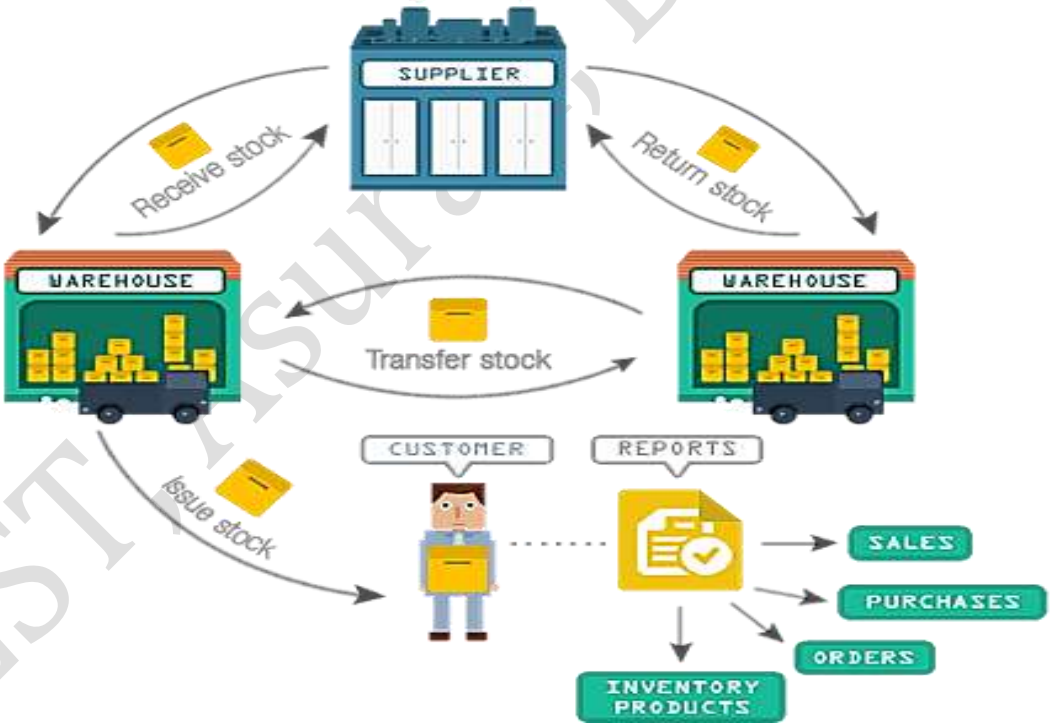
BHADRAK ENGINEERING SCHOOL & TECHNOLOGY (BEST),
ASURALI, BHADRAK

Industrial Engg. & Management (Th- 01)

(As per the 2020-21 syllabus of the SCTE&VT, Bhubaneswar, Odisha)



Sixth Semester

Mechanical Engg.

Prepared By: *Er A K Bhuyan*

INDUSTRIAL ENGINEERING & MANAGEMENT(TH-01)

TOPIC WISE DISTRIBUTION PERIODS

Sl. no	Name of the chapter as per syllabus	No. of periods as per syllabus	No. of periods actually needed	Expected marks
1	Plant Engineering	10	07	15
2	Operation Research	10	11	25
3	Inventory Control	10	10	25
4	Inspection And Quality Control	15	17	15
5	Production Planning and Control	15	15	20
Total		**60**	**60**	**100**

CHAPTER NO.- 01

PLANT ENGINEERING

Learning Objectives

1.1 selection of site of industry
1.2 plant layout
1.3 objectives and principles of plant layout
1.4 process layout, product layout, 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

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

1.1 Selection of Site of Industry

Selection of site for an industrial plant is governed by many considerations, both the economic analysis of the costs as well as judgment as to the modifying effects of other factors. The various factors are as follows-

- **Nearness to raw material:** It will cost less if the plant site is located near the raw material source. The plant must be located in such a place that the raw materials are easily available.
- **Transport facilities:** plant site must be located in such a place that, were transport facilities like roads, rails, water or air must be easily available.
- **Nearness to market:** plant must be near to the market for selling and exchanging its products.
- **Availability of labour:** plant site must be located in such a place where labors with stable force of adequate size and reasonable rates are available.
- **Availability of fuel and power:** plant site must be located in such a place where fuel and power both available easily.
- **Availability of water:** since water in adequate quantity is essential for every plant so the plant must be located in such a place where water availability is not so hard.
- **Climate condition:** the plant site must be located in such a place where climate condition is not harse or adequate for plant.
- **Land:** the plant site must be located in such a place where vast land must be available easily at low price.
- **Community Attitude:** plant must be located in such a place where community i.e local MLA, ward member, general public) must be friendly.

1.2 Plant Layout

It is defined as a technique of locating machines, processes and plant services within the factory so as to achieve the greatest possible output of high quality at the lowest possible total cost of manufacturing.

1.3 Objectives and Principles of Plant Layout

Objectives

- Proper and efficient utilization of available floor space.
- Transportation of work from one point to another.
- Proper utilization of production capacity.
- Reduce material handling cost.
- Utilize labour efficiently.
- Reduce accidents.
- Increase employee's moral.
- Increase profit and reduce loss.

Principles

- Material and labors should be moved over minimum distances.
- All available cubic space should be effectively utilized –both horizontally and vertically.
- Layout should be flexible enough to adaptable to changes required by expansion.
- Interdependent operations and processes should be located in close proximity to each other, to minimize product travel.
- All the plant facilities and services should be fully integrated into a single operating unit., to minimize cost of production.
- There should be in-build provision in the design of layout, to provide for comfort and safety of workers.
- A good layout should facilitate effective supervision over workers.
- A good layout should boost up employee morale, by providing them with maximum work satisfaction.

1.4 Process Layout, Product Layout, Combination Layout

Process Layout (Or Functional Layout)

In this type of layout, all machines performing similar type of operations are grouped at one location that is all lathes, milling machines etc are grouped in the shop and they will be clustered in like groups.

Lathe	Milling machine		Assembly	
Welding	Grinding	Inspection	Shipping and receiving	painting

Advantages: -

- Greater flexibility
- Lower investment
- Higher utilization of production
- Breakdown of one machine does not result in complete stopping of work.

Disadvantages:-

- Back tracking and long movement.
- Production planning and control is difficult.
- More space requirement.

Product Layout (Or Line Layout)

In this type of layout, all the machines are arranged in the sequences, as required to produce a specific product. It is called line layout because machines are arranged in a straight line. The raw materials are fed at one end and taken out as finished product to the other end.

Turning operation -> milling operation -> drilling operation -> assembly -> inspection -> package dispatch

Advantages: -

- Reduce material handling cost.
- Eliminates bottlenecks and idle capacity.
- Short manufacturing cycles.
- Small amount of work in process inventory.
- Simplified production planning.

Disadvantages: -

- Lack of flexibility of operations.
- Large capital investments.
- Breakdown of one machine in the sequence may result in stoppage in production.

Combination Layout

In actual practice, plants are rarely worked in product or process layout. Generally, plant works on a combination of these two layouts take the advantages of both layouts.

Example-1: refrigerator manufacturing uses a combination layout.

Example 2-Process layout is used to produce various operations like stamping, welding, heat treatment being carried out indifferent work centers as per requirement. The final assembly of the product is done in a product layout.

1.5 Techniques to Improve Layout

- Integration: - it means the integration of production centers facilities like workers, machinery, raw materials etc. in a logical and balanced manner.
- Minimum movement and material handling: - the number of movements of workers and material should be minimized.

- Smooth and continuous flow: - bottle necks, congestion points and backtracking should be removed.
- Cubic space utilization: - besides using the floor space of a room, if the ceiling height is also utilized, more material can be accommodated in the same room.
- Safe and improved environments: - working place safe, well ventilated and free from dust and noise increases the operating efficiency of the workers and thus better employer – employee relations.
- Flexibility: - in automotive and other industries where model of products changes after some time, it is better to permit all possible flexibility in the layout.

1.6 Principles of Material Handling Equipment

- Space utilization principle: make optimum use of cubic space.
- Unit load principle: - increase quantity, size weight of load handled.
- Gravity principle: -utilize gravity to move a material whenever practicable.
- Material flow principle: -plan an operation sequence and equipment arrangement to optimize material flow.
- Mechanization principle: -use mechanical and automated material handling equipment.
- Safety principle: -provide for safe handling methods and equipment.

1.7 Plant Maintenance

- It is defined as a set of activities that are necessary to keep machinery, parts and types of equipment in good operating conditions to avoid production stoppage and loss.

1.7.1 Importance of Plant Maintenance

- It helps in identify the cause of failure, example whether the failure is due to design defect or wear out failure.
- It also helps in deciding the type of maintenance and maintenance decision like replace and repair.
- It provides the necessary information regarding the life and reliability of the equipment.
- With the help of this tool spare parts management got initiated.

1.7.2 Break Down Maintenance: -

- Breakdown Maintenance implies that repairs are made after the equipment is failed and failed and cannot perform its normal function any more.
- It is an emergency-based policy in which the plant or equipment is operated until it fails and then it is brought back into running condition by repair.
- The maintenance staff locates any mechanical, electrical or any other faulty to correct immediately.

1.7.3 Preventive Maintenance: -

- Preventive maintenance is a type of maintenance that is regularly performed on a piece of equipment to loosen the likelihood of it failing.
- It is performed while the equipment is still working so that it does not breakdown unexpectedly.
- Preventive maintenance is of two types: -

Time based preventive maintenance: - a typical example of a time-based preventive maintenance is a regular inspection on a critical piece of equipment that would severely impact production in the event of a break down.

Usage- based preventive maintenance: - usage based triggers fires after a certain number of kilometers, hours or production cycles. An example of this trigger is a motor –vehicle which might be scheduled for service every 10,000 km.

1.7.4 Scheduled Maintenance: -

- Scheduled maintenance is a stich –in –time procedure aimed at avoiding breakdown.
- Breakdowns can be dangerous to life and as far as possible should be minimized.
- Scheduled maintenance practice incorporates inspection, lubrication, repair and overhaul of certain equipment which if neglected can result in break down.

POSSIBLE SHORT TYPE QUESTIONS WITH ANSWER

1. **Define a plant?**
   - A plant is a place where man, material, money, equipment, machinery etc. are brought together for manufacturing product.
2. **What is plant maintenance?**
   - It is defined as a set of activities that are necessary to keep machinery, parts and types of equipment in good operating conditions to avoid production stoppage and loss.
3. **Define plant layout?**
   - It is defined as a technique of locating machines, processes and plant services within the factory so as to achieve the greatest possible output of high quality at the lowest possible total cost of manufacturing.

POSSIBLE LONG TYPE QUESTIONS WITH HINTS

1. **Briefly explain the features governing while selecting the site for an industry?**
   - Hints: refer article no-1.1

1. **Write the objectives and principles of a good plant layout?**
   - Hints: - refer article no-1.3

2. **What is plant maintenance? Explain different types of plant maintenances**?
   - Hints: -refer article no- 1.7

CHAPTER NO.- 02

OPERATION RESEARCH

Learning Objectives:

2.1 Introduction to Operation Research
2.2: Define Linear Programming Problem (LPP)
2.3: - Solution of LPP by Graphical Method
2.4 Evaluation of Project Completion Time by Critical Path Method And PERT
2.5 Explain Distinct Features of PERT With CPM

Introduction

Historically, the term operation research originated during second world war when U.S.A and Great Britain 's Armed Forces sought the assistance of scientists to solve complex and very difficult strategically and tactical problems of war fare, like making machine mines harmless or increasing the efficiency of antisubmarine aerial warfare etc.

2.1 Introduction to Operation Research: -

Operation research employs mathematical logic to complex problems requiring managerial decisions. It is defined as, "the organized application of modern science, mathematics and computer techniques to complex military, government, business problems arising in the management of large system of men, materials, money and machines."

Applications: -

- Inventory problems
- Material handling
- Dealing with waiting times
- Dividing adverting budget.
- Marketing
- Traffic control.

2.2: Define Linear Programming Problem (LPP):

It is a mathematical model or techniques for efficient and effective utilization of limited resources to achieve organization objectives (maximize profits or minimize cost).

It is also known by the name of optimization problem.

LPP is helpful in developing and solving a decision-making problem by mathematical techniques.

2.3: - Solution of LPP by Graphical Method: -

Steps for solution of LPP by graphical methods are as follows:

Step -1: formulate the LPP

Step-2: construct a graph and plot the constraint lines.

Step-3: determine the valid side of each constraint lines.

Step-4: identify the feasible solution region.

Step-5: find the optimum points.

Step -6: calculate the coordinates of optimum points.

Step -7: evaluate the objective function at optimum points to get the required maximum/minimum value of the objective function.

Problem-1: solve the following LPP by using graphical method.

Maximize $Z = 12X_1 + 16X_2$

Subjected to, $10X_1 + 20X_2 \leq 120$

$$8X_1 + 8X_2 \leq 80$$

X_1 and $X_2 \geq 0$

Solution: - Maximize $Z = 12X_1 + 16X_2$ (objective function)

$10X_1 + 20X_2 = 120$..... (1) } two constraints

$8X_1 + 8X_2 = 80$..... (2)

When $X_1 = 0$ in equation 1

$10(0) + 20X_2 = 120$

- ⇨ $0 + 20X_2 = 120$
- ⇨ $20X_2 = 120$
- ⇨ $X_2 = 120/20 = 6$

When $X_2 = 0$, in equation 1, we have

$10X_1 + 20(0) = 120$

- ⇨ $10X_1 + 0 = 120$
- ⇨ $10X_1 = 120$
- ⇨ $X_1 = 120/10 = 12$

X1	0	12
X2	6	0

When $X_1 = 0$, in equation 2

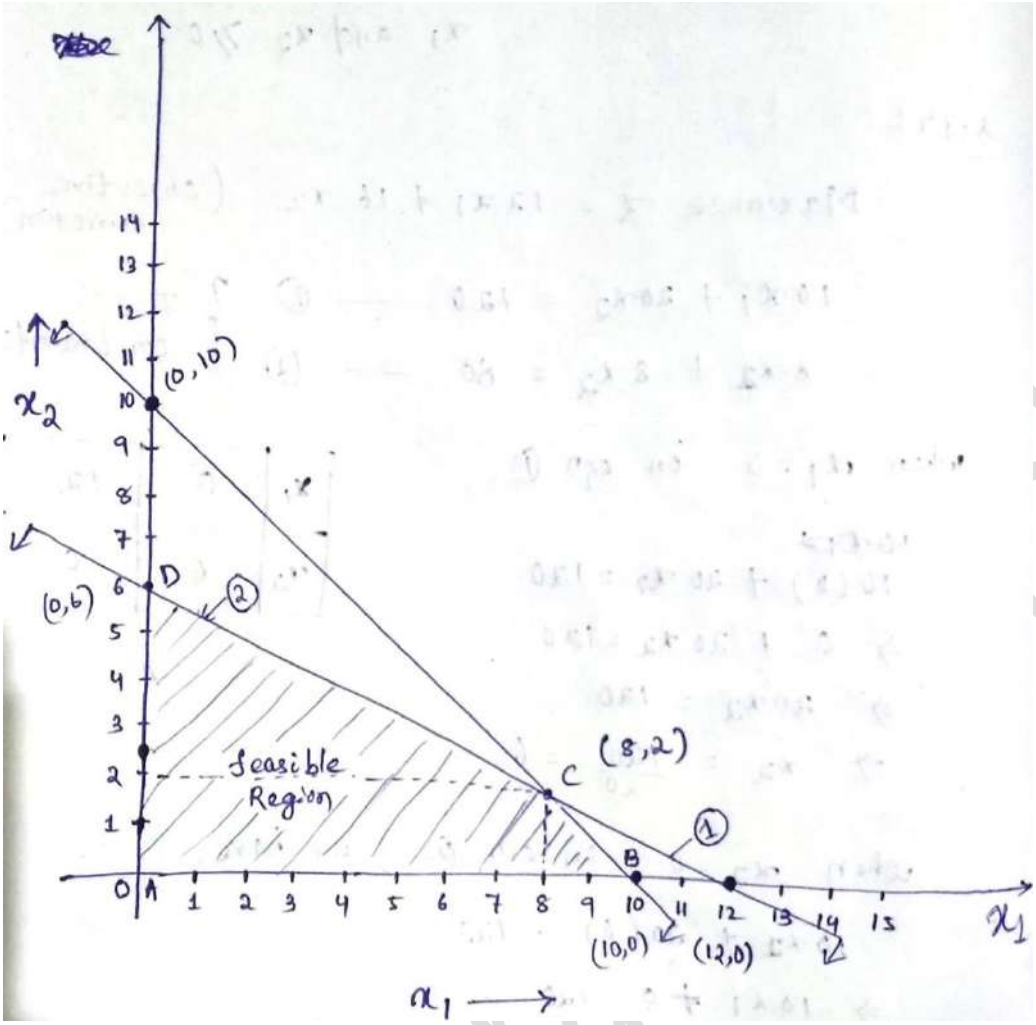
- ⇨ $8(0) + 8X_2 = 80$
- ⇨ $0 + 8X_2 = 80$
- ⇨ $8X_2 = 80$
- ⇨ $X_2 = 80/8$
- ⇨ $X_2 = 10$

X1	0	10
X2	10	0

When $X_2 = 0$ in equation 2, we have,

$8X_1 + 8(0) = 80$

- ⇨ $8X_1 = 80$
- ⇨ $X_1 = 80/8 = 10$



Now to find the optimum solution let us substitute the four corner points in the objective function.

Maximize $Z = 12X_1 + 16X_2$

A (0,0) $Z(A) = 12(0) + (16(0) = 0$

B (10,0) $Z(B) = 12(10) + 16(0) = 120$

C (8,2) $Z(C) = 12(8) + 16(2) = 128$

D (0,6) $Z(D) = 12(0) + 16(6) = 96$

Since the type of objective function is maximization, the solution corresponding to maximum Z value will be selected as the optimum solution.

So optimum solution (C)

$X_1 = 8$ and $X_2 = 2$

Z(optimum) = 128

Problem-2: Solve the following LPP by using graphical method.

Minimize $Z = 4X_1 + 6X_2$

Subjected to, $X_1 + X_2 \geq 8$

$6X_1 + X_2 \geq 12$

X_1 and $X_2 \geq 0$

Solution: - Minimize $Z = 4X_1 + 6X_2$ (objective function)

$X_1 + X_2 = 8$..... ……. (1) two constraints

$6X_1 + X_2 = 12$ .....(2)

When $X_1=0$ in equation 1

$(0) + X_2 = 8$

⇨ $X_2 = 8$

When $X_2= 0$, in equation 1, we have

X_1	0	8
X_2	8	0

$X_1 + (0) = 8$

⇨ $X_1 = 8$

When $X_1 = 0$, in equation 2

⇨ $6(0) + X_2 = 12$

⇨ $0 + X_2 = 12$

⇨ $X_2 = 12$

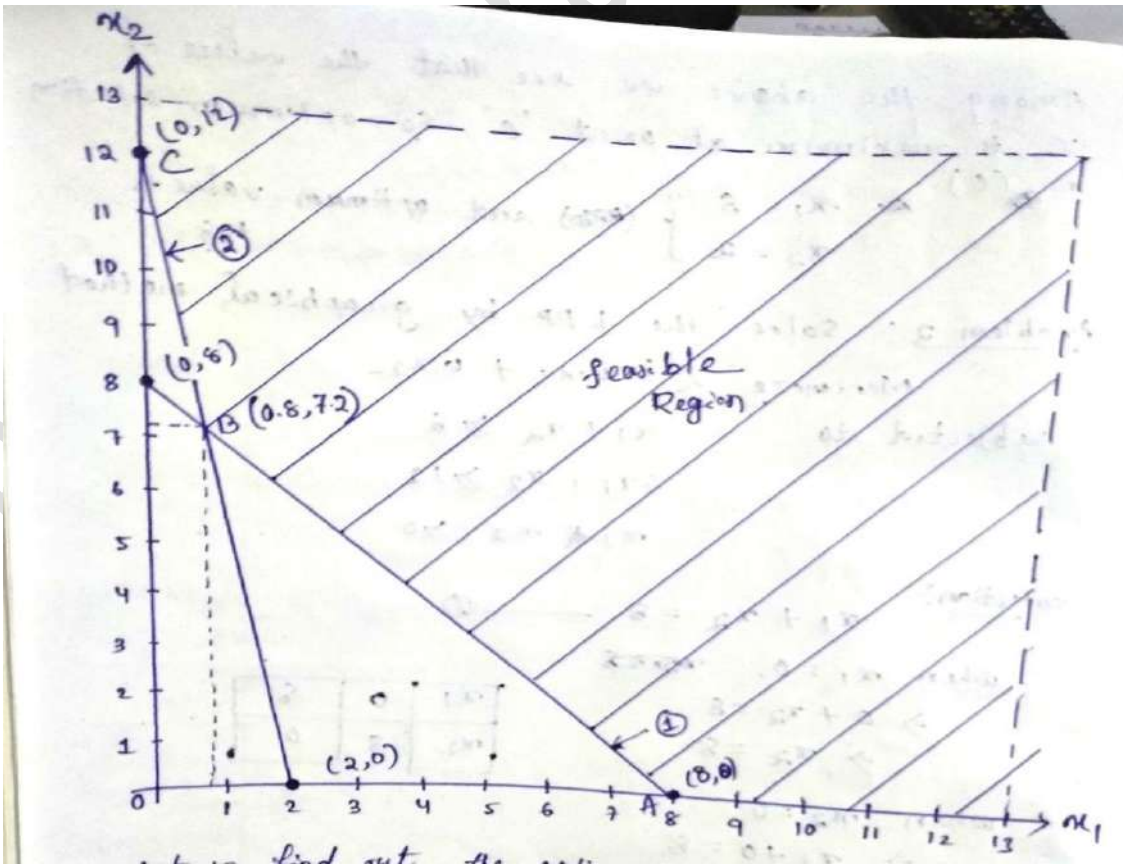
When $X_2=0$ in equation 2, we have,

$6X_1 + (0) = 12$

X_1	0	2
X_2	12	0

⇨ $6X_1 = 12$

⇨ $X_1 = 12/6 = 2$



Now to find the optimum solution let us substitute the four corner points in the objective function.

Minimize $Z = 4X_1 + 6X_2$

A (8,0) $Z(A) = 4(8) + 6(0) = 32$

B (0.8,7.2) $Z(B) = 4(0.8) + 6(7.2) = 3.2 + 43.2 = 46.4$

C (0,12) $Z(C) = 4(0) + 6(12) = 0 + 72 = 72$

Since the type of objective function is minimization, the solution corresponding to minimum Z value will be selected as the optimum solution.

So optimum solution (C)

$X_1 = 8$ and $X_2 = 0$

Z(optimum) = 32

Problem-3: solve the following LPP by using graphical method.

Maximize $\mathbf{Z = 100X_1 + 60X_2}$

Subjected to, $\mathbf{5X_1 + 10X_2 \leq 50}$

$\mathbf{8X_1 + 2X_2 \geq 16}$

$\mathbf{3X_1 - 2X_2 \geq 6}$

$\mathbf{X_1}$ **and** $\mathbf{X_2 \geq 0}$

Solution: - Maximize $Z = 100X_1 + 60X_2$ (objective function)

$5X_1 + 10X_2 = 50$.....(1) } two constraints

$8X_1 + 2X_2 = 16$ .....(2)

$3X_1 - 2X_2 = 6$ .....(3)

When $X_1 = 0$ in equation 1

$5(0) + 10X_2 = 50$

⇨ $10X_2 = 50$

⇨ $X_2 = 50/10 = 5$

When X2= 0, in equation 1, we have

$5X_1 + 10(0) = 50$

⇨ $5X_1 = 50$

⇨ $X_1 = 50/5 = 10$

When $X_1 = 0$, in equation 2

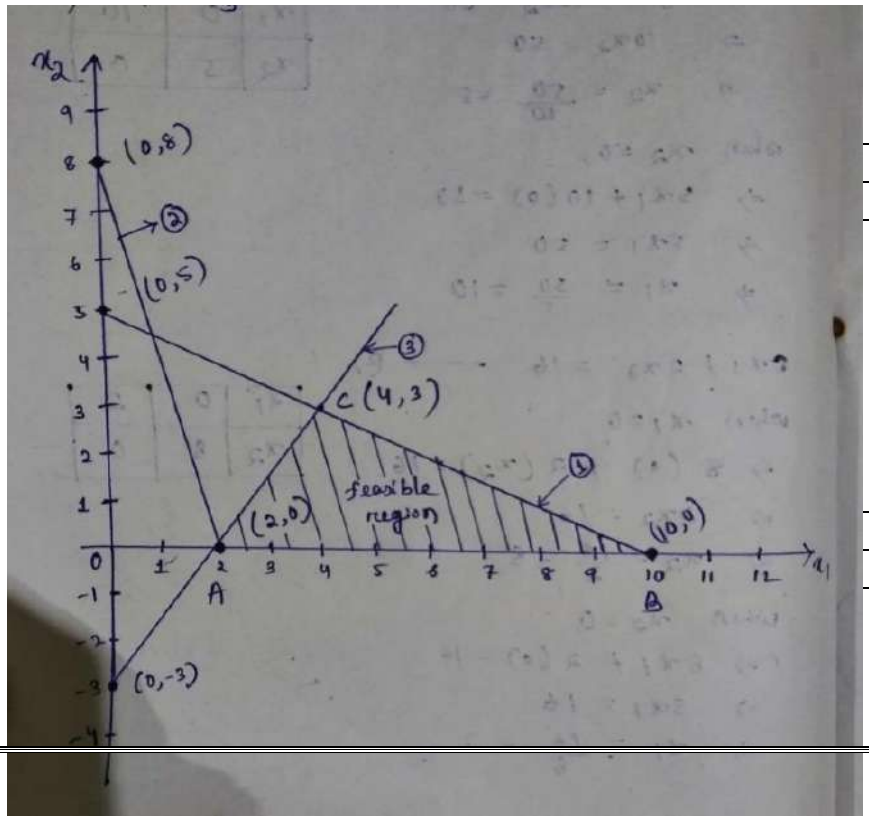
⇨ $8(0) + 2X_2 = 16$

⇨ $0 + 2X_2 = 16$

⇨ $X_2 = 16/2 = 8$

When $X_2 = 0$ in equation 2, we have,

$8X_1 + 2(0) = 16$



⇨ $8X_1 = 16$

⇨ $X_1 = 16/8 = 2$

When $X_1 = 0$, in equation 3

⇨ $3(0) - 2X_2 = 6$

⇨ $-2\ X_2 = 6$

⇨ $X_2 = 6/-2 = -3$

When $X_2 = 0$ in equation 3, we have,

$3X_1 - 2(0) = 6$

⇨ $3X_1 = 6$

⇨ $X_1 = 6/3 = 2$

X1	0	2
X2	-3	0

Now to find the optimum solution let us substitute the four corner points in the objective function.

Maximize $Z = 100X_1 + 60X_2$

A (2,0) $Z(A) = 100(2) + 60(0) = 200$

B (10,0) $Z(B) = 100(10) + 60(0) = 1000$

C (4,3) $Z(C) = 100(4) + 60(3) = 400 + 180 = 580$

Since the type of objective function is maximization, the solution corresponding to maximum Z value will be selected as the optimum solution.

So optimum solution (B)

$X_1 = 10$ and $X_2 = 0$

Z(optimum) = 1000

2.4 Evaluation of Project Completion Time by Critical Path Method And PERT: -

Project Management: -

- A project consists of interrelated activities which are to be executed in a certain order before the entire task is completed.
- The activities are inter-related in a logical sequence which is known as precedence relationship.
- Project is represented in the form of network for the purpose of analytical treatment to get solutions for scheduling and controlling its activities.

Techniques: -

- CPM: -critical path method
- PERT: -project Evaluation and review technique.

Phases of project Management: -

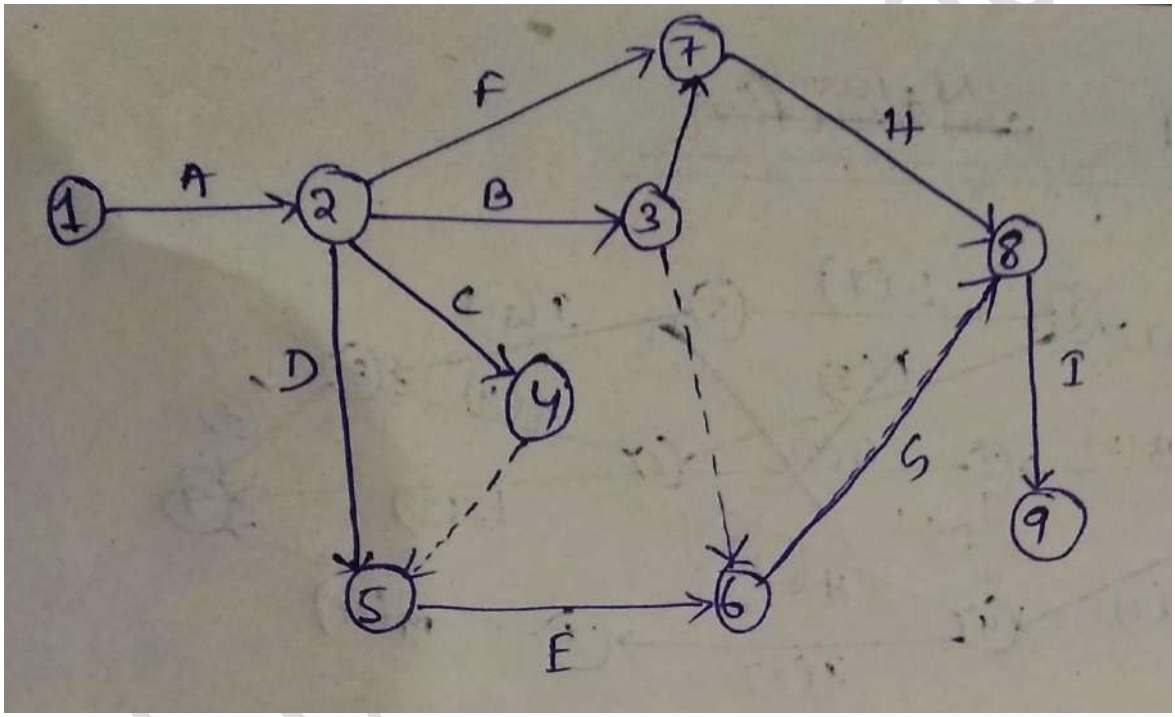
1. Planning-
   - Divide the project into distinct activities.
   - Estimating the requirement for each activity.
   - Establishing precedence relationship among the activities.
   - Construction of the arrow diagram(network)

2. Scheduling- Determines the start and end time of each activity.
3. Controlling- Uses the arrow diagram and time chart for continuous monitoring and progress reporting

Evaluation Of Project Completion Time by Critical Path Method (CPM): -

- Critical path method (CPM) is a resource-utilization algorithm for scheduling a set of project activities. The essential technique for using CPM is to construct a model of the project that includes the following:
- A list of all tasks required to complete the project
- The dependencies between the tasks
- The estimate of time (duration) that each activity will take to complete.

Guide Lines for Network Construction: -



- The starting event and ending event of an activity base called tail event and head event, respectively.
- The network should have a unique starting node (tail event).
- The network should have a unique completion node (head event).
- No activity should be represented by more than one arc in the network.
- No two activities should have the same starting node and the same ending node.
- Dummy activity is an imaginary activity indicating precedence relationship only. Duration of dummy activities is zero.

Problem-4: -

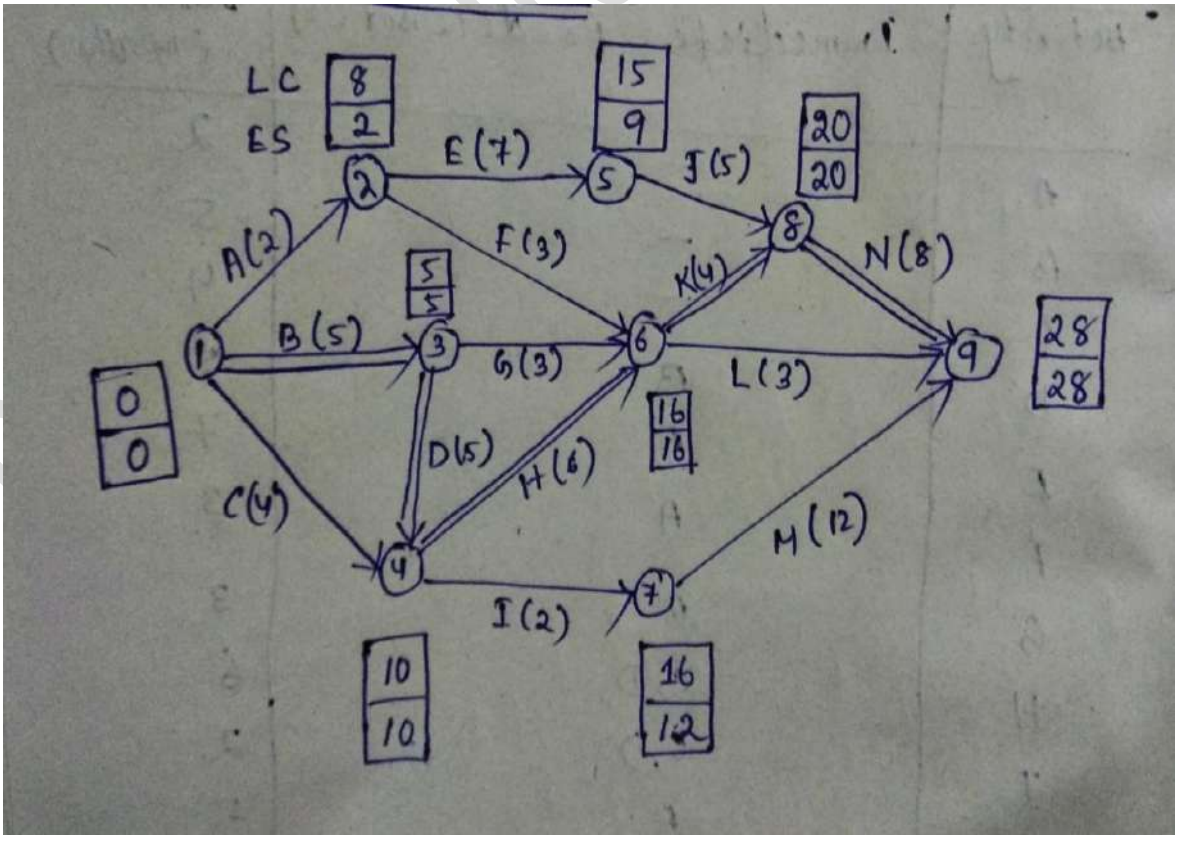
ACTIVITY	IMMEDIATE PREDECESSOR(S)	DURATION(MONTHS)
A	-	2
B	-	5
C	-	4
D	B	5
E	A	7
F	A	3
G	B	3
H	C, D	6
I	C, D	2
J	E	5
K	F, G, H	4
L	F, G, H	3
M	I	12
N	J, K	8

Consider the details of a project as shown in the table.

a) Construct the CPM network
b) Determine the critical path and project completion time
c) Compute total float and free floats for non-critical activities.

Solution: -

a) CPM NETWORK: -



b) 1-3-4-6-8-9 = B-D-H-K-N = 5+5+6+4+8 = 28 is the critical path.

Hence the duration of critical path is 28 months and project duration is 28 months.

C) Summary of total floats and free floats:

Activity (i, j)	Duration (D_{ij})	Total float (TFij) **$LC_l - ES_i - D_{ij}$**	FREE float (FFij) **$ES_j - ES_i - D_{ij}$**
A (1-2)	2	8-0-2=6	0
B (1-3)	5	5-0-5=0	0
C (1-4)	4	6	6
D (3-4)	5	0	0
E (2-5)	7	6	0
F (2-6)	3	11	11
G (3-6)	3	8	8
H (4-6)	6	0	0
I (4-7)	2	4	0
J (5-8)	5	6	6
K (6-8)	4	0	0
L (6-9)	3	9	9
M (7-9)	12	4	4
N (8-9)	8	0	0

Any activity will have zero total float and zero free float is called critical activity.

2.5 Explain Distinct Features of Pert with CPM

PERT	CPM
• A probabilistic model with uncertainty in activity duration. Expected time is calculated from t0, tm and to.	• A deterministic model with well-known activity time based upon past experience.
• An event-oriented approach.	• An activity-oriented system.
• PERT terminology uses words like network diagram, events and stack.	• CPM terminology employs works like arrow diagrams, nodes and floats.
• The uses of dummy activity are required for representing the proper sequencing.	• The uses of dummy activity are not necessary.
• PERT finds application in projects where resources (men, materials and money) are always available as and when required.	• CPM is employed to those projects where minimum overall costs are of primary importance.
• It is used mostly in research and development projects.	• It is used in construction projects.

POSSIBLE SHORT TYPE QUESTIONS WITH ANSWER

1. **Define LPP?**

   It is a mathematical model or techniques for efficient and effective utilization of limited resources to achieve organization objectives (maximize profits or minimize cost)

2. **Define CRITICAL activity?**

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

   It is marked either by a thick arrow or by double cross on the arrow distinguish it from a non-critical activity.

3. **Define operation research?**

Operation research employs mathematical logic to complex problems requiring managerial decisions. It is defined as, "the organized application of modern science, mathematics and computer techniques to complex military, government, business problems arising in the management of large system of men, materials, money and machines."

POSSIBLE LONG TYPE QUESTIONS WITH HINTS

1. **Use graphical method to find the optimal solution of following**

Maximize Z =12x +24y
Subjected to x+4y ≤ 20
3x+y ≤ 15
X, Y ≥0

Hints: -Refer problem no-1

2. **A small engineering projects consists of six activities namely P, Q, R, S, T, V with duration of 5,7,6,5,4 and 4 days respectively. Draw the network diagram and EST, LST, EFT, LFT and floats. Find the total project durations.**

Hints: -Refer problem no-4

CHAPTER NO.-3

INVENTORY CONTROL

Learning Objectives

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 Cost associated with inventory.

3.6 Terminology in Inventory Control

3.7 Explain and Derive Economic Order Quantity for Basic Model.

3.8 Define and explain ABC analysis

Inventory: -

Inventory is a detailed list of those movable items which are necessary to manufacturer a product and to maintain the equipment and machinery in good working order.

The quantity and value of every item is also mentioned in the list.

Inventory Control: -

Inventory control is concerned with achieving an optimum balance between two completing objectives. The objectives are:

- To minimize investment in inventory.
- To minimize the service level to the firm's customer and it's own operating department.

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

3.1 Classification of Inventory: -

Inventory may be classified as follows-

- Raw inventories: - They include, raw material and semi-finished products supplied by another firm and which are raw items for present industry.
- In process inventories: -They are semi-finished goods at various stages of manufacturing cycles.

- Finished inventories: -They are the finished goods lying in stock rooms and waiting dispatch.
- Indirect inventories: -They include lubricants and other items (like spare parts) needed for proper operation, repair and maintenance during manufacturing cycles.

3.2 Objectives of Inventory Control:

- To ensure continuous supply of materials spares and finished goods so that production should not suffer at any time and the customer's demand should also be met.
- To avoid both overstocking and under-stocking of inventory.
- To maintain investment in inventories at the optimum level as required by the operational and sales activities.
- To keep materials cost under control so that they contribute in reducing cost of production and overall cost.
- To eliminate duplication in ordering or replenishing stocks. This is possible with the help of centralizing purchases.
- To minimize losses through deterioration, pilferage, wastages and damages.
- To design proper organization for inventory management. Clear ut accountability should be fixed at various levels of the organization.
- To ensure perpetual inventory control so that materials shown in stock ledgers should be actually lying in the stores.
- To ensure right quality goods at reasonable prices. Suitable quality standards will ensure proper quality stocks. The price analysis, the cost analysis and value analysis will ensure payment of proper prices.
- To facilitate furnishing of data for short term and long-term planning and control of inventory.

3.3 Functions of Inventories: -

- To keep better customer satisfaction.
- Maintain smooth and efficient production flow.
- To avoid delays in deliveries.
- To avoid problems during scarcity of materials in the market.
- To take advantage of quality discounts.
- To have an advantage amidst the market price fluctuation.
- To allow possible increase in output.
- To have better utilization of manpower and available machinery.
- Avoid rejection of material.

3.4 Benefits of Inventory Control: -

- Inventory control protects a company from fluctuations in demand of its products.
- It enables a company to provide better services to its customers.
- It keeps a smooth flow of raw-materials and aids in continuing production operations.
- It checks and maintains the right stock and reduces the risk of loss.
- It helps to minimize administrative workload, manpower requirement and even labour cost.
- It tries to protect fluctuation in output.
- It makes effective use of working capital by avoiding over-stocking.

- It helps to maintain a check on loss of materials due to carelessness or pilferage (stealing).
- It facilitates cost accounting activities.
- It avoids duplication in ordering of stock.

3.5 Cost Associates with Inventory

Following are different costs associates with inventory in an organization

1. Purchase Cost (P.C): -

- It is also called nominal cost.
- It is the cost incurred in buying from outside source.
- This cost may vary according to the quantity purchased.
- Example-unit price Rs.20 for up to 100 units., Rs.19.50 for more than 100 units.
- P.C =No of units purchased × cost/unit.

2. Ordering cost (O.C)/set up costs: -

- It occurs whenever the stock replenishes.
- It is associated with processing and chasing the purchase order.
- It is also called procurement cost.
- It is independent to order size.
- O.C = Number of orders × cost/order.

3. Carrying cost/ Holding cost (H.C):

- It is associated with storing an item in the inventory.
- It is proportional to the amount of inventory and time taken to holding that inventory.
- It is expressed in terms of rate per unit
- H.C = Average inventory for a period × Holding cost /unit time.

4. Stockout cost (S.C)

- It is the cost incurred when customers are not being served.
- This cost implies the shortages or absences of inventory.
- It includes potential profit loss, good will loss, loss of production time, fast transportation cost, discount etc.
- S.C = Average no. of units short × shortage cost / unit time

3.6 Terminology of Inventory Control: -

Terminology is a general word for the group of specialized words or meanings relating to a particular field, and also the study of such terms and their use. This is also known as terminology science. Some important terminologies of Inventory control are: -

- ABC analysis
- Economic order Quantity (EOQ)
- Purchase cost
- Ordering cost
- Holding cost
- Annual demand
- Shortage cost

- Inventory cycle stock etc.

3.7 Explain and Derive Economic Order Quantity for Basic Model:

Economic Order Quantity (EOQ): -

EOQ is one of the techniques of inventory control which minimize total Holding and ordering cost of the year.

The EOQ technique can solve the problems of material manager.

Derivation of EOQ for basic model: -

Let Q is the economic lot size or EOQ

C is the cost of one item.

I is the cost of carrying inventory

P is the procurement cost associated with one order

U is the total quantity used per period say annually.

Number of purchase order to be furnished= total quantity/EOQ

Total procurement cost = number of purchase orders × cost involved in one purchase

=U×P/Q…….(a)

Average annual inventory= Q/2

Inventory carrying cost=Average inventory× cost per items × cost of inventory in percent per period.

=Q/2 ×C× I……..(b)

Total cost, T= a +b=U×P/Q. + Q/2 ×C ×I

To minimize the total cost , differentiate T w.r.t, Q and put it equal to zero

$$\frac{dT}{dQ} = \frac{d}{dQ}\left(\frac{U*P}{Q} + \frac{Q}{2} * C * I\right)$$

⇨ $0 = -U.P.Q^{-2} + \frac{C.I}{2}$

⇨ $\frac{UP}{Q^2} = \frac{C.I}{2}$

⇨ $Q^2 = \frac{2U.P}{C.I}$

⇨ $Q = \sqrt{\frac{2U.P}{C.I}}$

Problem 1: Given That, Annual usage, U =60 units, Procurement cost, p =Rs.15per order Cost per piece, C = Rs.100, Cost carrying inventory I, a % including expenditure on obsolescence, taxes, insurance, deterioration etc. =10%. Calculate E.O.Q.

Solution: - $Q = \sqrt{\frac{2U.P}{C.I}} = \sqrt{\frac{2*60*15}{100*(\frac{10}{100})}} = 13.41$

Therefore, number of order per year = 60/13.41= 4.47 say 5

Hence Q or E.O.Q =60/5 =12 units (Ans)

Problem 2: find the economic order quantity from the following data:

Average annual demand =30,000 units, Inventory carrying cost =12% of the unit value per year. Cost of placing an order =Rs.70, Cost of unit =Rs 2

Solution: -: - Q = $\sqrt{\frac{2U.P}{C.I}} = \sqrt{\frac{2*30000*70}{2*(\frac{12}{100})}} = 4184$

Therefore, number of order per year = 30000/4184= 7.17 say 7

3.8 Define and Explain ABC Analysis: -

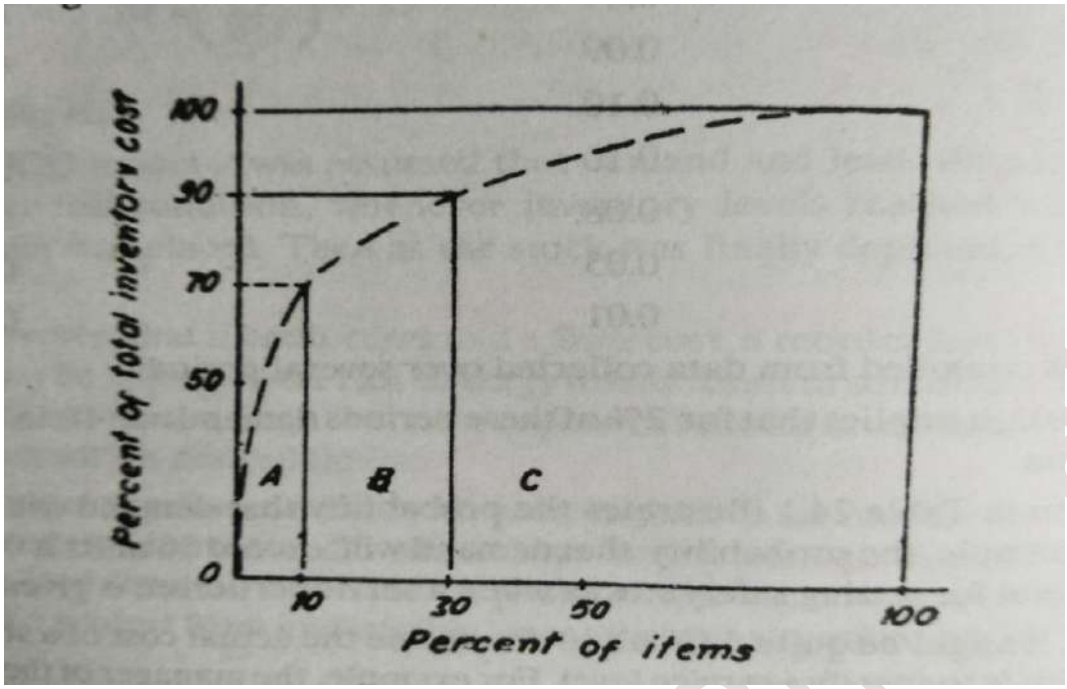
ABC analysis helps segregating the items from one another and tells how much valued the item is and controlling it to what extent is in the interest of the organization.

Procedural steps: -

- Identify all items used in an industry.
- List all the items as per their value.
- Count the numbers of high valued, medium valued and low valued items.
- Find the percentage of high, medium and low valued items. High valued items normally contribute for 70% of the total inventory cost and medium and low valued items,20 and 10% respectively.
- A graph can be plotted between percent of items (on X axis) and % of total inventory cost (on Y axis)
- It can be seen that 70% of total inventory cost is against 10% of total items (called A items),20% against 20%of the items (B items) and 10% against a big bulk that is 70% of the items (called C items)

Thus, ABC analysis furnishing the following information.

- A items are high valued items but are few in numbers. They need a careful and close inventory control. Such items should be thought in advanced and purchase in small quantities well in time. Proper record and handling and storage facilities should be provided for them.
- B items are medium valued items and need moderate control. They are purchased on the basis of past requirements and a procurement order is placed as soon as the quantity touches reorder point. These items are less costly.
- C items are low valued items, but maximum numbered items. These items do not need any control, rather controlling them is uneconomical. These are least important items like clips, all pins washer, rubber bands etc. They are generally procured just before they finished.



POSSIBLE SHORT TYPE QUESTIONS WITH ANSWER

1. **Define inventory?**
   - Inventory is a detailed list of those movable items which are necessary to manufacturer a product and to maintain the equipment and machinery in good working order.
2. **Define inventory control?**
   - Inventory control may also define as the scientific method of finding out how much stock should be maintained in order to meet the production demands and able to provide right type of material at right time in the right quantity and at competitive prices.
3. **Define EOQ?**
   - EOQ is one of the techniques of inventory control which minimize total Holding and ordering cost of the year. The EOQ technique can solve the problems of material manager.

POSSIBLE LONG TYPE QUESTIONS WITH HINTS

1. **Describe the objective and functions of inventory control?**
   - Hints: -Refer article no-3.2 and 3.3
2. **Define and explain ABC Analysis?**
   - Hints: -Refer article no- 3.8
3. **Define and explain the EOQ of basic model?**
   - Hints: -Refer article no- 3.7

CHAPTER NO.- 4

INSPECTION AND QUALITY CONTROL

Learning Objectives

4.1 Define Inspection and Quality Control

4.2 Describe 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 Manufactured Products

4.6 Explain the Concept of Statistical Quality Control (SQC), 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 (QMS), Registration/certificate 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

……..

4.1 Define Inspection and Quality Control

Inspection

It is an activity of measuring, examining, testing one or more characteristics of a product or service and comparing the results with specified requirements in order to establish whether conformity is achieved for each characteristic.

Quality Control

It is an operational technique or a system of maintaining standards by reviewing, checking, inspecting and testing.

4.2 Describe Planning of Inspection

Inspection plans help us to describe how a quality inspection of one or several materials is to take place. In the inspection plan, we define the sequence of inspection operations and the

range of specifications available for inspecting inspection characteristics. We can integrate the following master data in your inspection plans:

QM-specific data

- Master inspection characteristics.
- Inspection methods , to define the procedures used in the inspections.
- Code groups and selected sets.
- Sampling procedures for sample determination.
- Dynamic modification rules , to change inspection scopes based on the expected quality level.

Other master data

- Reference operation sets , to structure operations and inspection characteristics.
- Work centre , to define where the inspection is to take place.
- Production resources/tools.
- Classes in the class system , to classify inspection plans.
- Scheduling, to check the expected run time and modify it if necessary.
- Material master records for the materials that are inspected with the inspection plan.
- Vendor master records.
- Customer master records .

4.3 Types of Inspection

- Revolving process, patrolling or floor inspection,
- Fixed inspection,
- Key-point inspection,
- 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 cannot be brought on the workplace. In this case, workers brought the sample to a centralized position of the workplace, at the 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.

4.4 Advantages and Disadvantages of Quality Control

Advantages

- Workers take more care as they have to do it.
- Increase motivation-sense of responsibility
- Reduce cost, as no inspection team to pay
- Less scrap and reworking

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.

4.5 Factors that Affect the Quality of Manufactured Products

- Money: - It is the most important factor affecting the quality of a product in the production.
- Materials: -For a high-quality product, the raw materials involved in production process must be of high quality.
- Management: - If the management is quality conscious rather than merely quantity conscious, organisation can maintain adequate quality of products.
- People: -People employed in production and design must have knowledge and experience in their respective areas.
- Market: -Management must emphasized on market before quality of the product. It is useless to talk about the quality when the market for the product is lacking.
- Machines and Methods: -To maintain high standards of quality, companies are investing in new machines and following new procedures and methods these days.

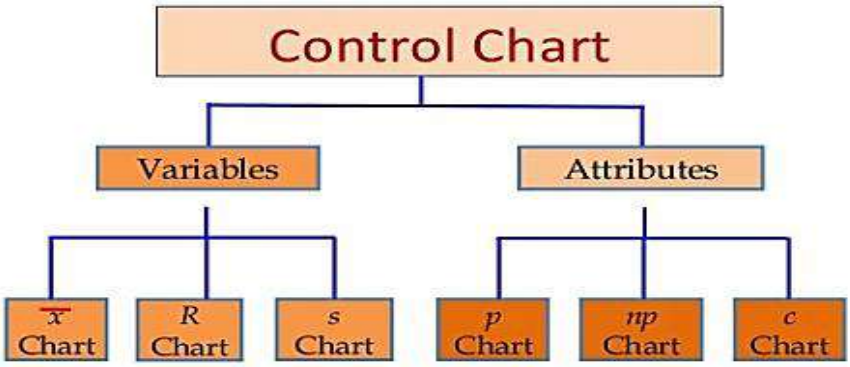
4.6 Concept of Statistical Quality Control (SQC), Control charts (X, R, P and C-Charts)

Control charts: It is graphical presentation of collected information and detects variation in the processing and warns if there is any departure from the specified tolerance limits.

Benefits of using a control chart

- helps to understand the variations that are always present in processes.
- See when something is going wrong or may go wrong. These problem indicators let you know that corrective action needs to be taken.
- Notice patterns within plotted points. The patterns indicate possible causes, which can help you find possible solutions.
- Predict future performance. Generate new ideas for improving quality based on your analysis.

Types of Control Charts: -



X Bar and R Control Charts: -

- X bar and R chart is used to monitor the process performance of a continuous data and the data to be collected in subgroups at a set time periods.
- It is actually two plots to monitor the process mean and the process variation over the time and is an example of statistical process control.
- These combination charts help to understand the stability of processes and also detects the presence of special cause variation.
- X-bar chart: The mean or average change in process over time from subgroup values. The control limits on the X-Bar brings the sample's mean and centre into consideration.

- R-chart: The range of the process over the time from subgroups values. This monitors the spread of the process over the time.

$\bar{x}$ Chart Control Limits

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

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

R Chart Control Limits

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

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

n	A2	D3	D4
2	1.88	0	3.27
3	1.02	0	2.57
4	0.73	0	2.28
5	0.58	0	2.11
6	0.48	0	2.00
7	0.42	0.08	1.92
8	0.37	0.14	1.86
9	0.34	0.18	1.82
10	0.31	0.22	1.78
11	0.29	0.26	1.74

P-chart: -

- It can be a fraction defective chart or % defective chart.
- Each item is classified as good (non-defective) or bad (defective).
- This chart is used to control the general quality of the component parts and it checks if the fluctuation in product quality is due to chance cause alone.
- P- 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.

$$\text{Control line}(CL) = \bar{p}$$

$$\text{Upper control line} = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

$$\text{Lower control line} = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

C- charts: -

- 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.
- p-chart considers the no. of defective pieces in a given sample, while C-chart takes into account the no. of defects in each defective piece or in a given sample.
- The c-chart is preferred for large and complex parts. Such parts being few and limited.

$$\bar{c} = \frac{\sum c}{k} = \frac{\text{Add up all the c values}}{c}$$

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

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

4.7 Methods of Attributes

4.8 Concept of ISO 9001-2008

- ISO 9001:2008 is a quality management system standard, first published in 1987 by ISO (International Organization for Standardization). This standard is designed to help organizations ensure that they meet all requirements of customers and stakeholders.
- ISO 9001 is considered as a key factor for doing business in global markets and for improving competitiveness.
- The top three countries for the total number of certificates issued are China, Italy and Germany, while the top three for growth in the number of certificates in 2013 are Italy, India and the USA.
- It is the most popular standard worldwide and up to the end of December 2013, at least 1, 129, 446 certificates had been issued in 187 countries.
- The table below summarizes the statistics of the ISO 9001 certifications around the world.

Standard	Number of certificates in 2013	Number of certificates in 2012	Evolution	Evolution in %
ISO 9001	1,129,446	1,096,987	32,459	3%

- Recent surveys show that 85% of certified organizations have experienced external benefits, while 95% of them have experienced internal benefits. They also have reported increased customer demand, employee awareness, operational efficiency and higher quality.
- ISO 9001 applies to all types and sizes of organizations that wish to:
    1. Establish, implement, maintain and improve an QMS;
    2. Assure conformity with the organization's stated quality policy;

3. Demonstrate conformity to others;
4. Seek certification/registration of its QMS by an accredited third-party certification body
5. Make a self-determination and self-declaration of conformity with this International Standard.

4.9.1 Quality management system (QMS), Registration/certificate procedure

Quality management system (QMS)

A quality management system (QMS) is defined as a formalized system that documents processes, procedures, and responsibilities for achieving quality policies and objectives. A QMS helps to coordinate and direct an organization's activities to meet customer and regulatory requirements and improve its effectiveness and efficiency on a continuous basis.

Benefits Of Quality Management Systems

- Meeting the customer's requirements, which leading to more customers, more sales.
- Meeting the organization's requirements, creating growth, and profit
- Defining, improving, and controlling processes
- Reducing waste
- Preventing mistakes
- Lowering costs
- Engaging staff
- Setting organization-wide direction

Elements And Requirements of A QMS

Each element of a quality management system helps achieve the overall goals of meeting the customers' and organization's requirements.

- The organization's quality policy and quality objectives
- Quality manual
- Procedures, instructions, and records
- Data management
- Internal processes
- Customer satisfaction from product quality
- Improvement opportunities
- Quality analysis

Registration/certificate procedure

ISO certification helps to improve your business credibility as well as overall efficiency of the business.

Pre-Requisite to ISO Certification Process

- **Choosing the type of ISO Certification:** -First of all, we need to choose the type of ISO certification required for your business. There are various types of ISO certification available such as:

    - ISO 9001 2008 – Quality Management
    - ISO 14001 – Environmental Management
    - ISO 27001 – Information security Management
    - ISO 22008 – Food Safety Management and so on.

- **Choosing an ISO Certification Body:** -ISO itself does not provide certification to the companies. Certification is done by the external bodies. It is very important that you choose recognized and credible certification body. While choosing the ISO registrar, we should keep the followings in mind:

    - Evaluate several ISO Certification service providers.
    - Check if they are following the CASCO standards. CASCO is the ISO committee that works on issues relating to conformity assessment.

- **Create an application /contract: -** The applicant and the registrar should agree on a contract. This contract usually defines rights and obligations of both parties and includes liability issues, confidentiality, and access rights.
- **Quality Documents Review:** -The ISO auditor will view all your quality manuals and documents related to various policies and procedures being followed in the organization.
- **Make an Action Plan:** -After the ISO auditor communicates the existing gaps in your organization, you should prepare an action plan to eliminate these gaps. Prepare the list of the required tasks to be performed to bring the desired changes in your organization. You may be required to give training to your employees to work efficiently while adapting to new procedures. Make all the employees aware of the ISO standards in terms of work efficiency and quality standards.
- **Initial Certification Audit:** -The initial certification audit is divided into two categories- **Stage 1 and Stage 2**.

Stage 1: The ISO auditor will audit the changes made by you in the organization. They will then try to identify the possible non-conformities in your systems and procedures to the desired quality management system. They will

divide these non-conformities into minor and major non-conformities.

The applicant must carefully assess all these non-conformities and get it aligned as per the desired quality standards through modification in the techniques and processes used by the organisation.

Stage 2: After all the required changes are done in the organisation, the ISO auditor does the final auditing. The auditor will check whether all the non-conformities have been eliminated or not as per ISO quality standards. If the ISO auditor is satisfied, they will prepare the final ISO audit report and forward it to the registrar.

- **Completing the ISO Certification: -**After all non-conformities are addressed and all the findings are put in the ISO audit report, the registrar will grant you the ISO certification.
- **Surveillance Audits: -**Surveillance audit is basically conducted to ensure that ISO quality standards are being maintained by the organization. It is conducted from time to time.

4.9.2 Benefits of ISO For an Organization

- Continuous Improvement
- Better internal management
- Less wastage
- Increase in efficiency, productivity and profit
- Consistent outcomes, measured and monitored
- Increase Business Opportunities
- Customer Satisfaction
- Minimises mistakes
- Improves reporting and communications
- Better quality products and service
- More reliable production scheduling and delivery
- Standards maintained by annual assessments

4.9.3 JIT, Six Sigma, 7S, Lean Manufacturing

JIT: -

Just-in-time also known as JIT is an inventory management method whereby labour, material and goods are re-filled or scheduled to arrive exactly when needed in the manufacturing process.

JIT approach has the capacity, when adequately applied to the organisation, to improve the competitiveness of the organisation in the market, minimizing wastes and improving production efficiency and product quality.

History of JIT

JIT was first developed and applied in the Toyota manufacturing plants in order to meet consumer demands with minimum delays. Taiichi Ohno of Japan is referred to as the father of JIT. Toyota met the increasing challenges for survival through a management approach that was entirely focused on people, systems and plants.

Significance of JIT

It identifies and correct the obstacles in the production process.

It shows the hidden problems of inventory.

It increases the inventory turnover and reduce the holding cost.

It prevents a company from using excessive inventory and smoothens production operations.

One example of a JIT system is a car manufacturer, the parts required in the manufacturing of cars do not arrive before or after they are needed; rather, they arrive only when they are needed.

Elements involved in JIT

- **Continuous improvement:** Attacking fundamental problems and anything that does not add value to the product.
- **Simplicity:** Simple systems are simple & easy to understand, easily manageable and the chances of going wrong are very low.
- **Eliminating waste:** There are seven types of waste:
    - Waste from product defects.
    - Waste of time.
    - Transportation waste.
    - Inventory waste.
    - Waste from overproduction.
    - Processing waste.

Advantages of JIT:

- JIT keeps stock holding costs to a minimum level.

- JIT helps to eliminate waste.
- No Chances of expired of products.
- As only essential stocks are to be maintained, thus less working capital is required.
- A minimum re-ordering level is set so becomes a boon to inventory management too.
- JIT emphasizes the 'right-first-time' concept, so that rework costs and the cost of inspection is minimized.
- Greater efficiency and High-quality products can be derived.
- Better relationships are fostered along the production chain.
- Higher customer satisfaction due to continuous communication with the customer.
- Overproduction is eliminated.

Disadvantages of JIT: -

- JIT approach states ZERO tolerance for mistakes, making re-work difficult in practice, as inventory is kept to a minimum level.
- Risk of Running Out of Stock
- Dependency on Suppliers
- More Planning Required
- Transaction costs would be comparatively high depending upon the frequency of transactions

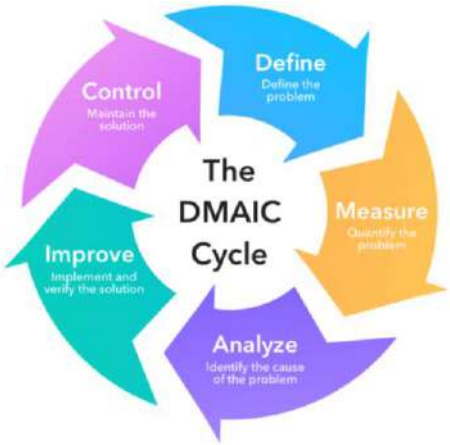
Six Sigma (6σ)

- Six Sigma is one of the foremost methodological practices for improving customer satisfaction and improving business processes.
- The Six Sigma methodology calls for bringing operations to a "six sigma" level, which essentially means 3.4 defects for every one million opportunities.
- Six Sigma goal is to use continuous process improvement and refine processes until they produce stable and predictable results.
- Six Sigma is a data-driven methodology that provides tools and techniques to define and evaluate each step of a process.
- It provides methods to improve efficiencies in a business structure, improve the quality of the process and increase the bottom-line profit.

Methodologies of Six Sigma

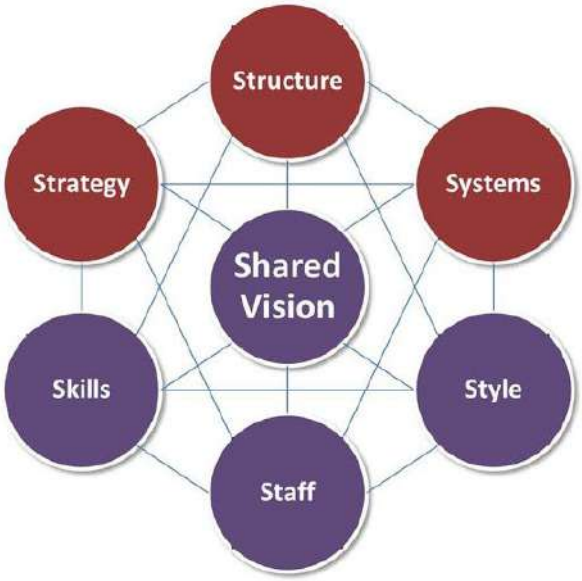
DMAIC: The DMAIC method is used primarily for improving existing business processes. The letters stand for:

- **D**efine the problem and the project goals
- **M**easure in detail the various aspects of the current process
- **A**nalyse data to, among other things, find the root defects in a process
- **I**mprove the process
- **C**ontrol how the process is done in the future



7S

The McKinsey 7S Model refers to a tool that analyses a company's "organizational design." The goal of the model is to depict how effectiveness can be achieved in an organization through the interactions of seven key elements – Structure, Strategy, Skill, System, Shared Values, Style, and Staff.



Structure of the 7S Model

- Structure: - Structure is the way in which a company is organized
- Strategy: - Strategy refers to a well-curated business plan that allows the company to formulate a plan of action.
- Systems: -It is the business and technical infrastructure of the company that establishes workflows and the chain of decision-making.
- Skills: -It forms the capabilities and competencies of a company that enables its employees to achieve its objectives.
- Style: -The attitude of senior employees in a company establishes a code of conduct, through their ways of interactions and symbolic decision-making.

- Staff: -Staff involves talent management and all human resources related to company decisions, such as training, recruiting, and rewards systems.
- Shared Values:- The mission, objectives, and values form the foundation of every organization and play an important role in aligning all key elements to maintain an effective organizational design.

Lean manufacturing: -

It is a production process based on an ideology of maximising productivity simultaneously minimising waste within a manufacturing operation.

The lean principle sees the waste that doesn't add value that the customers are willing to pay for. The benefits of lean manufacturing include reduced lead times and operating costs and improved product quality.

The types of waste include processes, activities, products or services that require time, money or skills but do not create value for the customer.

The 5 Principles of Lean manufacturing: -

1. Value: Eliminating waste allows manufacturers to deliver value to customers.

2. Map the Value Stream: If the value stream stops moving forward at any point, waste is the inevitable by-product. The lean manufacturing principle of flow is about creating a value chain with no interruption in the production process and a state where each activity is fully in step with every other.

3. Create Flow: Creating flow is about removing functional barriers to improve lead times. This ensures that processes are smooth and can be undertaken with minimal delay or other waste.

4. Establish a Pull System: In Lean Manufacturing, workflow is precise, making sure things are made just in time at the right time in the right amount. Lean Manufacturing eliminates the traditional manufacturing approach of producing products based on forecast and replaces it with a pull approach that dictates nothing is made until the customer orders it.

5. Perfection: The Lean Manufacturing Approach strives for perfection, minimizing defects and waste. As products are made, the pursuit of perfection continues, making for continuous improvements along each step of the process.

Advantages:

- Streamlined design: In the design stage, the Lean focus will be to establish a product with no unnecessary steps or waste. This results in a streamlined design that is easier to implement and bring to market.
- Reduced costs: Reduced waste results in lower costs, as time and resources are efficiently allocated.
- Increased efficiency: Employees follow the same process which is continually honed to ensure perfection. This reduces wasted employee time and maximizes labour power.
- Consistent quality: As the process of creation is standardized, there are no deviations that would result in poor quality products making it off the assembly line.

Disadvantages:

- Long roll out: Starting a Lean program can take a while as the initial process, value streams, and other necessities need to be reviewed and mapped out for the very first time. However, once implemented, a Lean process typically runs faster than a non-Lean one.
- Limited flexibility: As it is process-focused, it may seem that Lean limits creativity. However, the steps are designed to allow manufacturers to pivot with some frequency.
- It's ongoing: For those who need to check items off the to-do list, Lean manufacturing may not be ideal. It's an ongoing process that is never truly complete.

4.9.4. problems: -

Problem 1

Draw the X-bar and R -chart for the following observations.

Sample no Sample size 5	$\bar{x}$	R
1	7.0	2
2	7.5	3
3	8.0	2
4	10.0	2
5	9.5	3
6	11.0	4
7	11.5	3
8	4.0	2
9	3.5	3
10	4.0	2

The value of various factors is: A_2=0.58, D_3=0 D_4 = 2.11

Solution:

Sample no Sample size 5	$\bar{x}$	R
1	7.0	2
2	7.5	3
3	8.0	2
4	10.0	2
5	9.5	3
6	11.0	4
7	11.5	3
8	4.0	2
9	3.5	3
10	4.0	2
	$\Sigma \bar{x}$=76	ΣR =26

$$\bar{\bar{x}} = \frac{\Sigma \bar{x}}{\text{No.of samples}} = \frac{76}{10} = 7.6$$

$$\bar{R} = \frac{\Sigma R}{\text{No.of samples}} = \frac{26}{10} = 2.6$$

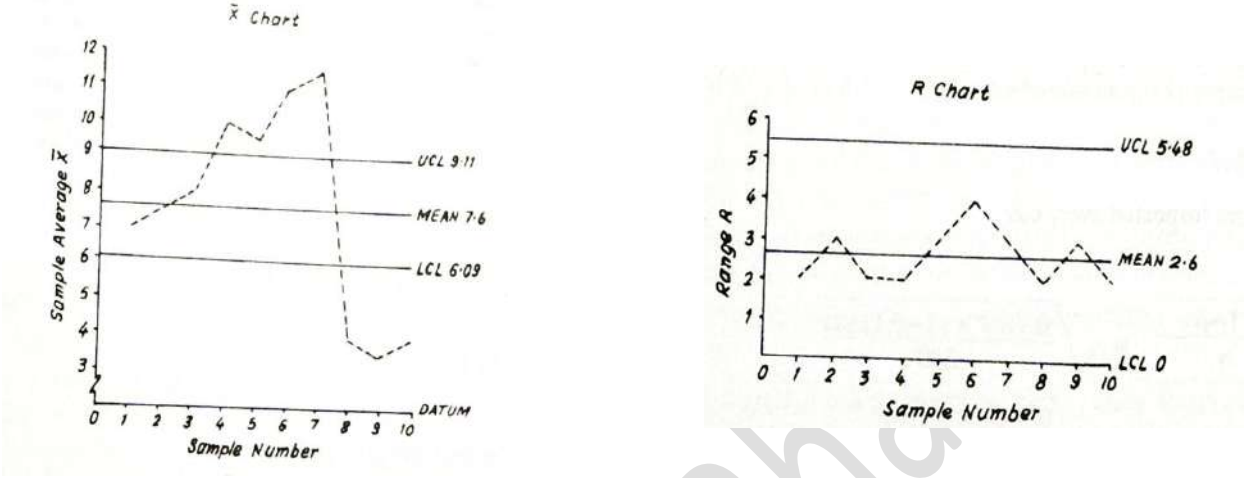
For $\bar{x}$ chart: Upper control limit (UCL) = $\bar{\bar{x}} + A_2 \bar{R} = 7.6 + 0.58 \times 2.6 = 9.11$

Lower control limit (LCL) = $\bar{\bar{x}} - A_2 \bar{R} = 7.6 - 0.58 \times 2.6 = 6.09$

For R chart: Upper control limit (UCL) = $D_4\bar{R} = 2.11 \times 2.6 = 5.48$

Lower control limit (LCL) = $D_3\bar{R} = 0 \times \bar{R} = 0$

From the $\bar{x}$ control chart, it appears that the process became completely out of control from 4th sample onwards.



problem 2

draw the p chart as per the following observations

Date	No of pieces inspected (a)	No of defective pieces found (b)
November 4	300	25
November 5	300	30
November 6	300	35
November 7	300	40
November 8	300	45
November 10	300	35
November 11	300	40
November 12	300	30
November 13	300	20
November 14	300	50

Solution

Date	No of pieces inspected (a)	No of defective pieces found (b)	Fraction defective P= b/a	% Defective 100P
November 4	300	25	0.0834	8.34
November 5	300	30	0.1000	10.00
November 6	300	35	0.1167	11.67
November 7	300	40	0.1333	13.33

November 8	300	45	0.1500	15.00
November 10	300	35	0.1167	11.67
November 11	300	40	0.1333	13.33
November 12	300	30	0.1000	10.00
November 13	300	20	0.0666	6.66
November 14	300	50	0.1666	16.66
Total number of days =10	**3000**	**350**		

We know that,

$\bar{p} = \frac{total\ no\ of\ defective\ pieces\ found}{total\ number\ of\ pieces\ inspected} = \frac{350}{3000} = 0.1167$

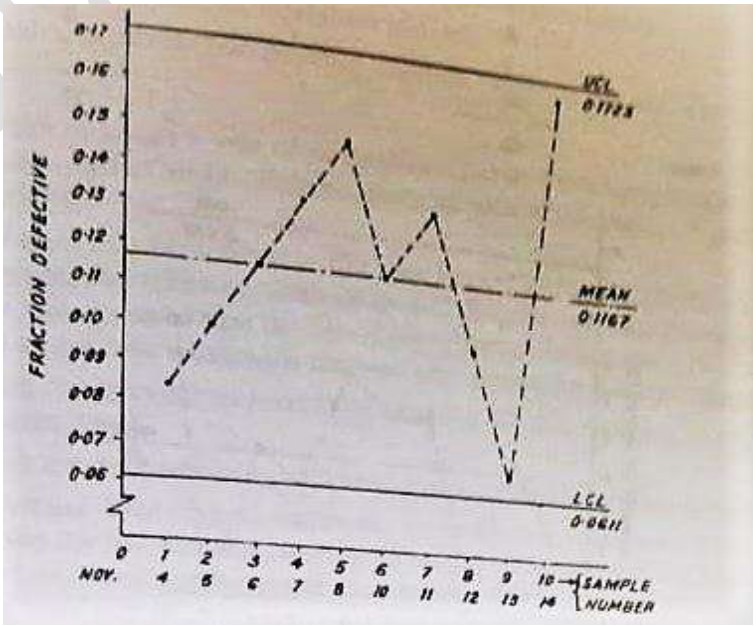
n= number of pieces inspected every day = 300

therefore, $\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} = \sqrt{\frac{0.1167\times(1-0.1167)}{300}} = \sqrt{\frac{0.1167\times0.8333}{300}} = 0.01852$

Upper control limit, UCL = $\bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} = 0.1167 + 3 \times 0.01852 = 0.17226 =$ 0.1723(Approx.)

Lower control limit, LCL = $\bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} = 0.1167 - 3 \times 0.01852 = 0.06114 =$ 0.0611(Approx.)

Mean, UCL and LCL are drawn on the graph paper, fraction defective values are marked and joined. It can be visualised that all the points lie within the control limits and hence the process is completely under control.



problem 3

Ten castings were inspected in order to locate defects in them. Every casting was found to contain certain number of defects as given below. It is required to plot a C-chart and draw the conclusions.

Castings	No of defects found on inspection(c)
1	2
2	4
3	1
4	5
5	5
6	6
7	3
8	4
9	0
10	7
Total =10	**37**

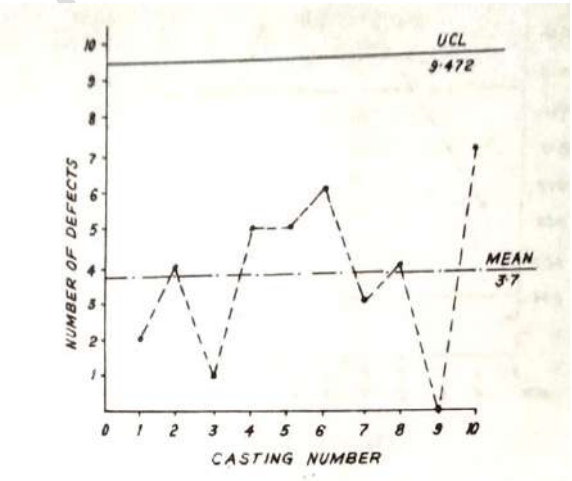
Solution:

Here, $\overline{c} = \frac{37}{10} = 3.7$

UCL = $\bar{c} + 3\sqrt{\bar{c}} = 3.7 + 3\sqrt{3.7} = 9.472$

UCL = $\bar{c} - 3\sqrt{\bar{c}} = 3.7 - 3\sqrt{3.7} = -2.072 = \text{ZERO}$

From the C-chart it is concluded that since all the values of C lie within the control limits, the process is under control. (Lower limit is negative and thus has been taken as being zero.)



POSSIBLE SHORT TYPE QUESTIONS WITH ANSWERS

1. **Define control charts?**

- It is graphical presentation of collected information and detects variation in the processing and warns if there is any departure from the specified tolerance limits.

2. Define lean manufacturing?

- Lean manufacturing is a production process based on an ideology of maximising productivity while simultaneously minimising waste within a manufacturing operation. The lean principle sees waste is anything that doesn't add value that the customers are willing to pay for. The benefits of lean manufacturing include reduced lead times and operating costs and improved product quality.

3. Define inspection and quality control?

- Inspection: -It is an activity of measuring, examining, testing one or more characteristics of a product or service and comparing the results with specified requirements in order to establish whether conformity is achieved for each characteristic.
- Quality Control: -It is an operational technique or a system of maintaining standards by reviewing, checking, inspecting and testing.

4. What is six sigma?

- The Six Sigma methodology calls for bringing operations to a "six sigma" level, which essentially means 3.4 defects for every one million opportunities. The goal is to use continuous process improvement and refine processes until they produce stable and predictable results.

5. Write the different types of control charts?

-

POSSIBLE LONG TYPE QUESTIONS WITH HINTS

6. Describe planning of inspection?

- Hints: refer article no-4.3

7. Describe the factors influencing the quality of manufacturing?

- Hints: refer article no-4.5

8. Write short notes on: lean manufacturing, 7s, six -sigma?

- Hints: -refer article no 4.9.3

…….

CHAPTER NO.- 05

PRODUCTION PLANNING AND CONTROL

Learning Objectives

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

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5.1 Introduction: -

Production planning and control refers to two strategies that work cohesively throughout the manufacturing process. Production planning involves what to produce, when to produce it, how much to produce, and more. A long-term view of production planning is necessary to fully optimize the production flow.

Production control uses different control techniques to reach optimum performance from the production system to achieve throughput targets.

5.2 Major functions of Production planning and control

- Improved organization for regular and timely delivery
- Better supplier communication for raw materials procurement
- Reduced investment in inventory
- Reduced production cost by increasing efficiency
- Smooth flow of all production processes

- Reduced waste of resources
- Production cost savings that improve the bottom line

5.3 Methods of forecasting

Forecasting

Forecasting is a technique that uses historical data as inputs for prediction of the direction of future trends.

Businesses utilize forecasting to determine how to allocate their budgets or plan for anticipated expenses for an upcoming period of time. Forecasting is important because it can be used for:

- Estimating the success of a new business venture
- Estimating financial necessities
- Helping managers make the right decisions
- Formulating effective plans for the future

The four main forecasting methods are:

- Straight-line method: It is the easiest forecasting method typically used by financial analysts to determine future revenues based on past trends.
- Moving average: This technique analyses the underlying pattern of a dataset to estimate future values.
- Simple linear regression: It is especially useful when analysing the connection between different variables, to get a more accurate prediction.
- Multiple linear regression: It is mainly used for forecasting revenues, in situations where two or more independent variables are needed for a projection.

5.3.1 Routing

- Routing lays down the flow of work in the plant that is it determines what work is to be done and where and how it will be done.
- Taking from raw material to the finished product, routing decides the path and sequence of operations to be performed on the job from one machine to another.
- The purpose of Routing is to establish the optimum sequence of operations. Routing in production management is related to considerations of layout, temporary storage of in-process inventory and material handling.

Routing Procedure

- Product analysis determines what to manufacture and purchase.
- Product-analysis is done again to determine materials required for production.
- Fix the manufacturing operations and their sequences.

- Decide the number of units to be manufactured in a batch (lot).
- Estimate the margin of scarp in each lot of production.
- Analyse the production cost.
- Prepare production control forms for effective routing.
- Prepare a separate route-sheet for each order.

5.3.2 Scheduling

- Scheduling is the process of arranging, controlling and optimizing work and workloads in a manufacturing process.
- Scheduling is used to allocate plant and machinery resources, plan human resources, plan production processes and purchase materials.
- The purpose of scheduling is to maximize the efficiency of the operation, minimize the production time and costs, by telling a production facility when to make, with which staff, and on which equipment.

Benefits of scheduling

- Process change-over reduction
- Inventory reduction
- Increased production efficiency
- Labour load levelling
- Accurate delivery date quotes
- Real time information

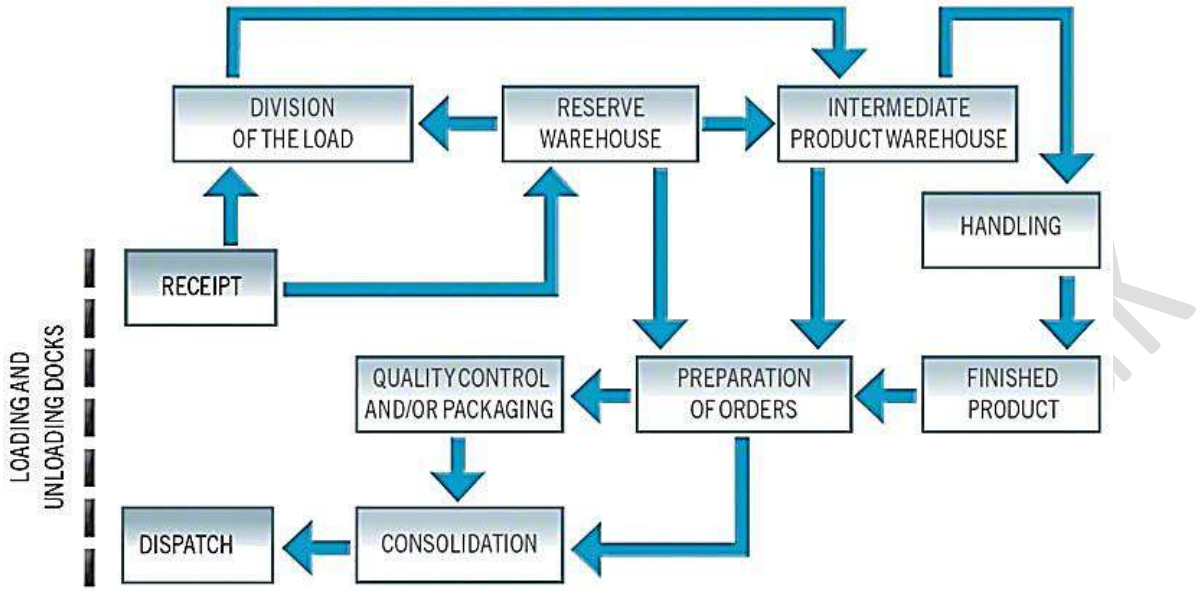
Concepts of scheduling

A key character of scheduling is the productivity, the relation between quantity of inputs and quantity of output. Key concepts here are:

- Inputs: Inputs are plant, labour, materials, tooling, energy and a clean environment.
- Outputs: Outputs are the products produced in factories either for other factories or for the end buyer.
- Output within the factory: The output of any one work area within the factory is an input to the next work area in that factory.
- Output for the next factory
- Output for the end buyer
- Resource allocation: Resource allocation is assigning inputs to produce output.

5.3.3 Dispatching

Dispatching is the routine of setting productive activities in motion through the release of orders and necessary instructions according to pre-planned times and sequence of operations embodied in route sheets and loading schedules.



Functions

- To ensure that the right materials are moved from stores to machines & from operation to operation.
- To distribute machine loading & schedule charts, route sheets.
- To instruct tools department to issue the right tools, accessories & fixtures in time.
- To authorize the work to be taken in hand as per the predetermined dates & time.
- To direct inspection at various stages of production for inspection report.

Dispatching Procedure:

Dispatch function may be centralized or decentralized.

In a Centralized dispatch system, a central dispatching department, orders directly to the work station. It maintains a full record of the characteristics and capacity of each equipment and work load against each machine. The orders are given to the shop supervisor, who runs his machines accordingly.

Advantages

- A greater degree of overall control can be achieved.
- It has greater flexibility
- Progress of orders can be readily assessed at any time because all the information is available at a central place.
- There is effective and better utilization of manpower and machinery.

In a Decentralized dispatching system, the shop supervisor performs the dispatch factions. He decides the sequence of handling different orders. He dispatches the orders and materials to each equipment and worker, and is required to complete the work within the prescribed duration. In case he suspects delay, with due reasons of the same, he informs the production control department.

Advantages

- Shop supervisor knows best about his shop; therefore, the work can be accomplished by the most appropriate worker and the machine.
- Communication gap is reduced
- It is easy to solve day-to-day problems

5.3.4 Controlling

The production control is the function of management which plans, directs and controls the material supply and processing activities of an enterprise so that specified products are produced by specified methods to meet an approved sales programme.

Functions

- Control Activities
- Control of Material Movement
- Availability of Tools is Controlled
- Quantity Produced is Controlled
- Control of Replacement
- Labour Efficiency and Control

Advantages

- Better service to customers
- Less overtime works
- Need of smaller inventories of work-in-process and of finished goods
- More Effective Purchasing
- More effective use of equipment
- Less loss of time
- Savings in the cost
- Less work-stoppages

5.4 Types of Production

Some of the most important types of production are:

- Mass or flow production
- Batch production and
- Job order Production

5.4.1 Mass or flow production:

This method involves a continuous production of standardized products on a large scale. Under this method, production remains continuous in anticipation of future demand. Standardized products are produced under this method by using standardized materials and equipment. There is a continuous or uninterrupted flow of production obtained by arranging the machines in a proper sequence of operations. Process layout is best suited method for mass production units. The product completed at one operation is automatically passed on to the next till its completion. There is no time gap between the work done at one process and the starting at the next. The flow of production is continuous and progressive.

Characteristics

- The units flow from one operation point to another throughout the whole process.
- There will be one type of machine for each process.
- The products, tools, materials and methods are standardised.
- Production is done in anticipation of demand.
- Production volume is usually high.
- Machine set ups remain unchanged for a considerable long period.
- Any fault in flow of production is immediately corrected otherwise it will stop the whole production process.

Advantages

- Standardized product
- Competitive advantage
- Cost savings
- Convenience
- Expanded market

Disadvantages

- Lack of customization
- Environmental impact
- High initial investment
- Decreased quality

5.4.2 Batch production

It is that form of production where identical products is produced in batches on the basis of demand of customers or of expected demand for products. It refers to the production of goods, the quantity of which is known in advance. Instead of making one single product as in case of job production, a batch or group of products are produced at one time. Under batch system of production, the work is divided into operations and one operation is done at a time. After completing the work on one operation it is passed on to the second operation and so on till the product is completed. Batch production can fetch the benefits of repetitive production to a large extent, if the batch is of a sufficient quantity. This method is generally adopted in case of biscuit and, motor manufacturing, medicines, tinned food and hardware's like nuts and bolts etc.

Advantages

- Less overall cost per each quantity.
- Machinery is not always on that saves the energy costs.
- Companies only focus on a small group of products, leading to greater quality control and product expertise.
- Smoother and more consistent production flow.
- Job satisfaction exists for operators.
- It reduces inventory.
- Labour cost reduced so the final price is lower.
- Production is faster.

Disadvantages

- High storage cost for large batches for the same products.
- Work is less interesting and repetitive works can demotivate workers.
- Material handling is complex of irregular and longer flows.
- Larger stock of raw materials must be kept.

5.4.3 Job order Production

Under this method peculiar, special or non-standardized products are produced in accordance with the orders received from the customers. As each product is non- standardized varying in size and nature, it requires separate job for production. The machines and equipment's are adjusted in such a manner so as to suit the requirements of a particular job.Ship building, dam construction, bridge building, book printing is some of the examples of job production.

Characteristics

- A large number of general-purpose machines are required.

- A large number of workers conversant with different jobs will have to be employed.
- There can be some variations in production.
- Some flexibility in financing is required because of variations in work load.
- A large inventory of materials, parts and tools will be required.
- The machines and equipment setting will have to be adjusted and readjusted to the manufacturing requirements.

Advantages

- It helps in the identification of the efficiency of machines and the workforce.
- It helps in cost control and better utilization of resources.
- With the help of the job order costing method, management can ascertain which job is profitable and which is not.
- It helps compare a similar job that will be done in the future and become the basis of future employment.

Limitations

- The economies of large-scale production may not be attained because production is done in short-runs.
- The demand is irregular for some products.
- The use of labour and equipment may be an inefficient.
- The scientific assessment of costs is difficult.

5.5 Principles of Product and Process Planning

Process Planning

Process planning is also called manufacturing planning, material processing, process engineering, and machine routing. It is the act of preparing detailed work instructions to produce a part. It is a complete description of specific stages in the production process. Process planning determines how the product will be produced or service will be provided. Process planning converts design information into the process steps and instructions to powerfully and effectively manufacture products.

Principles

- First define the outputs, and then look toward the inputs needed to achieve those outputs.

- Describe the goals of the process, and assess them frequently to make sure they are still appropriate.
- When mapped, the process should appear as a logical flow, without loops back to earlier steps or departments.
- Any step executed needs to be included in the documentation.
- People involved in the process should be consulted, as they often have the most current information.

Product Planning

The planning for any organization forms the backbone of production process. Planning of products helps organizations to understand the situation and also assists in committing accurate delivery time to the customers. Its purpose is to minimise production time and costs, efficiently organise the use of resources and maximise efficiency in the workplace.

Principles

- Customer Demand
- Materials
- Equipment
- Manpower
- Processes
- Controls

POSSIBLE SHORT TYPE QUESTIONS WITH ANSWERS

1. **Define Routing?**
   - **Routing** lays down the flow of work in the plant. It determines what work is to be done and where and how it will be done. Taking from raw material to the finished product, routing decides the path and sequence of operations to be performed on the job from one machine to another
2. **What are the important methods of forecasting?**
   - Straight-line method, Moving average, Simple linear regression, Multiple linear regression:
3. **What do mean by scheduling?**
   - Scheduling is the process of arranging, controlling and optimizing work and workloads in a production process or manufacturing process. Scheduling is used to allocate plant and machinery resources, plan human resources, plan production processes and purchase materials.

POSSIBLE LONG TYPE QUESTIONS WITH HINTS

1. **Write in brief different types of production?**
   Hints: - refer article no.5.4.1,5.4.2,5.4.3
2. **Describe in brief about the process of dispatching?**
   Hints: - refer article no.5.3.3
3. **Describe the principles of product and process planning?**
   Hints:- refer article no.5.5