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

Mean for sample i

$$\bar{\bar{x}} = \frac{\sum_{i=1}^{n} \bar{x}_i}{n}$$

Range for sample i

$$\bar{R} = \frac{\sum_{i=1}^{n} R_i}{\sqrt{n}}$$

Samples

Values of A2,D3 and D4 based on normal distribution

Subgroup Size	A2	D3	D4
2	1.88	0	3.27
3	1.02	0	2.57
4	.73	0	2.28
5	.58	0	2.11
6	.48	0	2.00
7	.42	.08	1.92
8	.37	.14	1.86
9	.34	.18	1.82
10	.31	.22	1.78

R CHART

It controls the general variability of the process and is affected by changes in process variability.

It is a chart for measure of spread.

It is used along with x bar chart.

R- Chart Control Limits

$$UCL_R = D_4\bar{R}$$

$$LCL_R = D_3\bar{R}$$

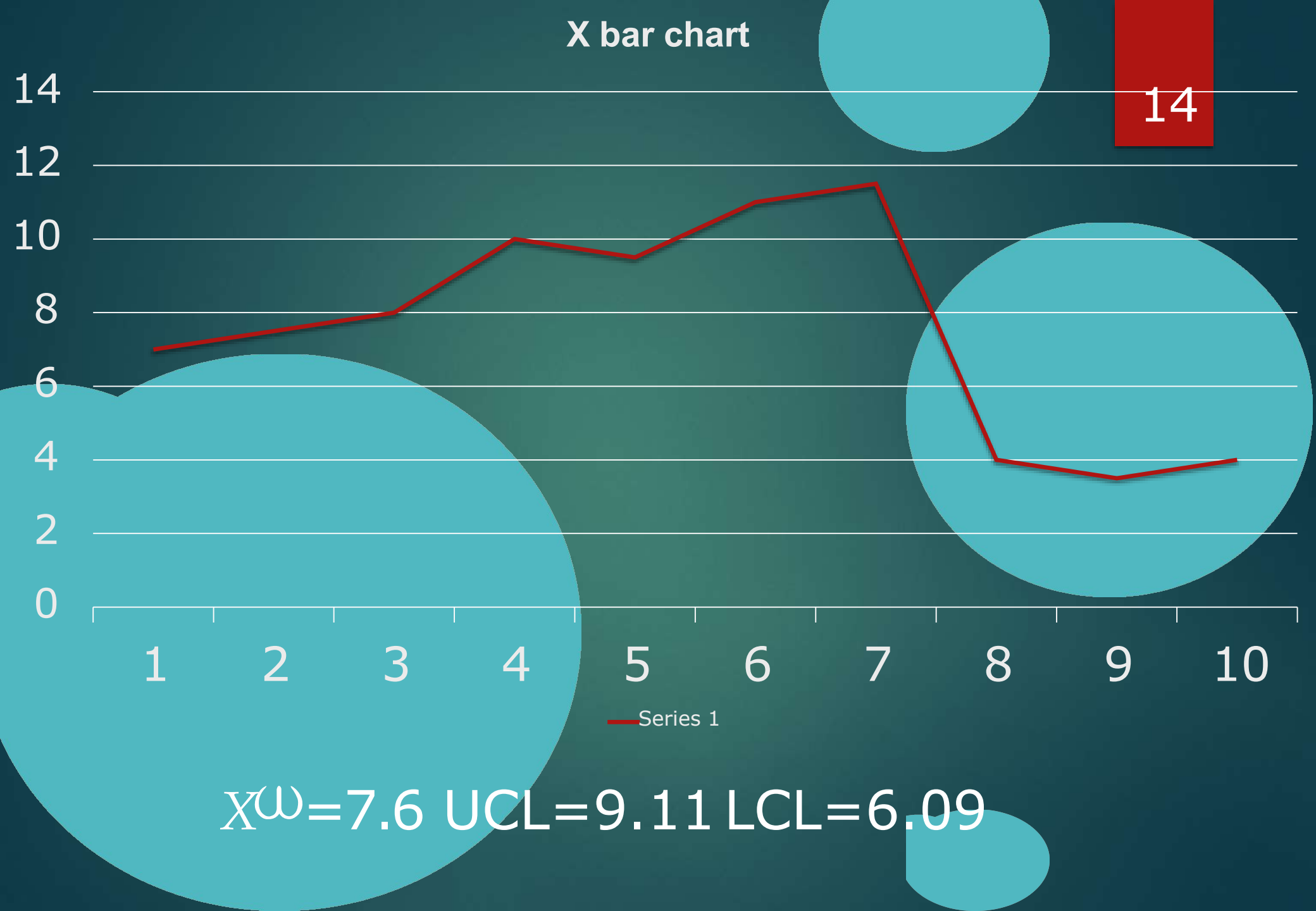
$$\bar{R} = \frac{\sum_{i=1}^{n} R_i}{n}$$

Range for Sample *i*

 # Samples

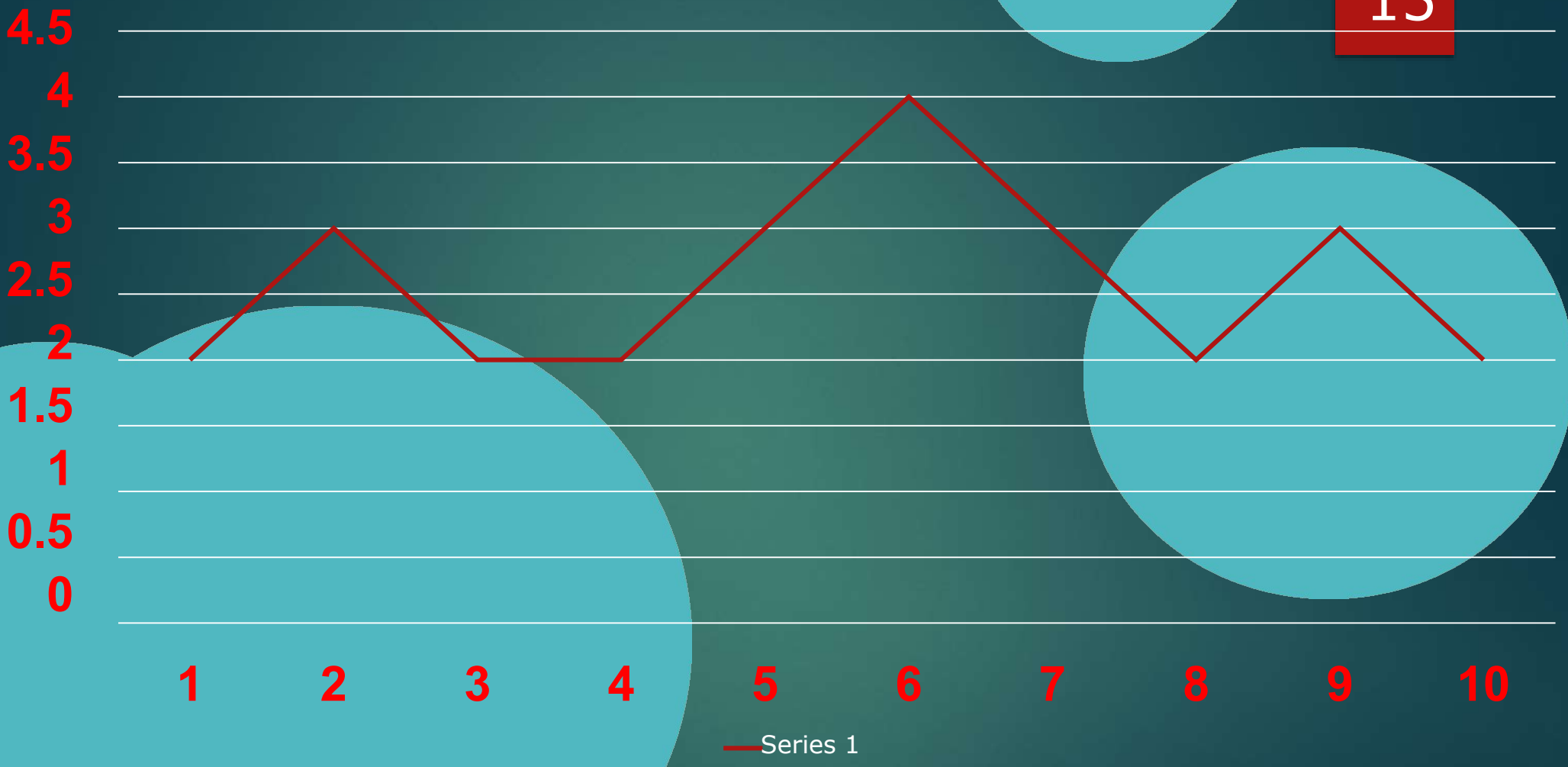
Example:Draw the Xbar chart and R chart for the following datas.

Sample no(sample size-5)	$\overline{X}$	R
1	7.0	2
2	7.5	3
3	8.0	2
4	10.0	2
5	9.5	3
6	11.0	4
7	11.5	3
8	4.0	2
9	3.5	3
10	4.0	2
	$\sigma\ \overline{X}$=76	$\sigma\ R$=26



$\bar{X}=7.6$ UCL=9.11 LCL=6.09

R CHART



$\overline{R}$=2.6 UCL=5.48 LCL=0

P Chart

- It is the fraction defective chart or % defective chart

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

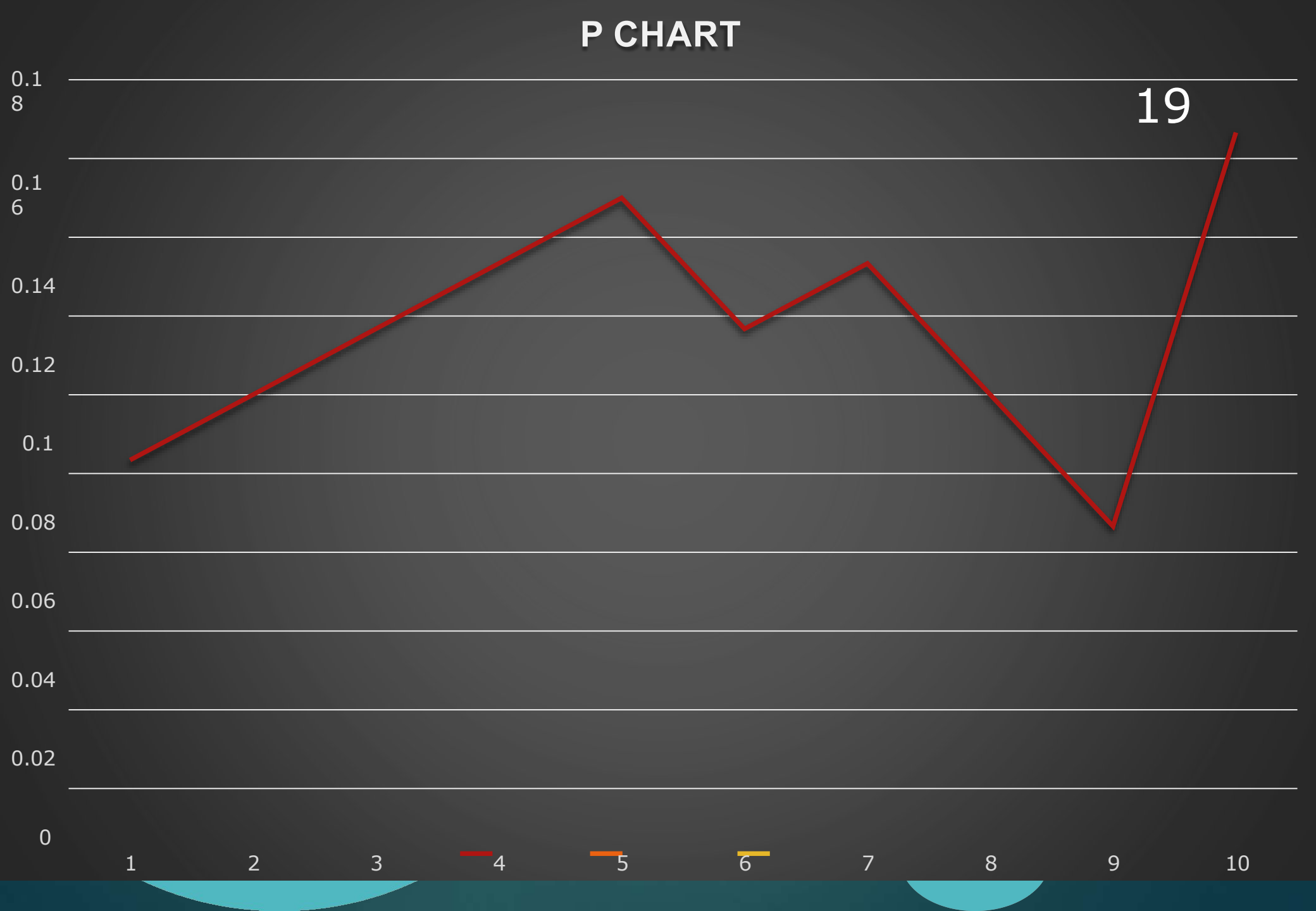
$$CL = \bar{p} = \sum p_i \Big/ \sum n_i$$

$$LCL = \bar{p} - 3\sqrt{\left(\frac{\bar{p}(1-\bar{p})}{n_i}\right)}$$

Example:Draw the p chart

date	Np of pieces inspected (a)	No of defective pieces found(b)	Fraction defective (p)	% of defective 100p
may1	300	25	0.0834	8.34
2	300	30	0.1	10
3	300	35	0.1167	11.67
4	300	40	0.1333	13.33
5	300	45	0.1500	15.00
6	300	35	0.1167	11.67
7	300	40	0.1333	13.33
8	300	30	0.1	10
9	300	20	0.0666	6.66
10	300	50	0.1666	16.66
	total=3000	total=350		

$\bar{P}$=0.1167 ,UCL=0.1723 ,LCL=0.0611


P CHART
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
19
1
2
3
4
5
6
7
8
9
10

Series 1
Column1
Column2

C CHART

- It is the control chart in which the number of defects in a piece are plotted.
- It controls number of defects observrd per unit.
- Sample size remains constant.

C-Chart Control Limits

$$UCL_{\bar{c}} = \bar{c} + 3\sqrt{\bar{c}}$$

$$LCL_{\bar{c}} = \bar{c} - 3\sqrt{\bar{c}}$$

$$\bar{c} = \frac{\sum_{i=1}^{k} c_i}{k}$$

 # Defects in Unit i

 # Units Sampled

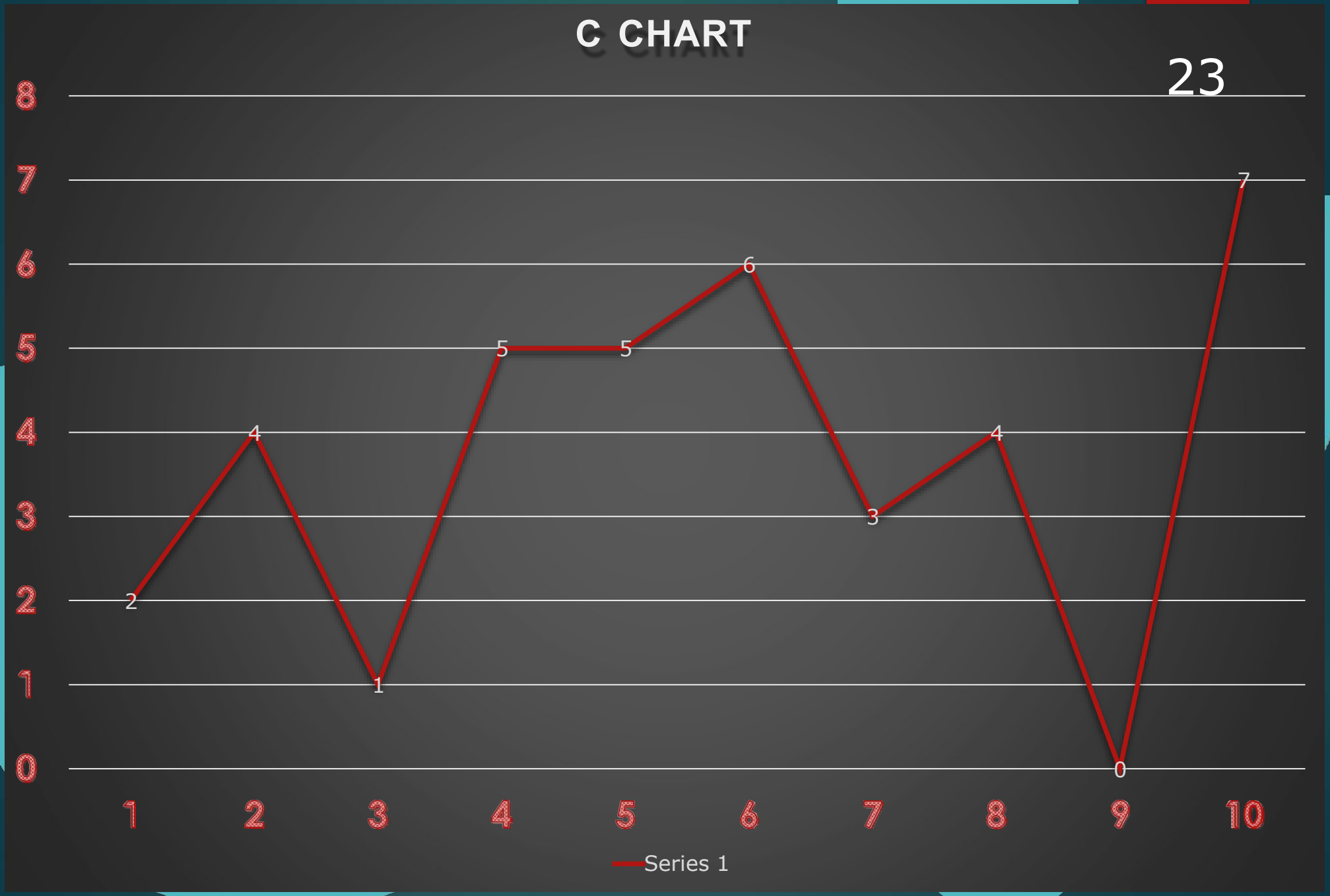
EXAMPLE:Draw the C chart.

product	No of defects (c)
1	2
2	4
3	1
4	5
5	5
6	6
7	3
8	4
9	0
10	7
	Total=37

$\bar{C}$=3.7

UCL=9.472

LCL=-


C CHART
23
8
7
6
5
4
3
2
1
0
2
4
1
5
5
6
3
4
0
7
1
2
3
4
5
6
7
8
9
10
Series 1

SIX SIGMA AN D ISO 9000

SUBMITTED BY

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SIX SIGMA

Six Sigma is a set of techniques and **tools for process improvement**. It was introduced by engineer Bill Smith while working at Motorola in 1986

Six Sigma seeks to improve the quality of the output of a process by identifying and **removing the causes of defects** and minimizing variability in manufacturing and business processes. It uses a set of quality management method

A six sigma process is one in which **99.99966% of all opportunities** to produce some feature of a part are statistically expected to be free of defects

The concept of sigma

- It is important to understand the difference between accuracy and precision
- Sigma is a measure of ***variation*** (the data spread)
- It is a statistical measure unit displaying a process capability and the measured sigma value is expressed by DPU(Defect Per Unit), PPM
- It is said that the process with higher sigma value is the process having smaller defects
- The more increase the sigma value, the more decrease the quality cost and Cycle Time

: The size or a standard deviation shows the distances between the inflection point and the mean. We could say the process has 3 sigma capability if 3 deviations are fit table between the target and the specification limit.

PROCESS

Define the priorities of customer with respect the quality

Measure the processes and the defects arising in product due to the process

Analyze the process to determine the most likely causes of defects.

Improve the process performance and remove the cause of the defects.

Ensure the improvements are maintained over time

DMAIC

DMAIC is a five-step method for improving existing process problems with unknown causes.

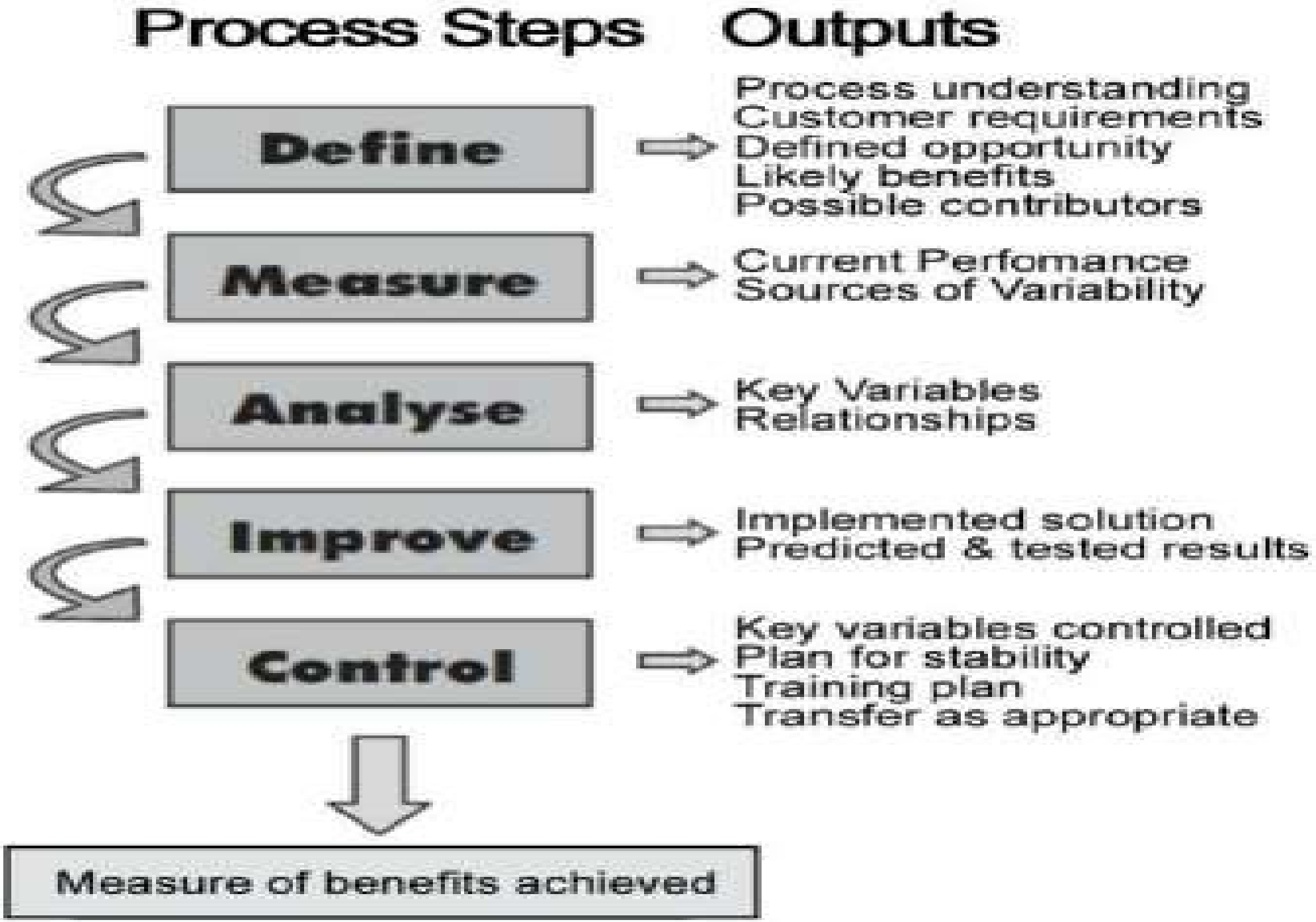
Define
Define the problem.

Measure
Quantify the problem.

Analyze
Identify the cause of the problem.

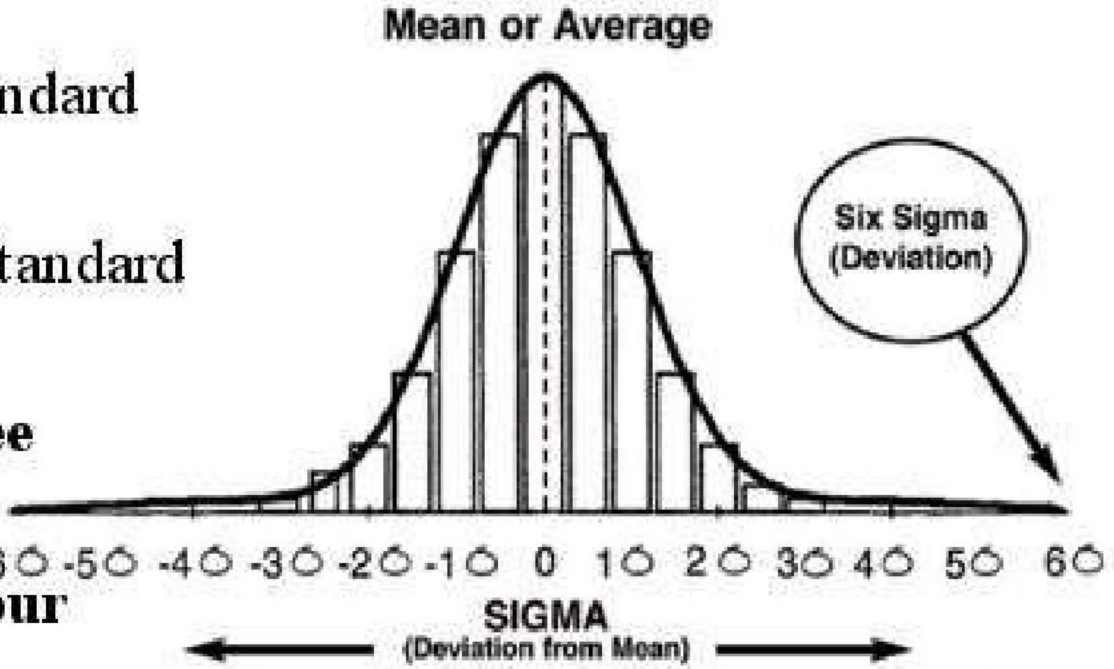
Improve
Implement and verify the solution.

Control
Maintain the solution.

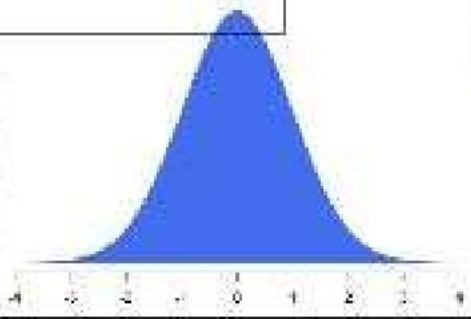

Process Steps
Outputs
Define
Process understanding
Customer requirements
Defined opportunity
Likely benefits
Possible contributors
Measure
Current Perfomance
Sources of Variability
Analyse
Key Variables
Relationships
Improve
Implemented solution
Predicted & tested results
Control
Key variables controlled
Plan for stability
Training plan
Transfer as appropriate
Measure of benefits achieved

Six Sigma Normal Curve

- 68% of the data points will fall within ± **one** standard deviation from the mean,
- 95% of the observations will fall within ± **two** standard deviations
- 99.73% of the data points will fall within ± **three** standard deviation from the mean.
- 99.9937% of the data points will fall within ± **four** standard deviation from the mean
- 99.99994% of the data points will fall within ± **five** standard deviation from the mean
- 99.9999998% of the data points fall within ± **six** standard deviation from the mean



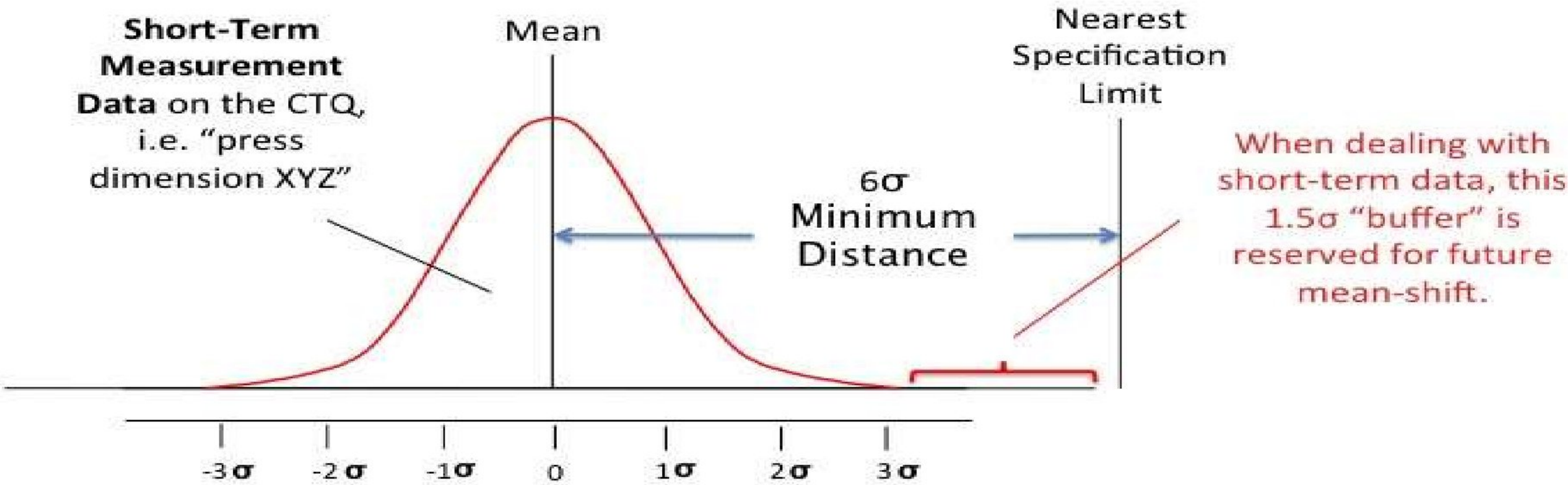
In a Six Sigma Process there are 6σ from either side of the mean



DMAIC Tools
Six Sigma Training Resources

Six Sigma Process Capability

A Six Sigma Process Has at Least Six Standard Deviations Between the Mean and the Nearest Spec Limit



Six Sigma DMAIC Process

- Develop Charter and Business Case
- Map Existing Process
- Collect Voice of the Customer
- Specify CTQs / Requirements

- Institutionalize Improvement
- Control Deployment
- Quantify Financial Results
- Present Final Project Results and Lessons Learned
- Close Project

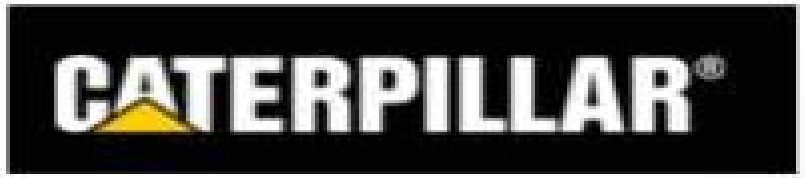
- Measure CTQs / Requirements
- Determine Process Stability
- Determine Process Capability
- Calculate Baseline Sigma
- Refine Problem Statement

- Select Solution (Including Trade Studies, Cost/Benefit Analysis)
- Design Solution
- Pilot Solution
- Implement Solution

- Identify Root Causes
- Quantify Root Causes
- Verify Root Causes

DMAIC = **D**efine, **M**easure, **A**nalyze, **I**mprove and **C**ontrol

Six Sigma Companies



DEFINITION

Iso 9000 is a series of standards published by ISO that defines ,establish and maintain an effective quality assurance system for manufacturing and service industries.

ISO 9000 standard is continuously being revised by standing technical committee and advisory groups who receives feedback from the proffessionals who are implementing the standard.

OBJECTIVE

- To faciliateinternational trade of goods and services.
- To obtain competitiveness by obtaining required quality in a cost effective way.
- Promoting a total quality control system.

Eight Quality Management Principles

ISO 9000 Series

ISO 9000	• Explains fundamental quality concepts and provides guidelines for the selection and application of each standard
ISO 9001	• Model for quality assurance in design, development, production, installation and servicing.
ISO 9002	• Model for quality assurance in the production and installation of manufacturing systems

ISO 9003

- Quality assurance in final inspection and testing.

ISO 9004

- Guidelines for the applications of standards in quality management and quality systems.

ISO 9000 and ISO 9004 are guidance standards. They describe what is necessary to accomplish the requirements outlined in standards 9001, 9002 or 9003.

Advantages

- Quality is maintained,
- ISO registration also has a significant bearing on market credibility as well.
- Opportunity to compete with larger companies,
- More time spent on customer focus,
- Confirmation that your company is committed to quality,
- May facilitate trade and increased market opportunities,
- Can increase customer confidence and satisfaction.

WHAT IS ISO 14000

- ISO 14000 is a series of voluntary international standards pertaining to environmental issues.
- They are designed to reduce the environmental effects from all aspects of business activities. It is believed that higher efficiency would be realized and "the cost of doing business" would also be reduced , by minimizing business exposure to environmental issues.

WHO SHOULD IMPLEMENT ISO 14000

- Any organization: manufacturers and service organizations.
- Any activities of each organization may cause the environmental aspects and impacts such as noise, dust, waste, contaminants in manufacturing process and ineffectively resources consumption in servicing. These can be minimized by implementing EMS.
- Although each country has already had her own environmental regulations, organizations are able to apply ISO 14000 series effectively within their system on voluntary basis and the benefit obtained is not only for organizations themselves but their society also.

- **Some of the standards under the ISO 14000 series**
- ISO 14001 is the EMS standard and it has a companion standard ISO14004
- 14010 series of standards are about auditing
- 14020 is about environmental labeling.
- 14030 is a standard on environmental performance evaluation.
- 14040 series standards are on environmental life cycle assessment(LCA) and they are the only part of ISO 14000 series that rely on competent engineering and environmental science.

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ENVIRONMENTAL POLICIES OF SOME COMPANIES:

- L&T
- ASHOK LEYLAND
- BILT
- TOYOTA KIRLOSKAR
- NIPPON TOYOTA MOOPEN MOTOR PVT.

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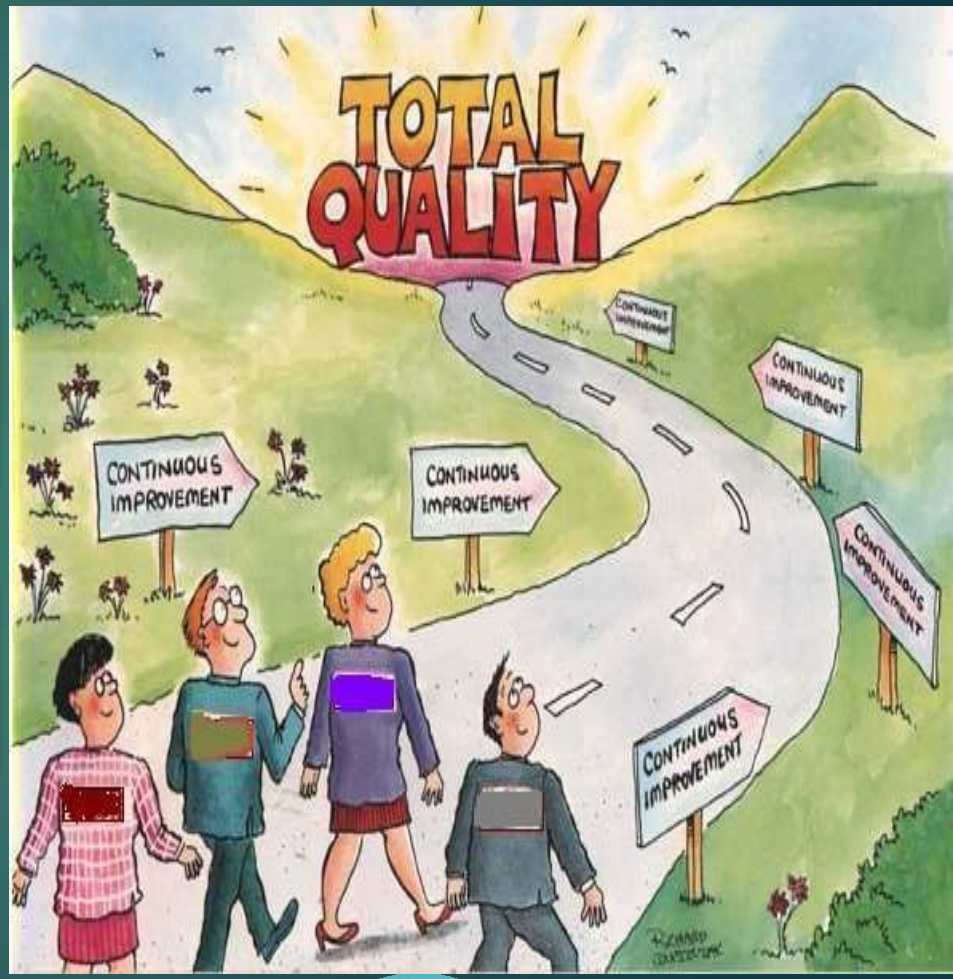
BENEFITS

- *Better conformance to environmental regulations,*
- *Greater marketability,*
- *Better use of resources,*
- *Higher quality goods and services,*
- *Increased levels of safety,*
- *Improved image and*
- *Increased profits.*

Total Quality Management (TQM) AND Just-In Time(JIT)

Total Quality Management

- **T** — Made up of the whole
- **Q** — Degree of excellence a product or service
- **M** — Act, art or manner of planning, controlling, directing



Content

Definition

An integrated organizational effort designed to improve quality at every level

Producing a nearly perfect product by eliminating errors in production

A continuous improvement management approach to meet customer satisfaction, profitability and competitiveness.

Concept


Produce quality work
Focus on the customer
A strategic approach to improvement
Improve continuously
Encourage mutual respect and teamwork

Characteristics

Committed management	Adopting and communicating	Closer customer relations
Closer provider relations	Benchmarking	Increased training
Open organization	Employee empowerment	Flexible production
Process improvements	Process measuring	

Aspects

Counting

- Tools
- Techniques
- Training

Customer

- Quality as a driving force and central concern

Culture

- Shared values
- Beliefs expressed by leaders

Principles

Customer focus

Leadership

People involvement

Process approach

System approach to management

Continuous improvement

Key Elements

- Focus on the Customer
  - Identify the organization's customers
  - Fulfilment of Customer requirement
- Employee Involvement
  - Motivating Workforce
  - Team Building and Training
  - Suggestion system
  - Reward a recognition
  - Gain Sharing & Performance Appraisal
- Continuous Improvement
  - Process
  - Performance
  - Commitment
  - Strategy

Advantages

- Improved quality
- Employee participation
- Team work
- Working relationships
- Customer satisfaction
- Employee satisfaction
- Productivity
- Communication
- Profitability
- Market share

Disadvantages

- Initial introduction cost
- Benefits may not be seen for several years
- Workers may be resistant to change

TQM Model


Customer Focus
Planning Process
Process Management
Process Improvement
Total Participation
Results

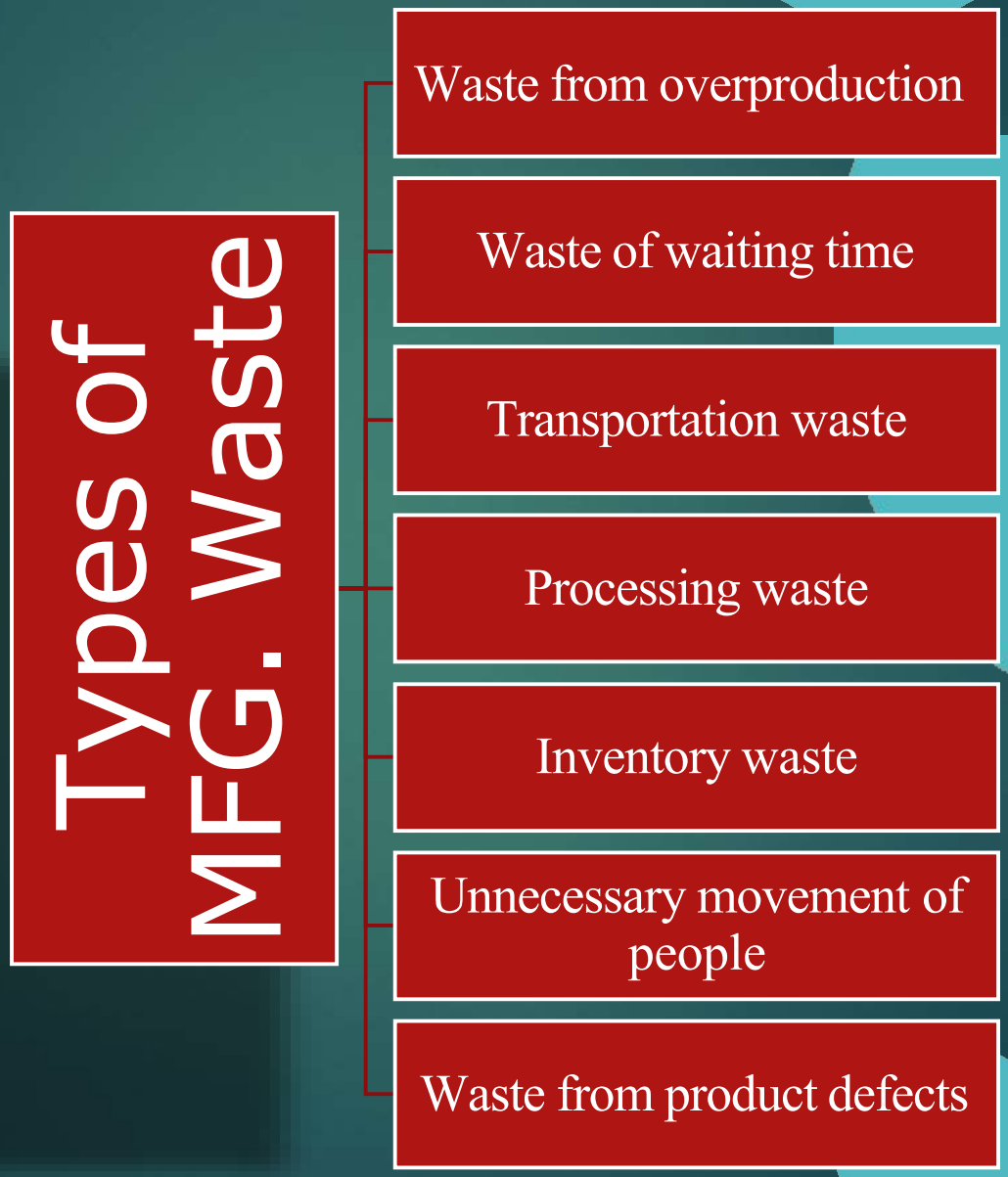
Just-In Time

Content

Introduction

- A Japanese management philosophy developed by Toyota
- Production of goods to meet customer demand exactly in time, quality and quantity
- Strive to eliminate sources of manufacturing waste

Just In Time


Types of MFG. Waste
Waste from overproduction
Waste of waiting time
Transportation waste
Processing waste
Inventory waste
Unnecessary movement of people
Waste from product defects

Objective

- Zero-defect goal in manufacturing
- Focus on continuous improvement
- Reduce inventories and inventory carrying costs
- eliminate waste
- Identifying and solving any waste related problem

Concept/Strategy

Quality	Design	Productivity	Part Cost
• Fast production • Correction of parts	• Fast response to engineering change	• Reduce rework • Reduce inspection • Part delay	• Low scrap cost • Low inventory cost

Elements

Striving for simplicity	A product oriented layout	Quality control	Poka-yoke
Preventive maintenance	Eliminating waste	Good housekeeping	Set up time reduction
Mixed production	Kanbans	Autonomation	Andon

Advantages

- Less space needed
- No excessive buying leading to less capital investment
- Waste reduction
- Smaller investment
- No excessive production leading to time & labour cost saving.

Disadvantages

- Risk of running out of stock
- Lack of control over time frame
- More planning required