GOVT. POLYTECHNIC KENDRAPARA

LECTURE NOTES

IEM

6th semester Mechanical

PREPARED BY

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PTGF MECHANICAL

TH1. INDUSTRIAL ENGINEERING & MANAGEMENT

Name of the Course: Diploma in MECHANICAL ENGINEERING			
Course code:		Semester	6th
Total Period:	60	Examination	3hrs
Theory Periods:	4P/W	Internal Assessment	20
Maximum Marks:	100	End semester Examination	80

A. RATIONALE:

Main objective of Mechanical Engineering is to produce goods and services for benefit to mankind. Such productions are done utilizing various resources like Men, Materials, machines and Money. Industrial engineering and quality control is the subject which allows optimized use of such resources and hence very important for a mechanical engineer.

B. COURSE OBJECTIVES:

After undergoing this course, the students will be able to:

1.Identify the place for a new plant set up and systematic arrangement of machinery and shop for smooth production.

2.Take right decisions to optimize resources utilizations by improving productivity of the lands ,buildings,people,material,machines,money,methods and management effectively.

3.Understanding of stock management and maintenance to reduce plant ideal time.

4 To use the charts to record the quality of products.

5.To eliminate unproductive activities under the control of the management, supervisor, worker and the design of products and processes.

C. CHAPTER WISE DISTRIBUTION OF PERIORDS

Sl. No.	Topic	Periods
1	PLANT ENGINEERING	10
2	OPERATION RESEARCH	10
3	INVENTORY CONTROL	10
4	INSPECTION AND QUALITY CONTROL	15
5	PRODUCTION PLANING AND CONTROL	15

D. COURSE CONTENT

1. PLANT ENGINEERING:

1.1 Selection of Site of Industry.

1.2 Define plant layout.

1.3 Describe the objective and principles of plant layout.

1.4 Explain Process Layout, Product Layout and Combination Layout.

1.5 Techniques to improve layout.

1.6 Principles of material handling equipment.

1.7 Plant maintenance.1.7.1 Importance of plant maintenance.

1.7.2 Break down maintenance.

1.7.3 Preventive maintenance.

1.7.4 Scheduled maintenance.

2. OPERATIONS RESEARCH:

2.1 Introduction to Operations Research and its applications.

2.2

Define Linear Programming

Problem,

2.3Solution of L.P.P. by graphical method.

2.4 Evaluation of Project completion time by Critical Path Method and PERT

(Simple problems)-

2.5Explain distinct features of PERT with respect to CPM.

3. INVENTORY CONTROL:

3.1 Classification of inventory.

3.2 Objective of inventory control.

3.3 Describe the functions of inventories.

3.4 Benefits of inventory control.

3.5 Costs associated with inventory.

3.6 Terminology in inventory control

3.7 Explain and Derive economic order quantity for Basic model. (Solve

numerical)

3.8 Define and Explain ABC analysis.

4. INSPECTION AND QUALITY CONTROL:

4.1Define Inspection and Quality control.

4.2Describe planning of inspection.

4.3 Describe types of inspection.

4.4 Advantages and disadvantages of quality control.

4.5 Study of factors influencing the quality of manufacture.

4.6 Explain the Concept of statistical quality control, Control charts (X, R,

P and C - charts).

4.7 Methods of attributes.

4.8 Concept of ISO 9001-2008.

4.9.1 Quality management system, Registration /certification procedure.

4.9.2 Benefits of ISO to the organization.

4.9.3 JIT, Six sigma,7S, Lean manufacturing

4.9.4 Solve related problems.

5.0 PRODUCTION PLANNING AND CONTROL

5.1 Introduction

5.2 Major functions of production planning and control

5.3 Methods of forecasting

5.3.1 Routing

5.3.2Scheduling

5.3.3 Dispatching

5.3.4 Controlling

5.4 Types of production

5.4.1 Mass production

5.4.2 Batch production

5.4.3 Job order production

5.5 Principles of product and process planning.**Syllabus to be covered before IA:** Chapter 1,2,3

Learning Resources:			
Sl. No.	***Name of Authors***	***Title of the Book***	***Name of the Publisher***
1	O.P.KHANNA	INDUSTRIAL ENGINEERING & MANAGEMENT	DHANPAT RAI & SONS

2	MARTAND TELSANG	INDUSTRIAL ENGG & PRODUCTION MANAGEMENT	S.CHAND
3	M.MAHAJAN	STATISTICAL QUALITY CONTROL	DHANPAT RAI &SONS

PLANT ENGINEERING

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

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

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

Plant location involves two major activities

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

Plant location problem

1. Selection of region
2. selection as a community

3. selection of a particular site
   Conditions that demand city location
   Conditions that demand sub-urban location
   Conditions demanding rural location

Factors affecting plant location

1. Nearness to raw material – It will reduce the cost of transporting raw material fromthe vendor's end to the plant sugar, cement, jute and cotton textiles.
2. Transport facilities – A lot of money is spent both in transporting the raw material and the finished goods speedy transport facilities ensure timely supply of raw materials to the company and finished goods to the customers, There are time basicmodes of physical transportation, air, road, rail, water and pipe line.
3. Nearness to market – It reduces the cost of transportation as well as the chances ofthe finished products getting damaged and spoiled in the way.
4. Availability of labour – Suitable labour force, of right kind, of adequate size (number), and at reasonable rates with its proper attitude towards work are a fewfactors which govern plant location to major extent. The purpose of the management is to face less boycotts, strikes or lockout and achieve lower labour cost per unit of production.
5. Availability of fuel and power – Steel industries are located near source of fuel (coal)to cut down fuel transportation costs. Electric power should remain available continuously in proper quantity and at reasonable rates.
6. Availability of water - Depending on the nature of the plant, water should be available in adequate quantity and should be of proper quality water is essential forpaper and chemical industries.
7. Climatic condition – Climate greatly influence human efficiency and behavior. Textilemills require humidity with the developments in the field of heating, ventilating and air conditioning, climate of the region doesn't present much problem of course control of climate needs money.
8. Financial and other aids – Certain states give aids as loans, feed money, machinery,built up sheds etc. to attract industrialist.
9. Land – Topography, area, the shape of the site, cost, drainage and other facilities, the probability of floods, earthquakes etc. influence the selection of plant location.
10. Community attitude – Community attitude towards their work and towards the prospective industries cab make or mar the industry. Success of an industry dependson the attitude of the local people whether they want work or not.

11. Supporting industries – All industries will not make all the components and parts byitself and it subcontracts the work to vendors
12. Social Infrastructures – Availability of community facilities like
    A. Housing facilities
    B. Recreational facilities
    C. Educational facilities
    D. Medical facilities
    are to be considered.
13. Law and taxation – the policies of the state gent and local bodies concerning labourlaws, building codes, safely its are the factors that demand attention.

Plant layout:

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

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

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

Objectives of plant layout:

1. Material handling and transportation is minimized and efficiently controlled.
2. Bottle necks and points of congestions are eliminated so that the raw material and semi finished goods move fast from one work station to another.
3. Workstations are designed suitably and properly.
4. Suitable places are allocated to production centers and service centers.
5. Movements made by the workers are minimized.
6. Waiting time of semi-finished products is minimized.
7. Working conditions are safer, better and improved.
8. Increased flexibility of changes in product design and for future expansion.
9. Utilization of cubic space (length, width and height).
10. These are improved work methods and reduced production cycle times.

11. Plant maintenance is simpler.
12. Increased productivity and better product quality with reduced capital cost.
13. A good layout permits materials to move through the plant at the desired speed withthe lowest cost.

Principle of plant layout:

1. Principle of integration:

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

2. Principle of minimum movements and material handling:

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

3. Principle of smooth and continuous flow :

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

4. Principle of cubic space utilization :

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

5. Principle of safety and security and satisfaction :

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

6. Principle of maximum flexibility :

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

Advantage of plant layout:

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

Factors influencing plant layout

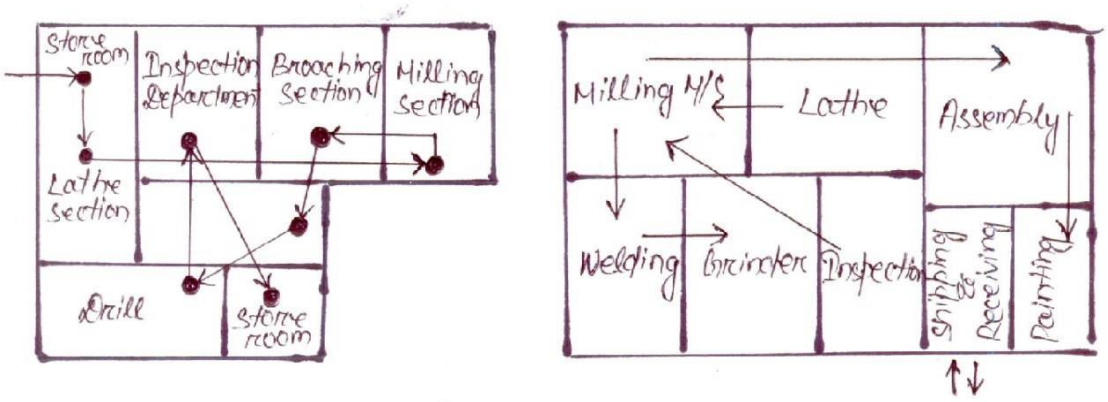
1. Type of production- Engg. Industry, process industry
2. Production system- Job shop, batch, mass production
3. Scale of production
4. Availability of total area
5. Arrangement of material handling system
6. Type of building- single storey, multi storey
7. Future expansion plan
8. Type of production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

Types of layout:

1. Process layout (Functional layout):

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

The arrangements of facilities are grouped together according to theirfunctions.



Advantages:

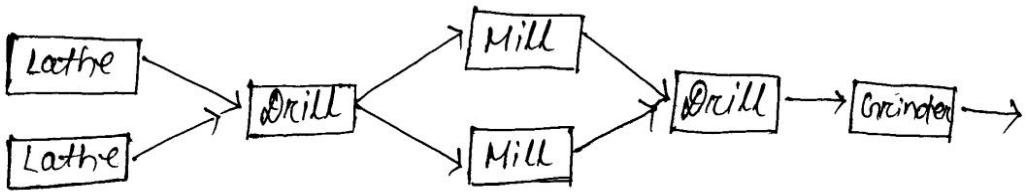
I. Wide flexibility exists during allotment of work to equipment and workers.
II. Better utilization of equipments
III. Lower investments on account of comparatively less no. of machine are used.
IV. Better product quality because to attend one type of machine.
V. Varieties of jobs coming as different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

Disadvantages:

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

Product layout (line layout):

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



Advantage:

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

Disadvantage:

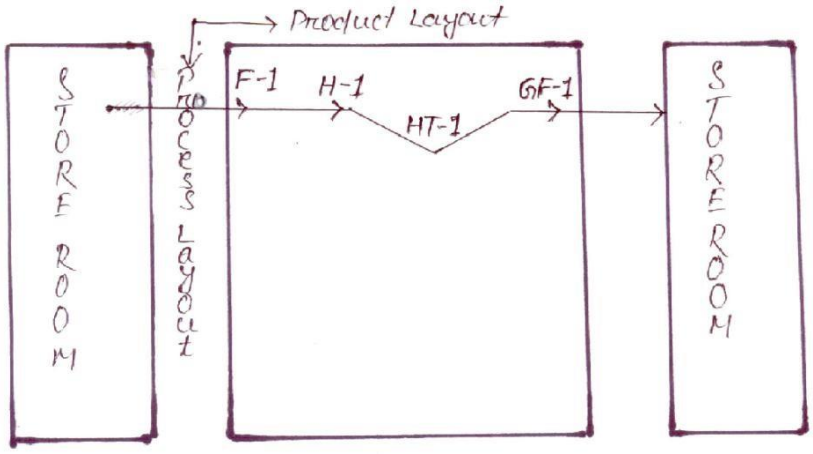
I. Lack of flexibility
II. Excessive idle time due to slowest machine
III. More machines to be purchased and kept which require high capitalinvestment
IV. One inspector has to attend a no. of machine in a production line.
V. It is difficult to increase production beyond the capacities of the productionlines.

2. Combination layout:

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

Ex – refrigerator manufacturing uses a combination layout.

Manufacturing various components → process layoutFor assembly of component → product layout



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

3. Fixed position layout:

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

Ex – ship building, aircraft manufacturer

Advantage:

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

Disadvantages:

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

Techniques to improve layout:

1. Accumulate basic data:

Such as

- Volume and rate of production
- Product specification and bill of material
- Process sheets indicating tools, equipments, the method and the productwhich will be manufactured
- Flow process charts

- Standard time to complete each operation

2. Analyze and co-ordinate basic data:
   In order to
   - The workforce size and type
   - No. of workstation required
   - Type of equipment required
   - Storage and other space requirements
   - Assembly chart and operation process chart help coordinating basic data
3. Decide equipment and machinery required:
   Can be calculated by
   - No. of articles to be produced
   - Capacity of each equipment
   - Time in which the order is to be completed
4. Select the material handling system:
   Which depends upon
   - Material or product to be moved
   - Container in which it will be moved
   - Length of movement
   - Frequency of movement
   - Speed of movement
5. Sketch plan of the plot:
   To mark building outline, roads, storage and service etc
   - The plan orientation should utilize maximum, the natural heat, light andother weather conditions.
6. Determine a general flow pattern:
   - The flow pattern of materials should be such that the distance involved isleast between the store and the shipping department through the production centers.
   - There should be minimum back tracking
   - Based upon the process or product requirement process, product orcombination layout.
   - Plant layout should be flexible to accommodate changes
7. Design individual workstations:

To get optimum

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

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

   Volume of each store item
   - No. of items to be kept at stores
   - Time of keeping the item
10. Make flow diagrams for workstations:
    And allocate them to areas on plot plan.

11. Plan and locate services areas such as offices, toilets, wash rooms, dispensary,cafeteria.
12. Make master layout by templates and models.
13. Check final layout:
    - Safe and economical material handling
    - Product design
    - Service area
    - Employee safety and comfort
14. Get official approval of the final layout about product drawings, BOM, manpower requirements, estimated expenditure.
15. Install the approved layout.

Principles of material handling equipment.

- **Planning Principle:** It establishes a plan which includes basic requirements, desirablealternates and planning for contingency.
- **Systems Principle:** It integrates handling and storage activities, which is cost effectiveinto integrated system design.
- **Unit Load Principle:** Handle product in a unit load as large as possible
- **Space Utilization Principle:** Encourage effective utilization of all the space available
- **Standardization Principle:** It encourages standardization of handling methods andequipment.

- **Ergonomic Principle:** It recognizes human capabilities and limitation by designeffective handling equipment.
- **Energy Principle:** It considers consumption of energy during material handling.
- **Ecology Principle:** It encourages minimum impact upon the environment during materialhandling.
- **Mechanization Principle:** It encourages mechanization of handling process whereverpossible as to encourage efficiency.
- **Flexibility Principle:** Encourages of methods and equipment which are possible toutilize in all types of condition.
- **Simplification Principle:** Encourage simplification of methods and process by removingunnecessary movements
- **Gravity Principle:** Encourages usage of gravity principle in movement of goods.
- **Safety Principle:** Encourages provision for safe handling equipment according to safetyrules and regulation
- **Computerization Principle:** Encourages of computerization of material handling andstorage systems
- **System Flow Principle:** Encourages integration of data flow with physical material flow
- **Layout Principle:** Encourages preparation of operational sequence of all systemsavailable
- **Cost Principle:** Encourages cost benefit analysis of all solutions available
- **Maintenance Principle:** Encourages preparation of plan for preventive maintenance andscheduled repairs
- **Obsolescence Principle:** Encourage preparation of equipment policy as to enjoyappropriate economic advantage.

Plant maintenance:

Plant-

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

Maintenance-

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

Importance of plant maintenance:

- Equipment breakdown leads to an inevitable loss of production
- An improperly maintained or neglected plant will sooner or later require expensiveand frequent repairs, because with the passage of time all machines or other facilities, building, etc wear out and need to be maintained to function properly.
- Plant maintenance plays a prominent in production management because plantbreakdown creates problem such as- loss of production time

    - ✓ Rescheduling of production
    - ✓ Spoilt materials (because sudden stoppage of process damages in-processmaterials)
    - ✓ Failure to recover overheads (because loss in production hours)
    - ✓ Need for overtime
    - ✓ Need for subcontracting work
    - ✓ Temporary work shortage- workers require alteration work

Types of maintenance:

Maintenance may be classified as

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

a) Corrective or breakdown maintenance:

- Corrective or breakdown maintenance implies that repairs are made after the equipment is out of order and it cannot perform its normal function any longer.Ex – electric motor will not start, a belt is broken.
- Under such conditions, production department calls on the maintenance department to rectify the defect. The maintenance department checks into thedifficulty and makes the necessity repairs.

- After removing the fault, maintenance engineers do not attend the equipment againuntil another failure or breakdown occurs.
- Breakdown maintenance is economical for those equipment whose down time andrepair costs are less.
- Breakdown type maintenance involves little administrative work, few records andcomparative small staff.

Causes of equipment breakdown:

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

Disadvantages of breakdown maintenance:

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

b) Scheduled maintenance:

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

c) Preventive maintenance:

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

Objective of FM:

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

Advantages:

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

d) Predictive maintenance:

- It is a newer maintenance technique.
- It uses human senses or other sensitive instruments such as audio gauges, vibration analysers, amplitude meters, pressure, temperature and resistance strain gauges topredict troubles before the equipment fails.
- Unusual sound coming out of a rotating equipment predict an trouble, an electriccable excessively hot at one point predicts an trouble.

In predictive maintenance, equipment conditions are measured periodically or on a continuous basis enables maintenance men to take timely action such as equipment adjustments, repair and overhaul.
It extends the service life of an equipment without fear of failure.

2. OPERATIONS RESEARCH:

Optimization techniques:

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

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

Method for optimizing:

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

Application:

Load allocation problems, component selection, load sharing.

Operation research:

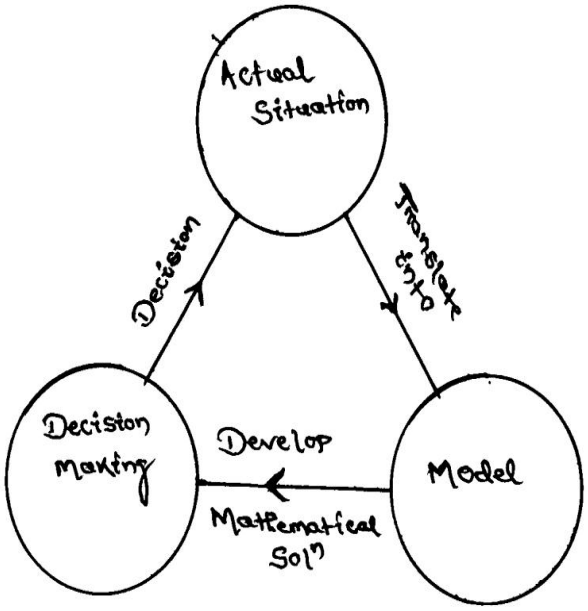
Operation research signifies research on operations. It is the organized application ofmodern science, mathematics and computer techniques to complex military, government, business or industrial problems arising in the direction and management oflarge systems of men, materials, money and machines

Methodology

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

Methods of operation research

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



Linear programming

Linear programming is powerful mathematical technique for finding the best use of limited resources of a concern. It may be defined as a technique which allocates scarce available resources under conditions of certainty in an optimum manner to achieve thecompany objectives which may be maximum overall profit or minimum overall cost.

LP can be applied effectively only if

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

Problem solving is based upon the system of linear equation:

Standard form of linear programming problem:

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

Optimize (maximum or minimize)

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

Subject to constraints

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

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

. . . .

. . . .

. . . .

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

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

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

a_{ij} (i = 1, 2, 3,……n)

(j = 1, 2, 3,……n)

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

LPP can solved by two methods.

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

Formulation of LP problem:

1. From the given problem, identify the key decisions to be made.
2. Identify the decision variables, whose values give the solution to the problem.
3. Write the objective in the quantitative terms and express it as a function of linearvariables.
4. Study the constraints and express them as a linear equation.

Graphical method:

We can solve LPP using two different method.

- ✧ Corner point method
- ✧ Iso-cost or Iso-profit method

Corner point method: To solve the problem using the corner point method you need to follow the following steps.

Step 1: Create a mathematical formulation from the given problem if not given.

Step 2: To convert the constraint in inequalities temporarily , in to equations.

Step 3: Draw straight lines on the graph paper using the constraint equations , and to mark the feasible solution on the graph paper.

Step 4: Find the coordinates of the feasible region (vertices) that we get from step3.

Step 5: Now evaluate the objective function at each corner point of the feasible region. Assume N and n denotes the largest and smallest values of these points.

Step 6: If the feasible region is bounded then N and n are the maximum and minimum value of the objective function.

Iso-cost or Iso-profit method:

Step 1
Step 2) **same as corner point method**
Step 3

Step 4: Find the convenient value of z (objective function) and draw the line of this objective function.

Step 5: If the objective function is maximum type then draw a line which is parallel to the objective function line and this line is farthest from the origin and only has a one common point to the feasible region.

OR

If the objective function is minimum type then draw a line which is parallel to the objective function line and this line is nearest from the origin and has at least one common point to the feasible region

Step 6: Now get the coordinates of the common point is used to find in step 5. Now , this point is used to find the optimal solution and the value of the objective function.

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

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

ANS:

Let Chair = X_1 Table = X_2

Maximum $Z = 20X_1 + 40X_2$

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

Subject to :

$X_1 + 4X_2 \leq 24$ (C_1)
$3X_1 + X_2 \leq 21$ (C_2)
$X_1 + X_2 \leq 8$ (C_3)
$X_1, X_2 \geq 0$ (C_4)

Where, C_1 is constraint No. 1.
C_2 is constraint No. 2.
C_3 is constraint No. 3.
C_4 is constraint No. 4.

Example 3 : A company produces two types of dolls A and B. Doll A is of superior quality and B is of lower quality. Profit on doll A and B is Rs 5 and Rs 3 respectively. Raw material required for each doll A is twice that is required for doll B. The supply of raw material is only1000 per day of doll B. Doll A requires a special crown and only 400 such clips are available per day. For doll B 700 crowns are available per day. Find graphically the product mix so thatthe company makes maximum profit.

ANS:

Max. $Z = 2x_1 + x_2$

$2x_1 + x_2 \leq 1000$
$x_1 \leq 400$
$x_2 \leq 700$
$x_1, x_2 \geq 0$

Graphical method:

1st step:

Formulate the LPM.

Max $Z = 20x_1 + 40x_2$

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

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

$x_1 + x_2 \leq 8$ (c_3)

$x_1, x_2 \geq 0$ (c_4)

c_1 is constrain no. 1 and so on.

2nd step:

2nd steps convert the constraint inequalities temporarily into

equations.

$x_1 + 4x_2 = 24$ (c_1)

$3x_1 + x_2 = 21$ (c_2)

$x_1 + x_2 = 8$ (c_3)

3rd step

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

4th steps:

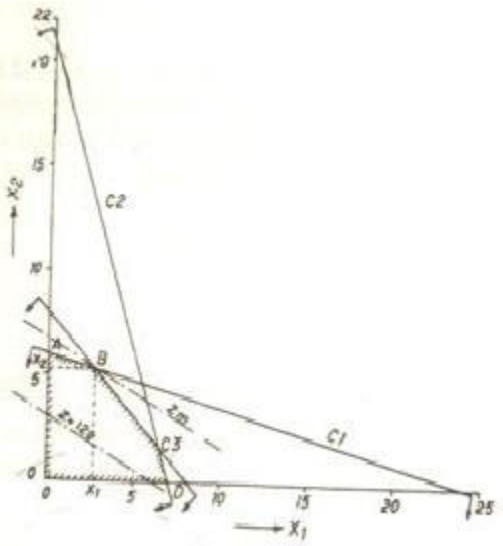
4th step is draw straight lines on the graph paper using constraint equations and tomark feasible solution on the graph paper.

Taking 1st constraint equation,

$x_1 + 4x_2 = 24$

$x_1 = 0, x_2 = 6$

$x_2 = 0, x_1 = 24$



Graphical method.

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

Similarly, c_2 and c_3 can be plotted.

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

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

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

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

5th step:

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

$X_1 = 0, x_2 = 3$

$X_2 = 0, x_1 = 6$

6th steps:

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

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

$x_1 + x_2 = 8$ (c_3)

$x_1 + 4x_2 = 24$ (c_1)

$3x_2 = 16 \Rightarrow x_2 = 5.3$

$3x_1 = 8 \Rightarrow x_1 = 2.7$

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

$\therefore$ The maximum value of Z is

$Z_m = 20x_1 + 40x_2 = 20 \times 8/3 + 40 \times 16/3 = 266.6$

Projects:

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

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

A network diagram:

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

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

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

Objective of Network Analysis:

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

Application of Network Analysis (PERT and CPM):

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

Basic concepts in network:

Network:

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

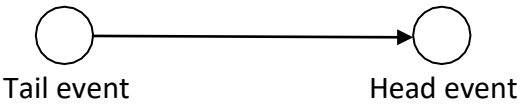
Activities:

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

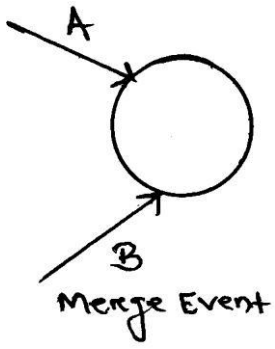
Event:

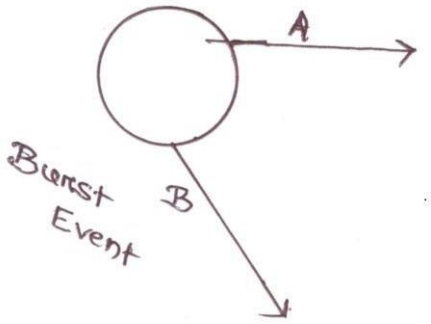
An event represents the start or completion of an activity. The beginning and endpoints of an activity are events.

Ex – Machining a component is an activity.
Start machining is an event.
Machining completed is an event.



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

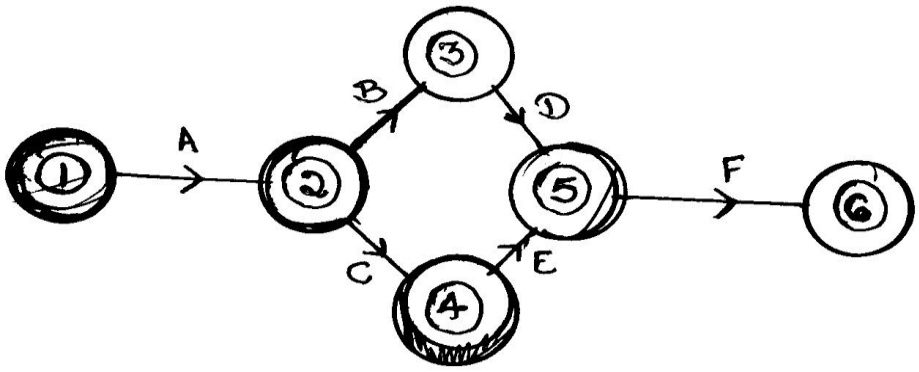




Predecessor and successor activities:

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

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



2-3, 2-4 are immediate successors

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

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

2-3 is the immediate predecessors.

Path:

An unbroken chain of activities between two events is called a path.Ex – A-B-D-F is a path connecting 1 & 6.

Dummy activity:

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

Terms related to network planning methods:

Event (node):

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

Ex – start the motor, loan approved.

Activity:

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

Ex – install machinery, arrange foreign exchange.

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

Activities are classified as:

1. Critical activities:

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

2. Non critical activities:

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

3. Dummy activities:

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

Critical path:

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

Duration:

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

Total project time:

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

Earliest start time (EST):

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

Earliest finish time (EFT):

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

Latest finish time (LFT):

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

Latest start time (LST):

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

LST = LFT – duration of that activity

Float or slack:

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

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

There are three type of float.

1. Total float:

   It is the additional time which a non-critical activity can consume withoutincreasing the project duration.

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

2. Free float:

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

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

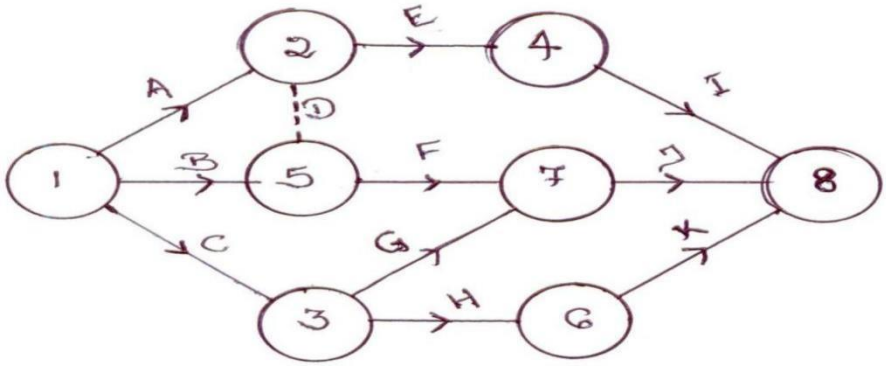
3. Independent float:

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

IF = EST of tail event – LFT of head event – activity duration.If IF is negative, then taken as 0.

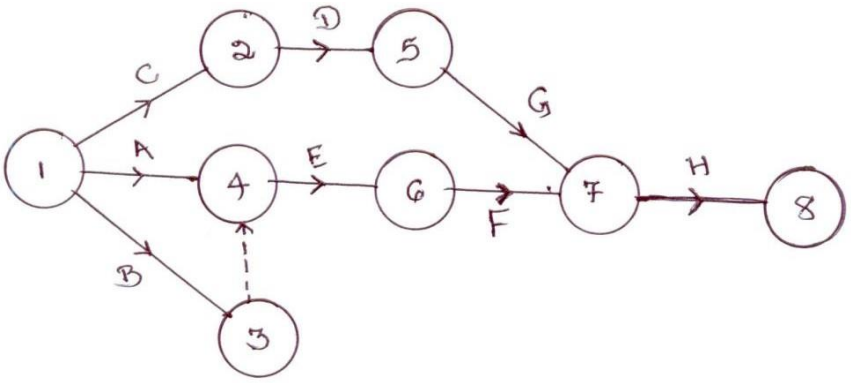
Numbering of events (Fulkerson's rule):

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



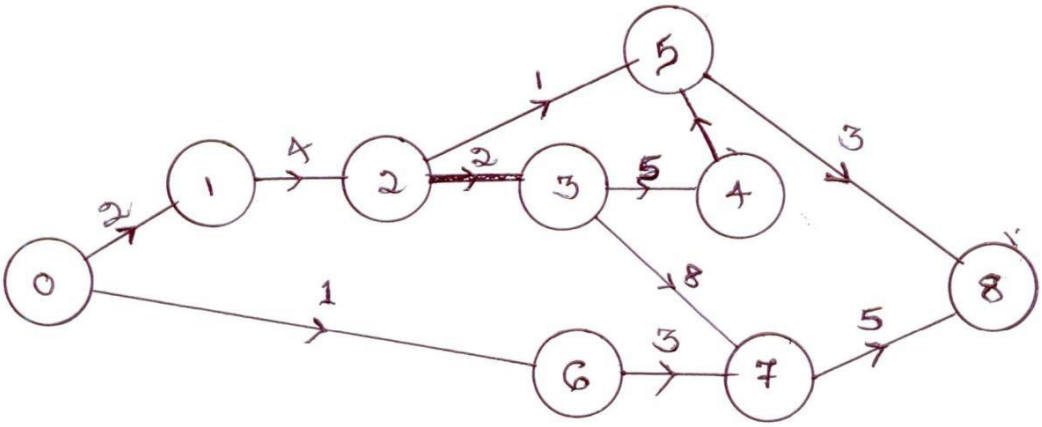
1. Construct the network from the information.

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



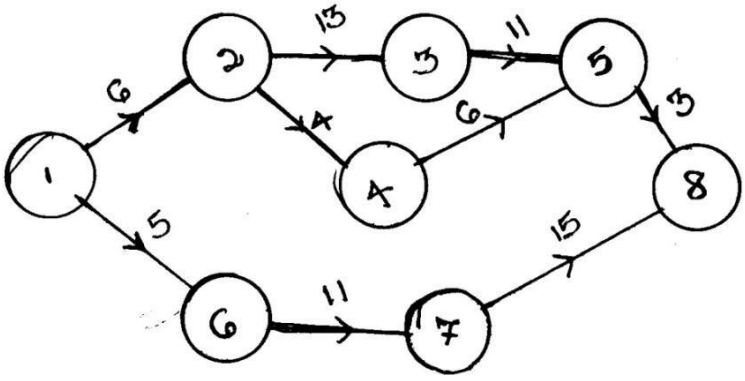
2. Construct the network from the information.

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



3. Construct the network from the information.

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



Critical Path Method:

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

Objective:

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

Programme Evaluation Review Technique (PERT):

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

It makes use of three time estimates.

I. Optimistic time (t_0)
II. Most likely time(t_m)
III. Pessimistic time (t_p)

I. Optimistic time (t_0):

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

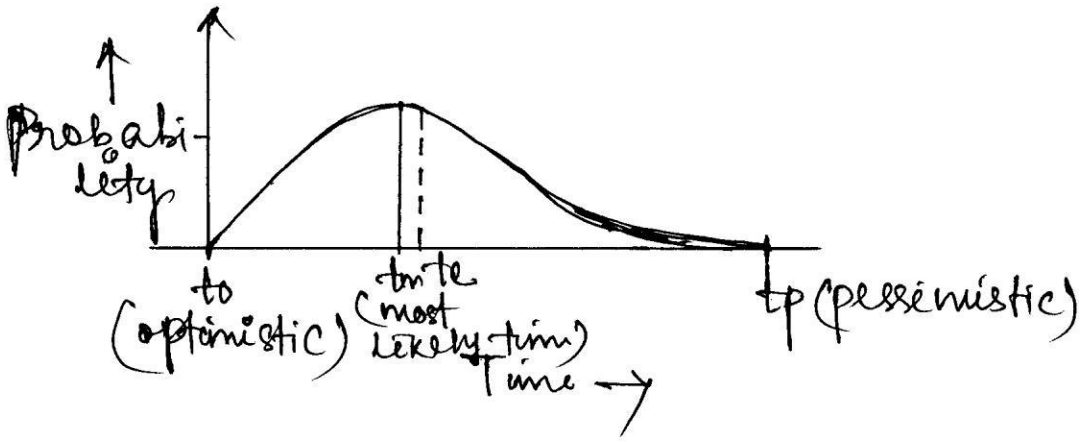
It is an estimate of minimum possible time to complete the activity under idealcondition.

II. Pessimistic time (t_p):

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

III. Most likely time(t_m);

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



According to β distribution curve $T_e = (1/6)x\ t_o + (2/3)x\ t_m + (1/6)x\ t_p$

$$T_e = (t_o + 4t_m + t_p)/6 \quad \text{----------1}$$

The standard deviation of time required to complete each activity.

$$\text{standard deviation } (\sigma) = (t_p - t_o)/6 \quad \text{----------2}$$

$$\text{Variance } \sigma^2 = ((t_p - t_o)/6)^2 \quad \text{----------3}$$

For the sake of statistical analysis the β-distribution is approximated to standard normal distribution whose statistics are given below.

$$Z = (x-\mu)/\sigma \quad \text{----------4}$$

Where x = Actual project completion time

μ = Expected project completion time

σ = Standard deviation of the expected project completion time.

$$\mu = \Sigma t_e \quad \text{----------5}$$

$$\sigma = \sqrt{\Sigma}\ \sigma^2 \quad \text{----------6}$$

Comparison between PERT and CPM

CPM	PERT
It is an activity oriented network	It is an event oriented network
It has deterministic approach . Probability value approaches to one here.	It has probabilistic approach. The probability distribution is of the type of β distribution
Only one time is calculated i.e , activity duration	Three types of times are estimated on the basis of which an expected time t_e is derived.
Time and cost are related by the curve , from this optimum time is derived which results in the minimum cost	Cost is directly proportional to time. Hence efforts are made to minimize the time so as to result in the minimum cost.
It is suitable for repetitive type of work where time and cost can be evaluated with fair degree of accuracy.	It is suitable for newer type of projects which have not been performed in the past and no exact assessment of time and cost are available.
Application: ✧ Construction work ✧ Maintenance work ✧ Civil engineering projects.	Application: ✧ Research work ✧ Lunching of space aircraft ✧ Development of missile programme

INVENTORY CONTROL

Inventory:

- Inventory is a detailed list of those movable items which are necessary to manufacture a product and to maintain the equipment and machinery in goodworking order.
- It represents those items which are either stocked for sale or they are in the processof manufacturing or they are in the form of materials which are yet to be utilized.
  Ex – money kept in the shape of HSS bit MS rod milling

Inventory control:

- It may be defined as the scientific method of finding out how much stock should bemaintained in order to meet the production demands and be able to provide right type of material at right time in the right quantities and at competitive prices.

- The objectives are
    1. To minimize investment in inventory
    2. To maximize the service levels to the firm's customers and its own operatingdepartment.

Types of inventories:

1. Raw inventories (raw materials):
    - Raw materials and semi-finished products supplied by another firm which are raw items for present industry.
    - Raw materials are those basic unfabricated materials which have not undergone any operation since they are received from the suppliers.
      Ex –round bars, angles, channels, pipes etc
2. Work-in-progress inventories:
    - Semi-finished products at various storages of manufacturing cycle
    - The items or materials in partially completed condition of manufacturing
3. Finished inventories:
    They are the finished goods lying in stock rooms and waiting dispatch.
4. Indirect inventories:
    - The inventories refer to those items which do not form the part or the finalproduct but consumed in the production process.
      Eg – machine spares, oil, grease, spare parts, lubricants
    - For proper operation, repair and maintenance during manufacturing cycle.

Objective of inventory control:

- Purchasing material at economical price at proper time and in sufficient quantity asnot to run slow
- Providing a suitable and secure storage location
- To maintain timely record of inventories of all the items
- A definite inventory identification system
- Adequate and responsible store room staff
- Suitable requisition procedure
- To provide a reserve stock

Advantages or benefits of inventory control

- One does not face shortage of materials

- Materials of good quality and procured in time minimized defect in finished goods.
- Delays in production schedules are avoided
- Production forgets are achieved
- Accurate delivery dates
- Economy in purchasing

Functions of Inventories:-

1) To ensure a continuous supply of materials and stock so that production should not suffer at the time of customers demand.
2) To avoid both overstocking and under-stocking of inventory.
3) To maintain the availability of materials whenever and wherever required in enough quantity.

Cost associated with inventory

1. Purchase (or production) cost:

   The value of an item is its unit purchasing or production cost.

2. Capital cost:

   The amount invested in an item is an amount of capital not available forother purchases.

3. Ordering cost:

   It is also known as procurement cost or replenishment cost or acquisition cost.

   Two type of costs- Fixed costs and variable costs.

   Fixed costs don't depend on the no. of orders whereas variable costs change

   w. r. t the no. of orders placed.

   I. Purchasing:

      The clerical and administrative cost associated with the purchasing, the cost of requisition material, placing the order,follow up, receiving and evaluating quotations.

II. Inspection:

The cost of checking material after they are received by the supplier for quantity and quality and maintaining records ofthe receipts.

III. Accounting:

The cost of checking supply against a given level of hand andthis cost vary in direct proportion to the amount of holding and period of holding the stock in stores.

This includes-

I. Storage costs (rent, heating, lighting etc.)
II. Handling costs (associated with moving the items. Such as labour cost,equipment for handling)
III. Depreciation, taxes and insurance
IV. Product deterioration and obsolescence
V. Spoilage, breakage

Inventory control terminology:

1. Demand:

   It is the no. of items (products) required per unit of time. The demand may be either deterministic or probabilistic in nature.

2. Order cycle:

   The time period between two successive orders is called order cycle.

3. Lead time:

   The length of the time between placing an order and receipt of items is calledlead time.

4. Safety stock:

   It is also called butter stock or minimum stock. It is the stock or inventory needed to account for delays in materials supply and to account for suddenincrease in demand due to rush orders.

5. Inventory turnover:

It the company maintains inventories equal to 3 months consumption it means that inventory turnover is 4 times a year i.e. the entire inventory isused up and replaced 4 times a year.

6. Reorder level:

   It is the point at which the replenishment action is initiated. When the stocklevel reaches ROL the order is placed for the item.

7. Reorder quantity:

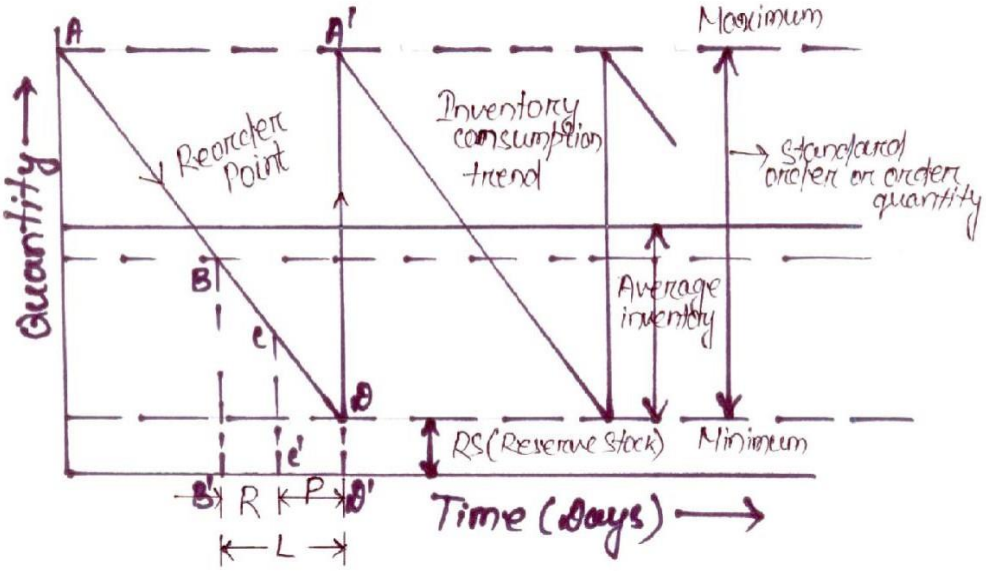
   This is the quantity of material to be ordered at the reorder level. Thisquantity equals to the EOQ.

Economic order quantity:

How much materials may be ordered at a time. An industry making bolts will definitely like to know the length of steel bars to be purchased at any one time. i.e. calledEOQ.

An economic order quantity is one which permits lowest cost per unit and is mostadvantageous.

Starting from an instant when inventory OA is in the stores, it consumes gradually in quantity from A along AD at a uniform rate. We know it takes L no. of days between initiating order and receiving the required inventory. As quantity reaches point B, purchase requisition is initiated which takes form B to C that is time R. from C to D is the procurementtime P. At the point D when only resource stock is left, the ordered material is supposed to reach and again the total quantity shoots to its maximum value i.e. the point A'(A=A')



Maximum quantity- OA is the upper or max limit to which the inventory can be kept inthe stores at any time.

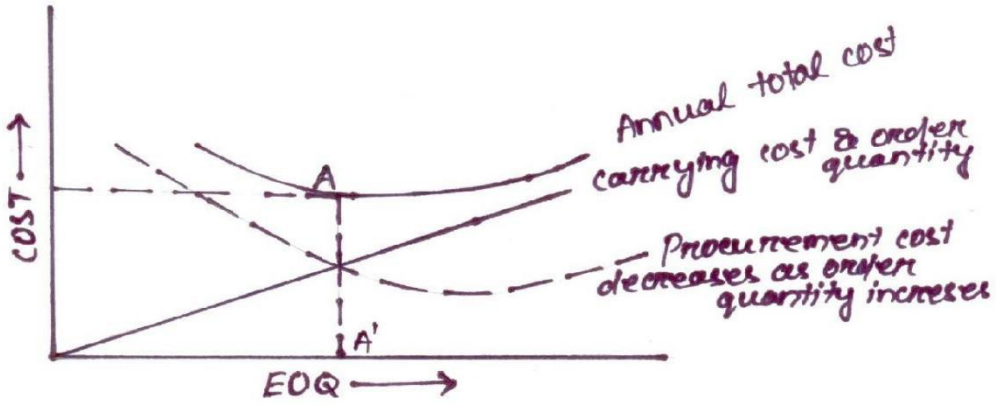
Minimum quantity- OE is the lower or minimum limit of the inventory which must bekept in the stores at any time

Standard order (A'D) - It is the difference between maximum and minimum quantity andis known as economical purchase inventory size.

Reorder point (B)- It indicates that it is high time to initiate a purchase order if not doneso the inventory may exhaust, even reserve stock utilized before the new material arrives.

From B' to D' it is lead time and it may be calculated on the basis of past experience.It includes-

a) Time to prepare purchase requisition and placing the order.
b) Time taken to deliver purchase order to the seller
c) Time for seller to get or prepare inventory
d) Time for inventory to be dispatched from the vendor's end and to reach thecostumer



Inventory procurement cost:

1. Receiving quotations
2. Processing purchase requisition
3. Following up and expediting purchase order
4. Receiving material and then inspect it
5. Processing seller's invoice

Procurement cost decrease as order quantity increases.

Inventory carrying cost:

1. Interest on capital investment
2. Cost of storage facility, up-keep of material, record keeping
3. Cost involving deterioration and obsolescence
4. Cost of insurance, property tax.

Carrying cost directly proportional to the order size or order quantity

Mathematical derivation of EOQ:

Let Q is the economic lot size or EOQ

C is the cost for one item.

I is the cost of carrying inventory in percentage per Period.

O is the procurement cost associated with one order.

A is the total quantity used per period or Annual demand/ Consumption

No. of purchase orders to be furnished = Total quantity/EOQ= $\frac{A}{Q}$

Total procurement cost = No. of orders × cost involved in one order

$$= \frac{A}{Q} \text{ x O}$$

Average quantity = $\frac{Q}{2}$

Inventory carrying cost = average inventory × cost per item × cost of carrying inventory in %

$$= \frac{Q}{2} \text{ x C x I}$$

Total cost (T) = $(\frac{Q}{2} \text{ xO}) + (\frac{Q}{2} \text{ x C x I})$

To minimize cost , $\frac{dT}{dQ}$ =0

$$\frac{d}{dQ}\left(\frac{A}{Q}\text{xO} + \frac{Q}{2}\text{x C X I}\right) = 0$$

$$-\text{AxOxQ}^{-2} + \frac{CI}{2} = 0$$

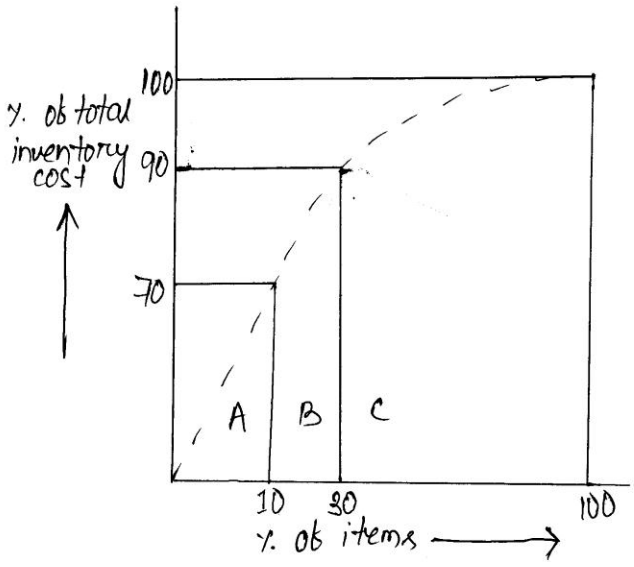
$$\frac{AO}{Q^2} = \frac{CI}{2}$$

$$Q^2 = \frac{2AO}{CI}$$

$$Q = \sqrt{\frac{2AO}{CI}}$$

ABC analysis:

ABC analysis helps differentiating the item from one another and tells how much valued the item is and controlling it to what extent is in the interest of an organization.



1. A-items:

   A items are high valued but are limited or few in number. They need careful and close inventory control and proper handling and storage facilities shouldbe provided for them.

   A items generally 70-80 % of the total inventory cost and 10 % of the totalitems.

2. B-items;

   B-items are medium valued and their umber lies in between A and C items.They need moderate control. They are purchased on the basis of past requirements.

   B-items generally 20-15 % of total inventory cost and 15-20 % of the totalitems.

3. C-items:

   C-items are low valued, but maximum numbered items. These items do not need any control. These are least important items, like clip, all pins, washers,rubber bands. No record keeping is done.

   C-items generally 10-5 % of the total inventory cost and constitute 75 % ofthe total items.

4.INSPECTION AND QUALITY CONTROL

INSPECTION: An item or component or product which is manufactured is required to perform certain functions. The act of checking whether a component actually does so or not is called inspection.

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

QUALITY CONTROL: A quality control system performs inspection , testing and analysis to conclude whether the quality of each product is as per laid quality standards or not.

PLANNING OF INSPECTION

While planning for inspection the following questions are decided before the inspection starts:

I. Where to inspect ?
II. When to inspect ?
III. How to inspect ?
IV. How much to inspect ?
V. What to inspect ?
VI. Who should inspect ?

Parameters (What to inspect ?)

The first phase of an inspection system is to decide what parameters are to be checked or inspected during the inspection. The parameters may be different for different kinds of jobs. So the inspector should know clearly about the parameters to be checked e.g. diameters , length etc. These make the variables to be studied in case of statistical analysis.

Time of Inspection (When to inspect ?)

There is no hard and fast rule as when the product is to be inspected but some general rules which may be followed are:

- Inspection should be done at each halt.
- Inspection should be done at each operation in the process.

The above rules help in fixing the responsibility for any defective work. This also helps in knowing where the quality is repeatedly not being followed. Broadly there are three stages of inspection.

- In coming material inspection.
- In process material inspection at each and every stage of halt.
- Outgoing or final inspection.

Person (Who should inspect ?)

Before we start inspection of a product or process , we should appoint the persons for a particular parameters or product. So that he will be responsible for any discrepancies , in the process for that particular parameters or product.

Place of Inspection (Where to inspect ?)

The place of inspection largely depends upon the manufacturing conditions, Circumstance and plant layout. Generally three types of locations are permitted for inspection. (Floor, Centralised , Separate room)

A) Floor Inspection : It can be done at the machine itself. In continuous production industries where every operation is linked through conveyors, it is not advisable to carry product at a separate place for inspection. The advantages of it can be enlisted as :

- It saves the transportation of material inspection room.
- It provides quick inspection service.
- It is best suited for bulky products.

B) Centralised/ Separate Inspection Room : In this system the products are brought to a separate inspection room or centrally located inspection counter. It has following advantages :

- Inspection conditions are better because precision instruments can be used.
- More accurate and rapid inspection.
- Less chances of inspector being influenced by personnel relations.

Types of Inspection :

1. Revolving inspection
2. Fixed inspection
3. Key-point inspection
4. Final inspection

Revolving inspection : In this type of inspection, the inspector walks around the workplace floor and checks machine to machine, samples of the work of various workers, and machines.The revolving inspection helps to find errors

during the process and before the final product is ready. It is more effective and not need to move the product to another department for checking.

Fixed inspection : Fixed inspection finds defects after the job has been completed. Fixed inspection is used when inspection equipment and tools can not be brought on the workplace. In this case, workers brought the sample to a centralized position of the workplace, at interval to check the quality.

Advantages of fixed inspection are the number of inspectors needed is less and workers and inspectors do not come in contact with each other, thus it eliminates the chance of approving the doubtful products

Key-point inspection : A key point is a stage of production beyond which it requires an expensive operation or it may not rework. Every product has a key point in its process of manufacturing. Inspection at key point separates faulty products and reject them from going to further processing. Thus avoid unnecessary further expenditure on those poor and substandard products. It reduces the cost of production.

Final Inspection : In the final inspection, the inspector checks the performance and appearance of the product before delivery.

These types of checking include destructive and non-destructive testing such as tensile testing, impact testing, fatigue testing, etc. The final stage of inspection ensures that the product should pass the X-ray radiography, ultrasonic inspection, etc.

Advantages and disadvantages of quality Control.

Advantages: It can help to prevent faulty good and services being sold.
It is not disruptive to production workers continue producing , inspector do the checking.
As with any quality system, business may benefit from an improved reputation for quality and this may increase sales.

Disadvantages: It does not prevent waste of resources when products are faulty.
The process of inspecting the goods or service costs money, e.g, the wages paid to the inspectors, the cost of testing goods in the laboratory.
It does not encourage all workers to be responsible for quality.

Major Factors that affect the quality of manufactured products

1. **Money:** Most important factor affecting the quality of a product is the money involved in the production itself. In the present day of tough and cut throat competition, companies are forced to invest a lot in maintaining the quality of products.
2. **Materials:** To turn out a high quality product, the raw materials involved in production process must be of high quality.
3. **Management:** Quality control and maintenance programmes should have the support from top management. If the management is quality conscious rather than merely quantity conscious, organisation can maintain adequate quality of products.
4. **People:**People employed in production, in designing the products must have knowledge and experience in their respective areas.
5. **Market:** Market of the product must exist before quality of the product is emphasized by management. It is useless to talk about the quality when the market for the product is lacking.For example, there is no demand for woolen garments in the hot climates is (e.g., southern part of India)
6. **Machine and Methods:** To maintain high standards of quality, companies are investing in new machines and following new procedures and methods these days.

STATISTICL QUALITY CONTROL:-

When stastical techniques are employed to Control quality or to solve quality control problems.Stastical quality control makes inspection more reliable and at the same time less costly.

It controls the quality level of the out going products.

Using stastical techniques, SQC collects and analyses data in assessing and controlling product quality. The technique SQC permits a more fundamental control.It scientifically fixes the process tolerances.

CONTROL CHARTS:-

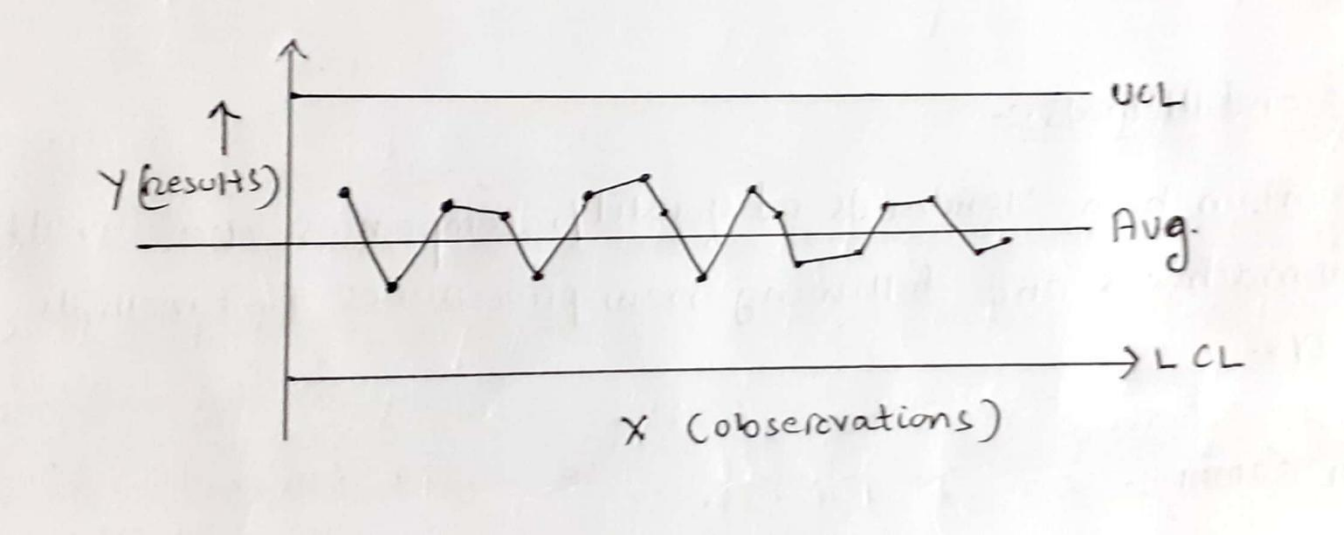
Stastistical process control (SPC) is the application of statistical technique to determine whether the out put of a process conforms to the product or service design. SPC is implemented through control charts that are used to monitor the out put of the process and indicate the presence of problems requiring further action.

Control charts can be used to monitor processes where out put is measured as either variables or attributes.

Characterstics of control charts:-

A control chart is a time-ordered diagram to monitor a quality characteristics, consisting of

- A nominal value or centre line.
- The average of several past samples.
- Two control limits used to judge whether action is required, an upper control limit (UCL) and lower control limit (LCL)
- Data points, each consisting of the average measurement calculated from a sample taken from the process, Ordered overtime.



$\bar{x}$

Control chart – Purpose and Advantages :

A control chart indicates whether the process is in control or out of control.
It determines process variability and defects unusual variations taking place in a process.
It ensures product quality level.
It warns in time, if the process is rectified at that time, scrap or percentage rejection can be reduced.
It provides information about the selection of process and setting of tolerance limits.

Type of control chart → Variables ($\bar{X}$ chart ,R chart, σ chart)

Type of control chart → Attribute (n-chart, np-chart, c-chart, u-chart)

Control charts are based on attributes or variables. In other wards quality can be controlled either through actual measurement (of dimension , weight , strength etc) or through attributes (as yes or No criteria) ,
A comparison of variables and attribute charts is given below.

Variable charts involve the measurement of the job dimensions and an item is accepted or rejected if its dimensions are with in or beyond the fixed tolerance limit , where as an attribute chart only differentiates between a defective item and a non-defective item with out going in to the measurements of its dimensions.
Variables charts are more detailed and contain more information as compared to attribute charts.
Attribute charts , being based up on go and no go data require comparatively bigger sample size.
Variable charts are relatively expensive because of the greater cost of collecting measured data.
Commonly used charts, like $\bar{X}$ and R charts for process control , P chart for analysing fraction defectives and C chart for controlling number of defects per piece , will be discussed below:

$\bar{X}$ chart :

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

When used along with R chart :

1) It tells when to leave the process along and when to chase and go for the causes leading to variation.
2) It secures information in establishing or modifying processes, specification or inspection procedure and
3) It controls the quality of incoming material

$\bar{X}$ and R charts when used together form a powerful instrument for diagnosing quality problem.

R-chart :

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

P-chart :

- It is a fraction defective chart or % defective chart (100P)
- Each item is classified as good(non-defective) or bad(defective)
- This chart is used to control the general quality of the component parts and it checks if the fluctuations in product quality (level) are due to chance cause alone.
- It can be used even if sample size is variable (I.e, different for all samples), but calculating control limits for each sample is rather cumbersome.
- Chart is plotted by calculating, first, the fraction defective and then the control limits. The process is said to be in control if fraction defective values fall within the control limits. In case the process is out of control an investigation to hunt for the cause becomes necessary.

C-chart :

- It is the control chart in which number of defects in a piece or a sample are plotted.
- It controls number of defects observed per unit or per sample.
- Sample size is constant.
- The chart is used where average number of defects are much less than the number of defects which would occur otherwise if everything possible goes wrong.
- Where as , P-chart considers the number of defective pieces in a given sample , C-chart takes in to account the number of defects in each defective piece or in a given sample.
- A defective piece may contain more than one defect , for example a cast part may have blow holes and surface cracks at the same line.
- The C-chart is preferred for large and complex part. Such parts being few and limited , however , restrict the field of use for C-chart as compared to P-chart

- C-chart is plotted in the same manner as P-chart except that the control limits are based on Poisson distribution which describes appropriately the distribution of defects.

$\bar{X}$ chart :

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

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

Where

$\bar{\bar{X}}$ = Central line of the chart , which can be either the average of past sample means or a target value set for the process.

$\bar{R}$ = Average of several past range values (I.e, R values) and the central line of the control chart.

A_2 = Constant to provide three-sigma limits for the sample mean.

R-chart :

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

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

Where

D_3 , D_4 = Constants that provide three standard deviation (3-σ) limits for the given sample size

P-chart :

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

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

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

n = Number of pieces inspected everyday.

D-chart :

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

Where, $\bar{c} = \frac{Total\ no\ of\ defects\ found\ on\ inspection}{Total\ Castings}$

What is ISO ?

1. **ISO** is the International Organization for standardization based in Geneva , Switzerland. On 23 Feb 1947, ISO began operations.
2. ISO develops technical standards to contribute in making the manufacturing and supply of goods and services more efficient , safer and cleaner.
3. Since 1947, ISO has published more than 15,000 standards.

About ISO 9001:

- It is a quality Management system standard.
- Initially published in 1987.
- First revision in 1994 , second revision in 2000.
- ISO 9001 : 2008 is the latest version released in 14 Nov 2008.
- Strong emphasis on customer satisfaction and continual Improvement.

ISO 9001 : 2008 QMS :

Quality :

Fitness for purpose/ defect free product.
Excellence.
Meeting customer Expectation and satisfaction.

Management :

Planning, Organizing, Directing, Controlling, Structuring.

System :

Work culture.
Frame-work
Policies and procedures.

Benefits of ISO certification to Organization

- Products are of consistent quality.
- Production is more efficient with less rework.
- Export marketing is easier.
- Increased market share.
- Customer confidence is enhanced as they expect products of consistent quality

JIT Technique (Just in time)

- Just-in-Time production is defined as a " philosophy that focuses attention on eliminating waste and purchasing or manufacturing
  Just enough of the right items just in time."
- It is a Japanese management philosophy applied in manufacturing which involves having the right items of the right quality and quantity in the right place and at the right time.
- Some observers have called JIT hand- to- mouth approach to production. It aims at having the right part at precise right time and in the right quantity to go in to assembly.

JIT philosophy is based upon two criteria.

1. JIT refers to production and supply of required number of parts when needed.
2. Another criteria is JIDOKA (self actuated) which means utilizing the full capacity of workforce I.e,the workforce is made responsible for producing quality products/parts just-in-time to support the next production process.

JIT management has high degree of several Japanese cultural aspects in its development.

Characteristics of JIT :

- JIT management allows an organisation to meet consumer demand regardless of the level of demand.

- The degree of time lapsed between material arrivals,processing and assembly of the final product for consumers is minimized.
- JIT allows a reduction in row material,work-in-process and finished goods inventories.
- This frees up a greater amount of space and time between operations with in plants.

Six sigma:

Six sigma is an approach to quality management that focuses on minimizing the defects in a product or service by measuring the number of defects in a process and systematically resolving them.Six sigma management tool can be widely applied to manufacturer,supply chains,engineering firms,finance,healthcare and many more

There are two methodologies that the six sigma approach utilizes.These provide a set of steps , a company must follow to optimize processes and ensure quality management.

The DMAIC Method:
The DMAIC method consists of five steps:

1. Define- Define what you want to achieve with your project.
2. Measure- Then you need to decide how you will measure your goals and which statistical analysis and data collection method you will use.
3. Analyze- To analyze the process and discover potential influencing variables.
4. Improve- You then need to make improvements based on the results of your Analysis.
5. Control- Finally,you will need to control the outcome by evaluating whether your changes have been successful or not

The DMADV Method:
The DMADV method, on the other hand, focuses on the development of a New product. This method also has 5 steps.

1. Define- Start by defining the purpose of the projects and set measurable goals.
2. Measure-The second step is to determine the customer requirements and define what characteristics should be measurable, so that data can be collected and compared with the specified requirements.

3. Analyze- The third step involves developing design alternatives, and identifying requirements and these determine the optimum combination of requirements. As well as determining the life cycle cost of the design and identifying the best available design option to meet the goals.
4. Design- The design phase involves developing a high-level design, and Then a more detailed model prototype to identify potential Flows before production.
5. Verify- The final phase is for the validation of the design.All relevant stakeholders should be satisfied with the design, and it should be effective in the real world

7S :

7S is a process for creating and maintaining an organized, clean, And high performance work place.

1S -Sort- separating the necessary item from the unnecessary item.
2S - Set in order - A place for everything and everything in its place
3S - Shine - Clean and inspect or inspect through cleaning.
4S - Standardize - Make up the rules, follow and enforce them.
5S - Sustain - Part of daily work and it becomes a habit
6S - Safety - Keeping yourself and others free from harm or danger
7S - spirit - Engaged , Encourages and motivates the team members to work in Better way.

Lean Manufacturing :

Lean Manufacturing is a systematic approach to identify and eliminates waste through continuous Improvement of Value stream
(Customer Value) enabling Product.
OR
Lean Manufacturing is a methodology which eliminates the NVA(Non-Value Added)Activities/Waste - from the system to maximize customer value. It Eliminates the waste from the system
To maximize the profit.
In Short Lean Manufacturing is all about to:

- ✓ Customer Value up
- ✓ Waste Down

6. PRODUCTION PLANNING AND CONTROLE

Production –Production are manufactured by the transformation of raw material intofinished goods

Planning- planning looks ahead, anticipates possible difficulties and decides in advance asto how the production is to be carried out.

Control- the control phase makes sure that programmed production is constantlymaintained

Need for PPC-

- To achieve effective utilization of firms resources
- To achieve the production objectives with respect to quality, quantity, cost andtimeliness of delivery.
- To obtain the uninterrupted production flow in order to meet customers demand w.r.t quality and committed delivery schedule.
- To help the company to supply a good quality products to the customer on thecontinuous basis at competitive rates

Objectives of PPC-

- Systematic planning of production activities to achieve the highest efficiency inproduction of goods
- To organize the production facilities like machines, men, etc. to achieve statedproduction objectives
- Optimum scheduling of resources
- To confirm to delivery commitments
- Materials planning & control
- To be able to make adjustments due to changes in demand and rush orders

Routing

- taking from raw material to the finished product, routing decides the path and sequence of operations to be performed on the job form one machine to another
- it determines what work is to be done and where and how it will be done

procedure

- the finished product is analysed from the manufacturing stand point in order to decide how many components can be made in the plant and how many others will be purchased form the outside through vendors, by sub contracting etc. make/buy decisions depends upon the work load in the plant, availability of equipment and personnel to manufacture all components and the economy associated with makingall components within the plant itself
- A parts list and a BOM is prepared showing name of the part, quantity, material specifications amount of materials required etc. The necessary materials thus can beproduced
- From production standards m/c capacities, m/c characteristics and the operations which must be performed at each stage of manufacture are
- established and listed inproper sequence on an operation and route sheet. the place of operations is also decided

  Operation and route sheet are separate. An operation sheet shows every thing aboutthe operation, i.e. operation description, their sequence, type of machinery, tools, setup and operation times, where as a route sheet besides listing the sequence of operations and relation between operation and machine, also details the section andthe m/c to whom the work will flow.

Operation and route sheet								
Component No. _____					Drawing _____			
Name of component _____					Quality _____			
Material _____					To be completed on _____			
Routing		Operation No.	Operation description	Tools required	Fixtures	Time		
Section	Machine					Set up	Operation	total

The difference between an operation sheet and a route sheet is that an operation sheet remains same for the components it the order is repeated but the route sheet may have to be revised it certain machines are already committed to other jobs.

- The next step is to determine the lot size or the number of components to bemanufactured in one lot or batch.
- Standard scrap factors and the places where scrap is very likely occur are identified causes for points out of control limits are explored and corrected. The variables likeworkers, machinery and schedules may adjust to minimize scrap.
- The cost of the component is analyzed and estimated through the information obtain in steps. The costs consist of material and labour charges and other specificand general indirect expenses.

Scheduling:

- Scheduling means when and in what sequence the work will be done. It involves deciding as to when the work will start and in a certain duration of time how muchwork will be finished.
- It determines which order will be taken up on which machine and in whichdepartment by which operator.

Scheduling procedure and techniques:

Master schedule:

Master schedule for the foundry shop Maximum production – 100 Hr Minimum production – 8 Hr			
Week-1	Week-2	Week-3	Week-4
15	15	20	15
25	25	12	10
20	28	32	
35			

- A master schedule resembles central office which possesses information about allthe orders in hand.
- As the orders are received, depending upon their delivery dates they are worked onthe master schedule when the shop capacity is full for the present week the newly acquired orders are carried over to due next week and so on.
- A master schedule updated continuously.

  - Advantages:

  - It is simple and easy to understand.
  - It can be kept current.
  - It involves less cost to make it and maintain.
  - It can be maintained by non-technical staff.

- A certain percentage of total weekly capacity can be allocated for rush orders.Disadvantages:

- It provides only overall picture.
- It does not give detailed information.Applications:

- For the purpose of loading the entire plant.
- In research and development organizations.
- For the overall planning in foundries, computer entries, repair shops etc.

Scheduling technique:

a) Perpetual schedule:

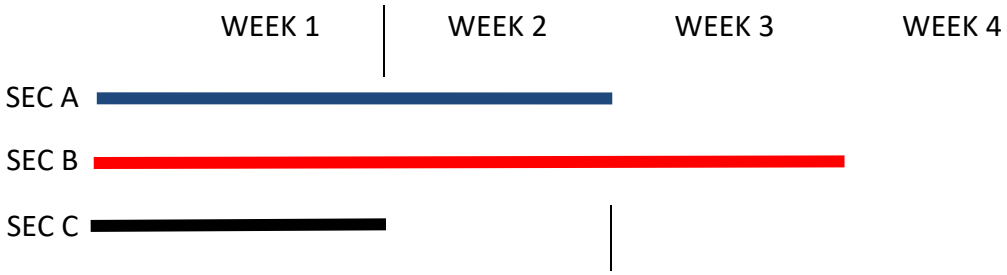
It is similar to master scheduling. It is simple and easy to understand. It involves less cost and can be maintained by clerical staff. The information isnot clear when work will take place.

i. Preparation of load analysis sheet from the orders in hand.

LOAD ANALYSIS SHEET			
	LOAD IN Hr/DAYS		
ORDER No.	SEC A	SEC B	SEC C
X-320	25	10	16
Y-210	10	15	10
Y-314	18	20	8
Z-150	8	25	------
.	.	.	.
.	.	.	.
.	.	.	.
.	.	.	.
.	.	.	.

Weekly capacity of section is calculated by adding total load against each section.

GANIT LOAD CHART



Color bars are shows the actual work load against each section.

Dispatching:

- Dispatching is the physical handing over of a manufacturing order to the operating facility through the release of orders and instructions previously developed plan of activity (time and sequence) established by the scheduling section of the production planning and control department.
- Dispatcher transmits orders to the various shops.
- Dispatcher determines by whom the job shall be done and it coordinatesproduction.
- It creates a direct link between production and sales.

Procedure:

The product is broken into different components and components into operations. A route sheet for the part C having three operations on it is shown.

ROUTE SHEET PART C
MATERIAL
OPERATION-1
OPERATION-2
OPERATION-3

a) Store issue order:

Authorize stores to deliver required raw material.

b) Tool order:

Authorize tool store to release the necessary tools. The tools can be collectedby the tool room attendant.

c) Job order:

Instruct the worker to proceed with the operations and forms the basis forworker's pay.

d) Time ticket:

It records the beginning and ending time of the operations and forms thebasis for worker's pay.

e) Inspection order:

Notify the inspectors to carry out necessary inspections and report thequality of the component.

f) Move order:

Authorized the movement of materials and components from one facility toanother for further operations.

Types of manufacturing system

1. Job type production:

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

2. Batch production:

   Manufacture of limited no. of products produced at regular intervals andstocked at warehouse.

   Ex: Chemical, pharmaceutical, assembly stops.

3. Repetitive or mass production:

   Manufactures several standard products produced and stacked in thewarehouses.

   High volume and low variety

Ex: plastic goods, manufacture & assembly stages of automobiles