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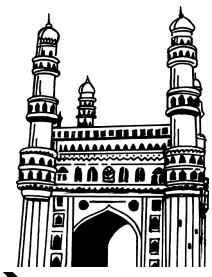

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PRODUCTION AND OPERATIONS MANAGEMENT

STUDY MANUAL

SOLVED MODEL PAPERS

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SYLLABUS

UNIT - I

Introduction to Operations Management: Functional Subsystems of Organization, Definition, Systems Concept of Production, Types of Production Systems, Flow, Job Shop, Batch Manufacturing and Project, Strategic Operations Management, Corporate Strategic, Generic Competitive Strategies, Functional Strategies, Productivity, World Class Manufacturing, Sustainable Operations Management, Industry 4.0.

UNIT - II

Product Design and Analysis: New Product Development, its Concepts, Steps of Product Design, Process Planning and Design, Selection of Process, Responsibilities of Process Planning Engineer, Steps in Process Planning. Process Design, Process Research, Pilot Plant Development, Capacity Planning, Enhanced Capacity using Optimization. Value Analysis, Value Engineering, Lean Production System.

UNIT - III

Plant Location and Plant Layout: Factors Influencing Plant Location, Break-even Analysis. Single Facility Location Problem, Multi facility Location Problems, Model for Multi Facility Location Problem, Model to Determine X-Coordinates of New Facilities, Model to Determine Y- Coordinate.

Plant Layout - Plant Layout: Introduction, Classification of Layout, Advantages and Limitations of Product Layout, Advantages and Limitations of Group Technology Layout, Layout Design Procedures.

UNIT - IV

Scheduling: Introduction, Johnson's Algorithm, Extension of Johnson's Rule. Job Shop Scheduling: Introduction, Types of Schedules, Schedule Generation, Heuristic Procedures, Priority Dispatching Rules. Two Jobs and m Machines Scheduling. Quality Control Concepts.

UNIT - V

Materials Management: Integrated Materials Management, Components of Integrated Materials Management, Materials Planning, Inventory Control, Purchase Management, e- Procurement, Green Purchasing, Stores Management, EOQ, Models of Inventory, Operation of Inventory Systems, Quantity Discount, Implementation of Purchase Inventory Model, Incoming Materials Control, Obsolete Surplus and Scrap Management, ABC Analysis, XYZ Analysis, VED Analysis, FSN Analysis, SDE Analysis.

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Ans : **(April-23, May-19, Dec.-19, Dec.-18, Aug.-17, Feb.-15, Imp.)**

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7. What do you mean by Strategy and Strategic Management? Explain the process of strategic management.

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Ans : **(April-23, Imp.)**

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2. Define New Product Development. What are the causes and factors for New Product Development?

Ans : **(April-23, Imp.)**

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3. What are the various steps involved in Product Design?

Ans : **(Dec.-19, May-19, Feb.-16, Aug.-15, Imp.)**

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Ans : **(Oct.-22, Aug.-21, May-19, Aug.-17)**

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7. Distinguish between value analysis and value engineering.

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8. What are the objectives of lean productions system?

Ans : **(Imp.)**

Refer Unit-II, Q.No. 26.

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1. What is meant by Plant Location? Explain the need of plant location.

Ans : **(Feb.-17, Aug.-16)**

Refer Unit-III, Q.No. 1.

2. Enumerate and explain the major factors governing plant location.

Ans : **(Dec.-19, Feb.-17, Aug.-16)**

Refer Unit-III, Q.No. 2.

3. Explain briefly about Break-even Analysis.

Ans : **(May-19, Aug.-17)**

Refer Unit-III, Q.No. 3.

4. The following are the potential sites for setting up of Ice factory. Using the following details, decide which site can be picked up for setting up of Ice factory.

Annual demand is 3,000 units

Selling price per unit is ` 300/-

Sites	Fixed cost (`)	Variable cost (`)
Mumbai	50,000	135
Ahemadabad	1,00,000	110
Bangalore	1,20,000	120

Ans : **(Dec.-19, Imp.)**

Refer Unit-III, Prob. 6.

5. What is Multi facility Location Problems? Explain its formulation.

Ans : **(April-23)**

Refer Unit-III, Q.No. 5.

6. "Plant layout involves, besides grouping of machinery an arrangement of other facilities also". Discuss.

Ans : **(Oct.-20)**

Refer Unit-III, Q.No. 14.

UNIT - IV

1. Explain the following terms in context of a job sequencing problem.

Ans : **(April-23, Dec.-19, April-19, Feb.-16)**

Refer Unit-IV, Q.No. 6.

2. What are the set of priority rules for scheduling jobs through single machine? Explain briefly each of them.

Ans : **(Dec.-18, Imp.)**

Refer Unit-IV, Q.No. 8.

3. Heuristic procedure is a quantitative technique for getting an optimal solution of a general job shop problem.

Ans : **(Oct.-20)**

Refer Unit-IV, Q.No. 12.

4. What are the disadvantages of Gantt chart as a scheduling tool?

Ans : **(Dec.-18)**

Refer Unit-IV, Q.No. 18.

5. Discuss the various types of Control Charts used for variables and attributes.

Ans : **(Imp.)**

Refer Unit-IV, Prob.No. 19

UNIT - V

1. Define Inventory. Explain the significance of Inventory.

Ans : **(Dec.-19, Imp.)**

Refer Unit-V, Q.No. 11.

2. Explain the different types of cost associated with inventory.

Ans : **(Feb.-17, Feb.-15, Aug.-15, Imp.)**

Refer Unit-V, Q.No. 13.

3. Explain briefly about Economic Order Quantity.

Ans : **(Aug.-16, Imp.)**

Refer Unit-V, Q.No. 15.

4. Explain in detail deterministic and probabilistic models of inventory.

Ans : **(Aug.-17, Imp.)**

Refer Unit-V, Q.No. 18.

5. From the following particulars, calculate the Economic Order Quantity (ECQ)

Annual requirements	**1,600 units**
Cost of materials per unit	**` 40**
Cost of placing and receiving one order	**` 50**

Annual carrying cost for inventory value 10%, carrying cost is estimated at cost price of materials.

Sol: **(Dec.-19)**

Refer Unit-V, Prob. No. 3.

6. Describe briefly about Q System.

Ans : **(Imp.)**

Refer Unit-V, Q.No. 21.

7. Compare and contrast fixed order quantity inventory system with fixed order period inventory system.

Ans : **(June-18)**

Refer Unit-V, Q.No. 23.

UNIT I

Introduction to Operations Management: Functional Subsystems of Organization, Definition, Systems Concept of Production, Types of Production Systems, Flow, Job Shop, Batch Manufacturing and Project, Strategic Operations Management, Corporate Strategic, Generic Competitive Strategies, Functional Strategies, Productivity, World Class Manufacturing, Sustainable Operations Management, Industry 4.0.

1.1 Introduction to Operations Management

1.1.1 Definitions

Q1. Define operations management. Explain the nature of operations management.

Ans : **(Oct.-22, Feb.-17, Imp.)**

Meaning

Operations management is a modern discipline (of practise) which deals with the process of planning, designing, operating and managing the systems and subsystems of an organization for the achievement of organizational goals.

Definitions

1. **According to H.A. Harding,** "Production management is concerned with those processes which convert the inputs into outputs. The inputs are various resources like raw materials, men, machines, methods, etc. and the outputs are goods and services."
2. **According to M.J.S. Harry,** the word production is often used to mean the same as manufacture. In order to go through a process of manufacturing itself, we need basically three things: someone to do the job, his equipment and the necessary materials. To run production, we require service activities which make sure that the manufacturing activity can go on and control to make sure that it goes in the right direction.
3. **According to E.S. Buffa,** "Production management deals with decision-making related to production processes so that the resulting goods or service is produced according to specifications, - the amounts and by the schedule demanded and at minimum cost."

Nature

1. **Production as a System**

As the main function of an operations system is to convert or transform a set of inputs into outputs, it is considered as a system. In production, a set of inputs constitute a production system, their conversion into desired products constitute a conversion-subsystem and a portion of output which has to be analysed in terms of cost, quality and quantity constitutes a control subsystems.

2. **Production as an Organizational Function**

The conversion subsystem is considered as the core component of any production system as it uses men, materials and machines for converting inputs, into outputs (finished goods). Production has become an integral part of every organization wherein personnel and departments are playing pivotal role in achieving the objectives of an organization.

3. **Decision Making in Production**

The Production/Operations manager has to make a series of decisions related to production as they are responsible for planning, organizing, staffing and controlling the entire process of production. These decision are divided into three different categories.

(a) Strategic Decisions : These decisions are long term in nature and are of strategic importance. They may be related to production processes, production technology, facility layout, allocating scarce resources etc. These decisions provide answers to question like - How much to produce, where to produce, when to produce, and so on.

(b) Operational Decisions : Such decisions are made to efficiently fulfill the market demand for products and services. It basically includes planning decisions. These decisions ensure that the organization is producing goods and services as per the requirements of the market, thereby, generating reasonable profit for the organization. The operational decisions are taken in production planning system, materials management, shop flow planning, demand inventory system etc.

(c) Control Decisions : These decisions are basically taken by the production for planning and controlling the day-to-day production activities. Such decision are taken based on the quality of the product/ service, productivity of workers, maintenance of machines and tools and so on.

Therefore, one can say that the nature of operations management is very wide as it covers all the areas of production like planning, designing, operating and managing the production system.

Q2. Discuss the characteristics of operations management.

(OR)

Write about the characteristics of operations management.

Ans : **(Oct.-22)**

1. Source of Competitive Advantage

Traditionally, production function operated in the similar manner as that of the other functions of the organization. However, today with the use of latest technology, computer and robotic aid, organizations have excess production capacity requires competitive advantage to survive in the market.

2. Use of Scientific Management

Now a days, operations management is making use of many scientific management techniques. Tools like linear programming. PERT charts and many others. Infact a separate field of Industrial Engineering (IE) has emerged to cater to the needs of operations management.

3. Service Orientation

Service sector is gaining greater relevance these days. The production system, therefore, needs to be organized keeping in mind the peculiar requirements of the service component. The entire manufacturing needs to be geared to serve

(i) Intangible and perishable nature of the services.

(ii) Constant interaction with clients (or) customers.

(iii) Small volumes of production to serve local markets, and

(iv) Need to locate facilities to serve local markets.

There is increased presence of professionals on the production, instead of technicians and engineers.

Q3. Describe the role of operations in strategic management.

Ans : **(Jan.-18, Imp.)**

1. Gaining Competitive Advantage

The company which holds greater competitive advantage over its competitors has greater chances of becoming successful. The organizations often make use of various production or operations function for attaining competitive ad vantage over its competitors in the areas like greater inventory turns, less new product lead times, less manufacturing lead times, greater quality, higher flexibility, greater customer service, less wastage.

2 Increases Productivity

High productivity helps the organization to be successful. Production function provides a underscope for achieving greater productivity. Effective operations management helps in controlling the cost and producing more from a given input at a reasonable cost.

3. Solves Difficult Problems

With the help of production and operations management, managers can easily solve difficult problems which are related to the selection of materials, scheduling, routing and controlling the activities.

4. Employee Satisfaction

Operations management helps in satisfying the employees by providing adequate wages job security, good working conditions and increased personal and job satisfaction. Employee satisfaction in rum helps the organization to be successful.

5. Customer Satisfaction

Customers are regarded as 'kings' of the organizations and hence satisfying customers is quite essential for the success of any organization. Operations management helps in satisfying the customers by providing them the right kind of products, at right place, at right price, at right time, in right quantity and in right quality.

6. Increases Suppliers

Operations management would help in increasing the confidence of suppliers management by realizing their bills without any delays. This in turn would increase the number of suppliers and helps the firm to be successful.

7. Increases Investors

Finance is regarded as the life blood of an business organization. For carrying out the business operations smoothly, finance is essential and plays a very important role. Operations management helps in increasing the number of investors by providing them greater security for their investments, adequate market returns, credibility and good image in the society.

8. Increases the Standard of Living of People

The standard of living of individuals greatly depends upon the production of goods and services. Increase in production would result in the increase of the standard of living of individuals. Increase in the standard of living of employees will help in increasing the employees' commitment towards the organization which would further help in the success of an organization.

Q4. Explain the Evolution of operation management.

(OR)

Discuss the evolution of production function.

Ans : **(Feb.-17, Imp.)**

1. Industrial Evolution

The evolution of modern operations management began when Adam Smith recognized the importance of division of labor, and the assigning of workers to tasks based on their individual skills and capabilities. The concept was adopted by Fredrick W. Taylor in his book "The Principles of Scientific Management".

2. Scientific Management

Fredrick W. Taylor introduced the concept of scientific management.

The concepts as follows :

- Each worker should be assigned a task based on his skill, and ability to learn.
- Standard output time is set for each task, using stopwatch studies. This should be used to plan and schedule future tasks.
- Instruction cards, routing sequences, and material specifications are used for coordinating the activities in a shop, and work methods and work flow should be standardized.
- Proper supervision by carefully selected and trained supervisors.
- Incentive pay systems to motivate workers.

3. Moving Assembly Line

In 1911, Henry Ford applied the principles of scientific management to a moving assembly line for the manufacture of the Model to Ford automobile by employing standardized product designs, mechanized assembly lines, specialized labor and interchangeable parts in production units. Ford was able to reduce the production time for a car. This was the first successful implementation of scientific management principles. This application of principles of scientific management was thus used world wide.

4. The Human Relationship Movement

In the Plant of the Western Electric Company in the 1927-1932 period, Hawthorne Studies were conducted by industrial engineers and were aimed at determining the optimal level of lighting to get maximum output from workers.

When these studies produced confusing results about the relationship between physical environment an worker productivity, the researchers realized that human factors must be affecting productivity. Thus for, the first time that researchers and managers alike, recognized that, psychological sociological factors affected not only employee motivation but their productivity as well.

5. Operations Research

At the beginning of World War II, Great Britain, desperately needed to solve a number of new and complex problems in warfare. With their survival at stake, the British formed the first OR teams by selecting the expertise of mathematicians, physicists and other scientists. With such teams, the British were able to achieve significant technological and tactical breakthroughs.

6. Computers and Advanced Operations Technology

Computerization has brought significant improvement in the production process. It was led to improvement in the quality of products and services, reduction in labor costs and wastage, increase in efficiency of the production process, etc.

7. The Service Revolution

The impact of service organizations on production management has been enormous. It is a challenge for manufacturing managers that they should formulate strategies and actions to manage service areas for better productivity, quality and competitiveness.

It is a process technology is suitable for those manufacturers who produces goods or provides services in small batches of many different products as per the requirement of costumers i.e., custom design.

Q5. Explain the scope of operation management.

Ans :

Due to the dynamic change in the business environment, the scope of production and operation management has increased. Following are the activities which are included under production and operations management functions:

1. Facility Location

Selecting appropriate location for the production

2. Plant Layouts and Material Handling

Deciding upon the machines, equipment and necessary devices which could lead to effectual and desired production in the most economic way. Preparation of plan layout for the establishment of machines in the required sequence. Storage of material and handling it in most effective way to avoid the wastage and delivery at the work centers as and when required.

3. Product Design

Designing the product and conceive the idea about its production.

4. Process Design

Determination of the production process which is most relevant and efficient in the given state of affairs.

5. Production and Planning Control

Planning the production and its various aspects how, when and where producing a particular product or its assembly will be done.

6. Quality Control

Controlling the production and ensuring the quality by setting the check points and taking the periodic measurements of the current performance.

7. Materials Management

Managing the inventories of raw material, semi-finished and finished goods in a way that neither excessive money may block in this non-productive operation nor the required material.

8. Maintenance Management

Analysis the deviations and formulating the corrective measures to stay in track with planned quality, time-schedule and predetermined cost schedules.

Q6. Explain the objectives of operations management.

Ans :

Operation Management involves manage-ment of the entire process responsible for converting inputs into outputs**.** The following are the objectives of Operations Management.

1. To provide customer service

The main objective of any operating management systems is to utilize resources judiciously for the satisfaction of customer needs and wants. Therefore, customer satisfaction is a key objective of operations management. Operation management focuses on providing the right products at a right price at the right time. Hence, this objective will influence the operations manager's decisions to achieve the required customer service.

2. Effective utilization of resources

Resources that are used in the business organization must be carefully utilized. Inefficient use of resources or inadequate customer service leads to commercial failure of an organization. Operations management is concerned essentially with the utilization of resources. It aims at obtaining maximum output from the available resources with minimum cost.

3. To reduce cost of production

Operation management aims at reduction in the cost of production of goods and services. The cost per unit of the product has to be set properly and all efforts should be taken to control the actual cost to pre-determined cost of production. Cost can be classified in to fixed cost and variable cost. The variable cost changes with every level of production. This variable cost can be checked by means of inventory and labour control techniques.

4. To improve product quality

Quality control and maintenance are the two important objectives of operations management. Quality control consists of all those activities, which are designed to define, maintain and control specific quality of products within reasonable limits. It is the systematic regulation of all variables affecting the goodness of the final product. In other words, quality control involves determination of quality standards and its actual measurement .It is necessary to ensure that the established standards are practiced and maintained. It does not attempt to achieve the perfect quality but to secure satisfactory or reasonable quality at a reasonable level of cost.

5. To fix time schedule

Another important objective of operation management is to establish time schedule for various operation activities. The schedule fixation includes the operating cycle time, inventory turnover rate, machine utilization rate, capacity utilization etc.

6. Proper utilization of Machinery

Operation management has to take number of decisions with regard to machinery and equipment. New machines should be installed and the old machines are to be replaced. It has to ensure judicious utilization of machinery and equipment.

7. Material control

Based on the sales forecast and production plans, the materials planning and control is done. This involves estimating the individual requirements of parts, preparing materials budget, forecasting the levels of inventories, scheduling the orders and monitoring the performance in relation to production and sales.

Q7. Discuss the recent trends in production and operations management.

Ans :

1. Global Market Place

Globalization of business has compelled many manufacturing firms to have operations in many countries where they have certain economic advantage. This has resulted in a steep increase in the level of competition among manufacturing firms throughout the world.

2. Production/Operations Strategy

More and more firms are recognizing the importance of production/operations strategy for the overall success of their business and the necessity for relating it to their overall business strategy.

3. Total Quality Management (TQM)

TQM approach has been adopted by many firms to achieve customer satisfaction by a never-ending quest for improving the quality of goods and services.

4. Flexibility

The ability to adapt quickly to changes in volume of demand, in the product mix demanded, and in product design or in delivery schedules, has become a major competitive strategy and a competitive advantage to the firms. This is sometimes called as *agile manufacturing.*

5. Time Reduction

Reduction of manufacturing cycle time and speed to market for a new product provide competitive edge to a firm over other firms. When companies can provide products at the same price and quality, quicker delivery (short lead times) provide one firm competitive edge over the other.

6. Technology

Advances in technology have led to a vast array of new products, new processes and new materials and components. Automation, computerization, information and communication technologies have revolutionised the way companies operate. Technological changes in products and processes can have great impact on competitiveness and quality, if the advanced technology is carefully integrated into the existing system.

7. Worker Involvement

The recent trend is to assign responsibility for decision making and problem solving to the lower levels in the organization. This is known as employee involvement and empowerment. Examples of worker involvement are quality circles and use of work teams or quality improvement teams.

8. Re-engineering

This involves drastic measures or break-through improvements to improve the performance of a firm. It involves the concept of clean-slate approach or starting from scratch in redesigning the business processes.

Q8. Distinguish between production management and operations management.

Ans : **(Feb.-17)**

S.No.	Nature	Production Management	Operations Management
1.	**Meaning**	Production Management cannotes administration of the range of activities belonging to the creation of products	Operations Management refers to the part of management concerned with the production and delivery of goods services.
2.	**Decision Making**	Related to the respects of production.	Related to the business activities.
3.	**Found in**	Enterprises where production is undertaken.	Banks, Hospitals, Companies including production companies, agencies etc,.
4.	**Objectives**	To produce right quality goods in right quantity at right time and at least cost.	To utilize resources, to the extent possible so as to satisfy customer wants.

1.2 FUNCTIONAL SUBSYSTEMS OF ORGANIZATION

Q9. Explain the Functional Subsystems of Organization.

Ans : **(Imp.)**

An organization consists mainly of four functional subsystems, viz. Marketing, Production, Finance and Personnel as shown in Fig. below.

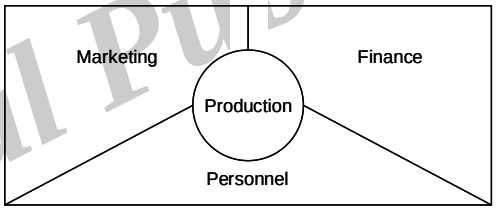


Figure: Functional subsystems of organization

1. Marketing

The marketing function of an organization aims to promote its products among customers, which helps to obtain substantial sales order. This, in turn, is communicated to the production subsystem which is concerned with the management of physical resources for the production of an item or provision of a service. This means that the available facilities also need to be managed to meet the current market requirements.

i) Managers in the marketing function are responsible for creating a demand for an organization's products and services.

ii) This responsibility entails activities such as identifying prospective customers, advertising and promoting products and services, storing, displaying and demonstrating products and services, supervising salespersons, setting sales prices, receiving revenues, and providing an interface with customers.

2. Production

To manufacture the products as per the specifications, the production function needs to organize its resources (raw materials, equipments, labour and working capital) according to the predetermined production plans.

i) A production system takes input - raw material, personnel, machines, buildings, technology, cash, and other resources and converts them into outputs products and services.

ii) This conversion process is the heart of what is called production and is the predominant activity of a production system.

iii) Operations managers manage the production system; their primary concern is with the activities of the conversion process or production.

3. Finance

The finance function provides authorization and control to all other subsystems to utilize money more effectively through a well designed mechanism.

i) Managers in the finance responsible for achieving the financial objectives of the firm.

ii) This responsibility entails activities such as providing liquidity, providing financial-performance information to other managers, preparing financial information for stockholders, establishing lines of credit, etc.

4. Personnel

The personnel function is a supporting function which plans and provides manpower to all other subsystems of the organization and to itself by formulating proper recruitment and training programmes. It also monitors the performance of the employees for better direction, promotions and results.

The functional subsystems of any business organization are interwoven by many linkages. They cannot function in isolation.

1.3 Systems Concept of Production

Q10. Define production. Explain in detail the systems concept of production.

(OR)

Briefly explain the systems perspective of production management.

(OR)

What is system concept of production.

(OR)

Explain concept of production.

Ans : **(April-23, May-19, Dec.-19, Dec.-18, Aug.-17, Feb.-15, Imp.)**

i) Meaning of Production

Production may be defined as conversion of inputs-men, machine, materials, money, methods and management (6Ms) into output through a transformation process. Output may be goods produced or services rendered.

Production is a method employed for making or providing essential goods and services for consumers. It is a process that puts intangible inputs like ideas, creativity, research, knowledge, wisdom, etc. in use or action. It is a way that transforms (convert) tangible inputs like raw-materials, semi-finished goods and unassembled goods into finished goods or commodities.

ii) Meaning of System

System is an arrangement or assembly of inter-dependent processes (activities) that are based on some logic and function. It operates as a whole and is designed (build) with an intention to achieve (fulfill) some objective or do some work. Huge systems are often a collection (assembly) of smaller sub-systems.

iii) Definition of Production System

Production system may be defined as,

'The methods, procedure or arrangement which includes all functions required to accumulate (gather) the inputs, process or reprocess the inputs, and deliver the marketable output (goods).

Production system utilizes materials, funds, infrastructure, and labour to produce the required output in form of goods.

Components

Production system consists of three main components viz., Inputs, Conversion Process and Output.

(a) **Inputs** include raw-materials, machines, man-hours, components or parts, drawing, instructions and other paper works.

(b) **Conversion process** includes operations (actual production process). Operations may be either manual or mechanical or chemical. Operations convert inputs into output. Conversion process also includes supporting activities, which help the process of conversion. The supporting activities include; production planning and control, purchase of raw-materials, receipt, storage and issue of materials, inspection of parts and work-in-progress, testing of products, quality control, warehousing of finished products, etc.

(c) **Output** includes finished products, finished goods (parts), and services.

The three components of a production system are depicted in this diagram.

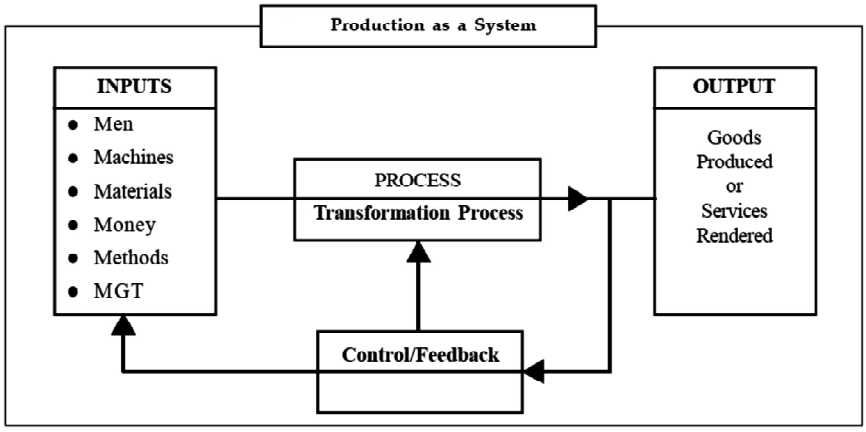


Fig.: Production as a System

Hence, we can say that, production system is a union or combination of its three main components viz., Inputs, Conversion Process, and Output. In short, everything which is done to produce goods and services or to achieve the production objective is called production system.

Examples

The examples of a production system are as follows:

(a) **Tangible goods :** Consider an example of a manufacturing industry like a Sugar Industry. Here, sugarcane is first used as an input, then the juice of sugarcane is processed through a conversion process, finally to get an output known as a refined sugar (used for mass consumption).

(b) **Intangible goods :** Consider an example from a service industry that of a software-development firm or company. Here, initially, written program codes are used as an inputs. These codes are then integrated in some database and are provided with a user-friendly interface through a conversion process. Finally, an output is made available in form of an executable application program.

Production system is a result of arranging inputs, their conversion process and output based on some logic and functions. Production system fails if any such arrangement made don't give a desired level of outcome.

Q11. Conceptualizing production system as a transformation process. Explain atleast two each of manufacturing and services with inputs and outputs.

Ans : **(Dec.-18)**

A production system is a system where in inputs (i.e., material, labour, capital and equipments) are transformed into useful outputs (such as finished goods and/or services).Transformation process is almost used in each and every business. The transformation process usually makes use of all the available resources to change/ transform the inputs into outputs. Inputs can be raw material, ready to sell product and a customer.

The following table shows the transformation process in manufacturing and services.

Component	S.No.	Typical Systems	Inputs	Resources Utilized	Transformation Process	Output
Manufacturing	**1.**	Automobile	Steel layers, components of engine	Labour force, machinery instruments	Manufacturing car	Finest quality cars
	2.	Garments Factory	Fabric, threads, buttons	Sewing machine and tailors	Making readymade garment	Latest fashioned readymady garment
Services	1.	Hospital	Patients	Nurses, doctors, medicines, machines and tools	Health care	Healthy individuals
	2.	Restaurant	Hungry customers	Chef, eatables, waiters, culture (or) ambience	Well -cooked, well well served, good ambience	Customer satisfaction

Q12. Discuss the duties and responsibilities of production managers in manufac-turing organizations.

Ans :

The following are the duties and responsibilities of production managers in manufacturing organizations:

1. Planning the geographical location of the factory.
2. Purchasing production equipments.
3. Layout of equipments within the factory.
4. Designing production processes and equipments.
5. Product design.
6. Designing production work and establishing work standards.
7. Capacity planning.
8. Production planning and scheduling.
9. Production control.
10. Inventory management.
11. Supply chain management.
12. Quality control.
13. Production equipment maintenance and repair.
14. Measurement and monitoring of productivity.
15. Industrial relations.
16. Health and safety.
17. Staff selection and liasoning.
18. Budgeting and capacity plannings.

Q13. "Production function, though is a vital function in an organization, it remains essentially a behind the scene non glamorous function". Comment on the statement.

Ans : **(Dec.-18)**

i) The statement given above is not true because production function plays a vital role in success of organization.

ii) It also helps in improving the standard of living by increasing production of goods and services.

iii) Usually, firms depend on production function to acquire competitive advantage.

iv) With the help of production function, firms can achieve competitive advantage in some of following areas such as customer service, flexibility, quality, wastage, inventory turns, manufacturing lead time, etc.

v) The scope of production function is much wide wherein productivity can be achieved by properly managing materials and lead time and by controlling the cost, more output can be produced from given input at reasonable cost.

vi) Production function also aims at adding value to product or service which builds strong relationship with customer.

vii) It is responsible to check whether goods produced are of good quality and are sold on reasonable price and at right time and place wherever demanded by the customer.

1.4 Types of Production Systems

1.4.1 Flow Shop

Q14. List out various types of Production Systems. Discuss in detail flow shop production system.

(OR)

What are the characteristics of flow production.

Ans : **(Oct.-22, Oct.-20, Dec.-19, Imp.)**

There are four basic types of production system such as,

1. Flow shop production (or) Continuous system
2. Job shop production system
3. Batch manufacturing
4. The project

Flow shop production system

Definition

According to Buffa, "Continuous flow production situations are those where the facilities are standardized as to routings and flow since inputs are standardized. Therefore a standard set of processes and sequences of the process can adopt".

Thus continuous or flow production refers to the manufacturing of large quantities of a single or at most a very few varieties of products with a standard set of processes and sequences. The mass production is carried on continuously for stock in anticipation of demand.

Characteristics

The following characteristics below are;

(i) The volume of output is generally large (mass production) and goods are produced in anticipation of demand.

(ii) The product design and the sequence of the operations are standardized i.e. identical products are produced.

(iii) Special purpose automatic machines are used to perform standardized operations.

(iv) Machine capacities are balanced so that materials are fed at one end of the process and the finished product is received at the other end.

(v) Fixed path materials handling equipment is used due to the predetermined sequence of operations.

(vi) Product layout designed according to a separate line for each product is considered.

Advantages

The following advantages below are;

(i) The main advantage of the continuous system is that work-in-progress inventory is minimum.

(ii) The quality of output is kept uniform because each stage develops skill through repetition of work.

(iii) Any delay at any stage is automatically detected.

(iv) Handling of materials is reduced due to the set pattern of the production line. Mostly the materials are handled through conveyor belts, roller conveyors, pipelines, overhead cranes, etc.

(v) Control over materials, cost, and output are simplified.

(vi) The work can be done by semi-skilled workers because of their specialization.

Disadvantages

The following are the disadvantages of flow shop / continuous production system,

1. The effective working of continuous production systems depends on effective plant maintenance and effective quality control.
2. In continuous production system, the managers has to spend significant efforts for the planning before starting the production.

1.4.2 Job Shop Production System

Q15. Define Job Shop Production System. State its advantages and disadvantages.

Ans : **(Oct.-22, Oct.-20, May-19, Dec.-19, Imp.)**

Meaning

Job or unit production involves the manufacturing of a single complete unit with the use of a group of operators and process as per the customer's order. This is a "special order" type of production. Each job or product is different from the other and no repetition is involved. The product is usually costly and non-standardised.

Customers do not make a demand for exactly the same product on a continuing basis and therefore production becomes intermittent. Each product is a class by itself and constitutes a separate job for the production process. Shipbuilding, electric power plant, dam construction, etc. are common examples of job production.

Characteristics

(i) The product manufactured is custom-made or non-standardised.

(ii) The volume of output is generally small.

(iii) Variable path materials handling equipment are used.

(iv) A wide range of general-purpose machines like grinders, drilling, press, shaper, etc. is used.

Advantages

The following are the advantages of job-shop-production,

1. The job shop production system requires small amount of investment in equipments and machinery.
2. It is flexible in nature.
3. In the job shop system, a mistake or defect in one operation, does not interrupts the whole process.
4. It involves less managerial problems and can be started easily.
5. The risk involved is less, and the chances of failure are also less.

Disadvantages

Job shop system has the following disadvantages,

1. The production system of job shop system is very complicated.
2. The job shop system faces difficulty in loading the machines.
3. It requires high inventories.
4. The cost of material handling involved in job shop system is high.
5. Highly skilled machine operators are needed for managing the job shop system.
6. As the raw materials are purchased on the basis of the order, its cost is high.

Q16. What does an operations Manager prefer Job shop production process ?

Ans : **(May-19)**

1. When there is a need to produce a high-variety goods. Job shop process uses flexible flow strategy for production of goods.
2. When the goods being produced are special and require high customization.
3. When the company has to meet unique requirements of customers.

For example, In restaurants, every customer orders different type of dishes and they are prepared by using different types of utensils and different receipts.

4. When the goods are to be produced in low volume.
5. When the processing requirement of each job is different.
6. When small products are to be produced at the first time itself.
7. When production has to be carried out at regular intervals of time.

1.4.3 Batch Manufacturing

Q17. Define Batch Manufacturing. What are the advantages and disadvantages of Batch Manufacturing?

Ans : **(Oct.-20, Dec.-19, Imp.)**

Meaning

Batch production pertains to repetitive production. It refers to the production of goods, the quantity of which is known in advance. It is that form of production where identical products are produced in batches on the basis of demand of customers' or of expected demand for products.

This method is generally similar to job production except for the quantity of production. Instead of making one single product as in case of job production, a batch or group of products are produced at one time. It should be remembered here that one batch of products may not resemble with the next batch.

It is defined as, "The manufacture of a product in small or large batches or lots at intervals by a series of operations, each operation being carried out on the whole batch before any subsequent operation is performed."

The batch production is a mixture of mass production and job production. Under it machines turn out different products at intervals, each product being produced for a comparatively short time using mass-production methods. Both job production and batch production are similar in nature, except that in batch production the quantity of product manufactured is comparatively large.

Advantages

The batch production method possesses the following advantages;

(i) The work is of a repetitive nature.

(ii) There is a functional layout of various manufacturing processes.

(iii) One operation is carried out on the whole batch and then is passed on to the next operation and so on.

(iv) The same type of machines is arranged at one place.

(v) It is generally chosen where trade is seasonal or there is a need to produce a great variety of goods.

Disadvantages

The batch production method possesses the following

i) In batch production, due to irregular and longer flows, material handling is difficult.

ii) Production planning and control is also complicated in batch production.

iii) Due to respective modification in set up, it results into higher set up costs.

iv) In batch production, work in process inventory is higher when compared to continuous production.

Q18. What are the differences between Job production and Batch production.

(OR)

Distinguish between Job production and Batch production.

Ans : **(Feb.-16)**

S.No.	Characteristics	Job Production	Batch Production
1.	**Volume of production (quantity)**	One (or) few jobs	Limited number of small lots
2.	**Product variety**	Larger variety	Medium (or) few variety
3.	**Layout**	Process (or) functional layout	Process (or) functional layout
4.	**Set up time**	High	High and frequent
5.	**Manufacturing cycle time**	Large	Medium
6.	**Material flow**	Discontinuous non-uniform, travel long distances.	Discontinuous
7.	**Equipment & machinery**	General purpose	General purpose with high production rate.

1.4.4 The Project Production

Q19. What do you mean by project production? State the characteristics of Project Production.

Ans : **(Oct.-20, Imp.)**

Meaning

A project refers to the process of creating a complex one-of-a-kind product or service with a set of well-defined tasks in terms of resources required and time phasing. Some examples of projects are: dam constructions, starting new industries, fabricating boilers, and so on.

Characteristics

(a) Definite beginning and definite end

Each project has a definite beginning and a definite end.

(b) Non-uniform requirement of resources

Requirement of resources for project production is not uniform. At the end of the project, resources from the project are redeployed elsewhere in other projects. Even during the life of the project, requirement of resources is not uniform. Generally resource requirement (men, materials, money, etc.) in the beginning of the project is low which builds up fast with the progress of the project as more and more resources are absorbed, then it levels off until there is gradual cutback as the project approaches completion.

(c) Involvement of different agencies

A project generally involves many tasks, each having its own specialization to be performed by different agencies. The tasks generally have strict precedence (i.e., certain tasks must be completed before the next begins) and as such co-ordination between agencies is of utmost importance.

(d) "Fixed position" layout

Where the output of a project is a product, such products are generally characterised by immobility during transformation. Operations on such products are carried out in "fixed position assembly type of layout" which can be observed in production of ships, locomotive, aircraft, construction of roads / buildings, etc.

(e) High cost overruns

Often delays take place in the completion of the projects. Such delays are generally very expensive due to escalation in the cost of factors of production and incident of penalties.

(f) Personnel problems

Project production has many personnel related problems namely :

- When there is a fast build up, staff is either borrowed from other departments or hired for short duration. Therefore, personnel involved in the project have limited (or short lived) interest in the project.
- Since each project has a limited duration, the staff starts spending more time for getting prepared for the next project.
- Site for the project may be in the underdeveloped region and it may change from project to project which causes dislocation of the normal life.

(g) Scheduling and control

Because of large number of activities, involvement of different agencies and strict precedence requirements, scheduling and control assumes great importance. Some network planning techniques like PERT and CPM have been found to be very useful to overcome the problems mentioned above.

1.5 STRATEGIC OPERATIONS MANAGEMENT

Q20. What do you mean by Strategy and Strategic Management? Explain the process of strategic management.

Ans : **(April-23, May-19, Dec.-19)**

i) Strategy

A strategy is a way of doing something. It usually includes the formulation of a goal and a set of action plans for accomplishment of the goal.

ii) Strategic Management

Strategic management may be understood as the process of formulating, implementing and evaluating business strategies to achieve organizational objectives. A more comprehensive definition of strategic management is "that set of managerial decisions and actions that determines the long-term performance of a corporation. It involves environmental scanning, strategy formulation, strategy implementation, evaluation and control." The study of strategic management therefore emphasises monitoring and evaluating environmental opportunities and threats in the light of a corporation's strengths and weaknesses.

Steps

The process of strategy making is depicted through a model which consists of different phases; each phase having a number of elements. Most authors agree on dividing the strategic management process into four phases consisting of about twenty elements. The model of strategic management is provided in figure :

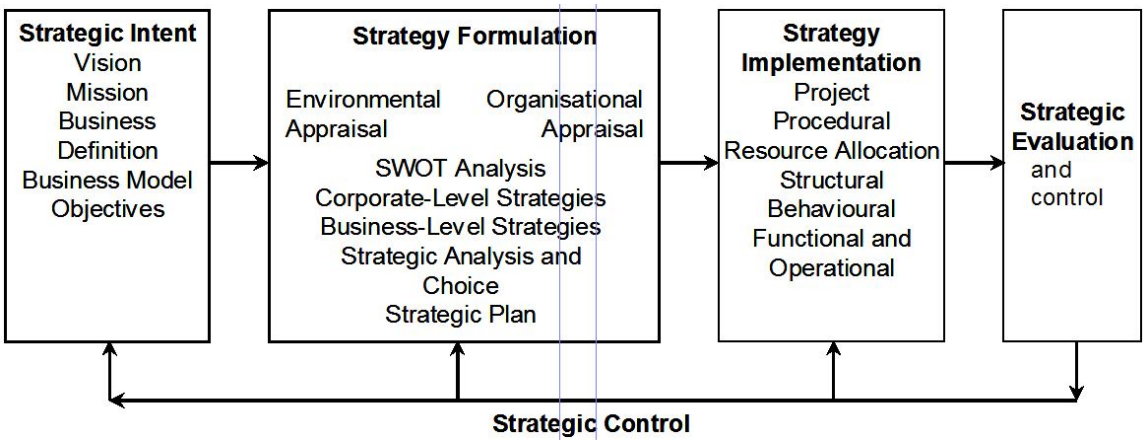


Figure : Comprehensive Model of Strategic Management

1. Strategic Intent

i) The hierarchy of strategic intent lays the foundation for the strategic management of any organization. In this hierarchy, the vision, mission, business definition, business model, and objectives are established.

ii) The strategic intent makes clear what the organization stands for. The element of vision in the hierarchy of strategic intent serves the purpose of stating what the organization wishes to achieve in the long-run.

iii) The mission relates the organization to the society. The business definition explains the businesses of the organization in terms of customer needs, customer groups, and alternative technologies.

iv) The business model clarifies how the organization creates revenue. The objectives of the organization state what is to be achieved in a given time period.

v) These objectives then serve as yardsticks and benchmarks for measuring organizational performance.

2. Strategy Formulation

i) Environmental and organizational appraisal deal with identifying the opportunities and threats operating in the environment and the strengths and weaknesses of the organization in order to create a match between them in such a manner that opportunities could be availed of and the impact of threats neutralised and to capitalise on the organizational strengths and minimise the weaknesses.

ii) Formulation of strategies takes place at four levels-corporate, business, functional, and operational.

iii) Among these levels, the major ones are the corporate and business-level strategies. Corporate-level strategies relate to the strategic decisions regarding the management of a portfolio of businesses.

iv) Business strategies aim at developing a competitive advantage in the individual businesses that a company has in its portfolio.

v) Strategic alternatives and choice are required for evolving alternative strategies, out of the many possible options and choosing the most appropriate strategy or strategies in the light of environmental opportunities and threats and corporate strengths and weaknesses.

vi) Strategies are chosen at the corporate-level and the business-level. The process used for choosing strategies involves strategic analysis and choice.

vii) The end- result of this set of elements is a strategic plan to be implemented.

3. Strategy Implementation

i) Strategy Implementation is the translation of chosen strategy into organizational action so as to achieve strategic goals and objectives.

ii) Strategy implementation is also defined as the manner in which an organization should develop, utilize, and amalgamate organizational structure, control systems, and culture to follow strategies that lead to competitive advantage and a better performance.

iii) Organizational structure allocates special value developing tasks and roles to the employees and states how these tasks and roles can be correlated so as maximize efficiency, quality, and customer satisfaction the pillars of competitive advantage. But, organizational structure is not sufficient in itself to motivate the employees.

iv) For implementation of strategy, the strategic plan is put into action through six sub-processes, which are project implemen-tation, procedural implementation, resource allocation implementation, structural implementation, behavioural implementa-tion, functional and procedural implementa-tion.

v) The emphasis in the imple- mentation phase of strategic management is on action.

4. Strategic Evaluation and Control

i) The last phase of strategic evaluation appraises the implementation of strategies and measures organizational performance.

ii) The feedback from strategic evaluation is meant to exercise strategic control over the strategic management process. Strategies may be reformulated, if necessary.

1.5.1 Corporate Strategic

Q21. What is a Corporate Strategy? State the objectives of Corporate Strategy.

Ans : **(Dec.-19, Imp.)**

Meaning

This is formulated by top management to oversee the interests and operations of an organization made up of more than one line of business. The corporate level strategy of the family controlled Siyaram Poddar Companies is to continuously innovate in all its businesses with the right technology, relentlessly cut costs and focus on the overseas markets.

In formulating corporate level strategy, the company should decide where it wants to be in 10 or 15 years hence, in at least eight areas : Market standing, innovation, productivity, physical and financial resources, profitability, managerial performance and development, worker-performance and attitudes and social responsibility.

In general, organizations would be interested in improving their productivity by formulating proper corporate strategies.

Objectives

The objectives of such corporate strategies are:

i) To increase the rate of return on investment.

ii) To increase sales turnover.

iii) To maximize profit.

iv) To Improve the economy of the nation.

v) To improve earning per share.

vi) To improve employment.

vii) To attain substantial market share.

Q22. Discuss briefly the various types of corporate level strategies.

Ans :

The various types of corporate level strategies are given below :

1. Stable Growth Strategy

In stable growth strategy, the objectives, percentage increase in each year's level of achievement expected, and mix of products and services offered to customers continue to be the same.

2. Growth Strategy

The various attributes of a growth strategy are :

(a) The growth rate of an organization is not necessarily more than that of the economy as a whole but it is more than the growth rate of the market in which the products of the organization are sold.

(b) Organizations will attempt to postpone or even eliminate the danger of price competition in their industry.

(c) Organizations will develop new products, new markets, new processes and new uses for old products.

(i) Concentration on a single product or service: This strategy aims to increase sales, profits or market share faster than it had in the past. Sometimes the sales turnover may not be as expected. To overcome such a situation, the following measures are suggested.

(a) The same product can be offered in new sizes, options, styles or colour.

(b) New products can be developed in the existing product line.

(c) The market can be expanded into new geographic areas, either nationally or internationally.

(d) Non-users can be encouraged to start buying while light users can be encouraged to buy more frequently.

(e) The market share can be increased through proper pricing strategies, product differentiation and advertising.

(ii) Concentric diversification: It is a growth strategy which involves adding new products or services that are similar to the organization's present products or services. The products or services that are added must lie within the scope of the organization's know-how and experience in technology, product line, distribution channels or customer base. This strategy becomes more viable when the industry to which the organization belongs, grows.

(iii) Vertical diversification: This strategy has two options, namely, forward integration and backward integration. Forward integration moves an organization into distributing its own products or services. Backward integration moves an organization into supplying some or all of the products (or) services used in producing its present products or services.

(iv) Horizontal diversification: It is a growth strategy in which an organization buys one of its competitors' facility or gets into his market. It can be accomplished through mergers.

(v) Conglomerate diversification: It is a growth strategy which aims to add new products or services that are significantly different from the organization's present products or services.

3. End game Strategies

(a) These strategies are used in an environment of declining product demand. This category of strategies includes leadership strategy, niche strategy, harvest strategy and disinvestment strategy.

(b) The leadership strategy means that an organization aims to achieve an above average profitability by becoming one of the few companies remaining in the industry.

(c) The niche strategy attempts to identify a segment of the declining industry that will either maintain stable demand or decline slowly.

(d) Harvest strategy aims to decrease investments, reduce maintenance, advertising and research in order to cut costs and improve cash flow. Quick disinvestment strategy aims to sell off the business in the early stage of the decline rather than harvesting and selling it later.

4. Retrenchment Strategies

These are used during economic recessions and during poor financial performance of organizations. These are short-term strategies.

This category of strategies includes

(i) Turnaround strategy

(ii) Disinvestment strategy

(iii) Liquidation strategy

(i) Turnaround strategy : The turnaround strategy aims to cut costs by using the following measures:

- Change management personnel both at the top and bottom levels.
- Cut down on capital expenditure.
- Centralize decision-making in an attempt to control costs.
- Reduce recruitment.
- Reduce advertising and promotion expenditures.
- Fire employees if required.
- Sell off some assets.
- Tighten inventory control.
- Improve the collection of accounts receivable.

(ii) Disinvestment strategy: The disinvestment strategy involves selling off a major part of the business which can be a strategic business unit, a product line, or a division.

(iii) Liquidation strategy: Liquidation strategy involves terminating an organization's existence either by selling off its assets or by shutting down the entire operation.

5. Combination strategies

(i) Simultaneous strategy: Combination strategies involve more than one strategy at the same time. This category of strategies can be divided into simultaneous combination strategies and sequential combination strategies.

An example of combination strategies may be retrenching in certain areas or products while pursuing a growth strategy in other areas or products.

(ii) Sequential strategy: A sequential strategy may involve using a turnaround strategy and then employing a growth strategy when conditions improve.

1.5.2 Generic Competitive Strategies

Q23. Explain different Generic Competitive Strategies in production with suitable examples.

(OR)

What are generic strategies ?

(OR)

Discuss generic competitive strategies in detail.

Ans : **(May-19, Dec.-19, Dec.-18, Aug.-17)**

Meaning

A company's competitive strategy consists of the business approaches and initiatives it undertakes to attract customers and fulfil their expectations, to withstand competitive pressures and to strengthen its market position. Competitive strategy has a narrower scope than business strategy. Competitive strategy deals exclusively with management's action plan for competing successfully and providing superior value to customers.

Porter has suggested that there could be basically three types of competitive (or business) strategies:

1. Low Cost leadership (lower cost/broad target).
2. Differentiation (differentiation/broad target).
3. Focus (lower cost or differentiation/narrow target).

1. Low Cost Leadership Business Strategy

i) When the competitive advantage of a firm lies in a lower cost of products or services relative to what the competitors have to offer, it is termed as cost leadership.

ii) The firm out performs its competitors by offering products or services at a lower cost then they can.

iii) Customers prefer a lower cost product particularly if it offers the same utility to them as the comparable products available in the market have to offer.

iv) When all firms offer products at a comparable price, then the cost leader firm earns a higher profit owing to the low cost of its products.

v) Cost leadership offers a margin of flexibility to the firm to lower price if the competition becomes stiff and yet earn more or less the same level of profit.

For example, Moser Baer India - a Noida, Uttar Pradesh "based world-class manu- facturing company - manufactures compact disks, known as, CD-Recordable (CD-`), for one-time recording of data. The global market is dominated heavily by Taiwanese companies who are acknowledged low-cost manufacturers of CD-` Moser Baer aims to become one of the top global companies in the data storage business. Its business strategy is a low-cost one, focused on achieving economies of scale and leveraging the competitive advantages it has in lower raw material and labour costs.

Benefits

i) Cost advantage is possibly the best insurance against industry competition.

ii) Powerful suppliers possess a higher bargaining power to negotiate price increase for inputs.

iii) Powerful buyers possess a higher bargaining power to effect price reduction.

iv) The threat of cheaper substitutes can be offset to some extent by lowering prices.

v) Cost advantage acts as an effective entry barrier for potential entrants who cannot offer the product/service at a lower price.

2. Differentiation Business Strategy

i) When the competitive advantage of a firm lies in special features incorporated into the product/service, which are demanded by the customers who are willing to pay for those, then the strategy adopted is the differentiation business strategy.

ii) The firm outperforms its competitors who are not able or willing to offer the special features that it can and does.

iii) Customers prefer a differentiated product/ service when it offers them a utility that they value, and are willing to pay more for getting such a utility.

iv) A differentiated product/service stands apart in the market and is distinguishable by the customers for its special features and attributes.

For example, Gait, a multimodal transport company, differentiated it services in a highly competitive and uniform market with tangibles like a risk insurance offer for shipments, refund on failure to deliver on time, door-to-door pick-up and delivery, time bound operations, and safer transportation. The company offers not one but several service features to differentiate itself from the run-of-the-mill transporters in the unorganised sector. Naturally, it charges a higher price for its services.

Benefits

i) Firms distinguish themselves successfully on the basis of differentiation thereby lessening competitive rivalry.

ii) Powerful suppliers can negotiate price increases that the firm can absorb to some extent as it has brand loyal ci stomers typically less sensitive to price increase.

iii) Powerful buyers do not usually negotiate price decrease as they have fewer options with regard to suppliers and generally have no cause for complain as they get the special features and attributes demanded.

iv) Differentiation is an expensive proposition. Newer entrants are not normally in a position to offer similar differentiation at a comparable price. In this manner, differentiation acts as a formidable entry barrier to new entrants.

v) For similar reasons as in the case of newer entrants, substitute product/service suppliers too pose a negligible threat to established differentiation firms.

3. Focus Business Strategy

i) Focus business strategies essentially rely on either cost leadership or differentiation but cater to a narrow segment of the total market. In terms of the market, therefore, focus strategies are niche strategies.

ii) The more commonly-used bases for identifying customer groups are the demographic characteristics (age, gender, income, occupation, etc.), geographic segmentation (rural/urban or Northern India/ Southern India), or lifestyle (traditional/ modern). For the identified market segment a focused firm uses either the lower-cost or differentiation strategy.

iii) A focuser's basis for competitive advantage is either lower costs than competitors in serving the market niche or an ability to offer niche members something they perceive is better suited to their own unique tastes and preferences.

iv) A focused strategy based on low cost depends on there being a buyer segment whose requirements are less costly to satisfy compared to the rest of the market.

v) A focused strategy based on differentiation depends on there being a buyer segment that is looking for special product attributes or seller capabilities.

For example, The Delhi based D.S. Narang has carefully positioned the 'Ayur' brand herbal shampoo at the lower end of the market by pricing it at less than half the price charged by other players.

Benefits

i) A focused firm is protected from competition to the extent that the other firms which have a broader target do not possess the competitive ability to cater to the niche markets.

ii) Focused firms buy in small quantities, so powerful suppliers may not evince much interest.

iii) Powerful buyers are less likely to shift loyalties as they might not find others willing to cater to the niche markets as the focused firms do.

iv) The specialization that focused firms is able to achieve in serving a niche market acts as a powerful barrier to substitute products/ services that might be available in the market.

v) For the same reason, the competence of the focused firm's acts as an effective entry barrier to potential entrants into the niche markets.

1.5.3 Functional Strategies

Q24. What do you understand by Functional Strategies? Explain various types of Functional Strategies.

Ans : **(Dec.-19, Imp.)**

Meaning

i) A functional strategy is a short-term game plan for a key functional area within a firm. Functional strategies clarify the grand strategy and provide specific details about the management of key functional areas in the near future.

ii) Functional strategies must be consistent with long-term objectives and the grand strategy.

iii) When compared to grand strategies, functional strategies have a shorter time horizon, greater specificity, and greater level of participation in their formulation.

iv) Functional strategies help in the implementation of the grand strategy by organizing and activating specific subunits (marketing, finance, production and operations, research and development, human resources, etc.) of the firm.

Types

Functional strategies are classified into four types:

1. Marketing strategies
2. Financial strategies
3. Personnel strategies
4. Production/Manufacturing strategies

1. Marketing Strategies

Marketing strategies consist of activities intended to move products or services from the producers to the customers or markets.

2. Financial Strategies

Financial strategies consist of activities aimed at acquiring funds to meet the organization's current and future needs, monitoring and controlling the financial results of the organization.

3. Personnel Strategies

Personnel strategies involve identification of human needs, devising proper reward system, mechanism of retaining employees, mechanism to match employees' competencies with the organization's present and future needs.

4. Production/Manufacturing Strategies

Production/operations function of an organization aims to provide products/services to its customers by using a combination of the following strategies to fill market gaps.

i) Timely delivery of products/services.

ii) Flexibility in meeting customers' demand in terms of change in product design or change in production volume.

iii) Quality of products/services to meet customers' specifications.

iv) Cost effectiveness in terms of low price for its products/services relative to that of its competitors.

These strategic alternatives form bases for the production/operations function. The selected strategies are translated into operations sub-goals with desired product characteristics, process characteristics and customer services.

Q25. i) Explain the role of operations management in strategic management.

ii) Do you agree with the view that operations strategies are essential part of business strategies?

Ans : **(Feb.-15, Imp.)**

i) Role

"Strategic management is the method of planning, implementing and evaluating the longterm strategies in order to achieve the business goals".

Traditionally, the role of operations management was limited to only designing and producing the goods or services. But, presently due to L.P.G, technological and structural changes, organizations are making use of operations as a tool of competitive advantages.

For example, Kellog's objective of becoming the market leader of breakfast cereals was achieved only after its operations were upgraded for large scale production and distribution of cornflakes. Similarly, Japanese automobile giant "Honda Inc" found that the demand for its 50 CC (small) bike was more than 250 CC and 350 CC bike in the United States. It quickly upgraded and expanded its production capacity and then started selling the 50 CC bikes in U.S retail market. "Today Honda is the market leader in the U.S bike industry".

An effective production/operations strategy is the one that is related to the business strategy and includes the following five elements,

i) Selecting the right product positioning system.

ii) Specialization of factories / service facilities, (each in a specific areas).

iii) Correct design of the product / service.

iv) Selecting the right process development technology.

v) Strategically setting the facilities and n.

ii) Yes, I agree that operations strategies are the essential and integral part of business strategies. According to Slack et al "operation strategy refers to the Pattern' (consistent) of strategic decisions and actions which set the role, objectives and

activities of operations Skinner's States that operation strategy is a top-down approach which needs to be designed for supporting and guiding the corporate strategies of the organization. He also explains that when a well designed operation strategy is implemented in the organization it automatically get coordinated with the firms higher level strategies to achieve and maintain competitive advantage. Business organizations set strategies for all its core activities like human resources, finance, operations (or manufacturing), technology, marketing and so on.

The high-level corporate strategies are formulated with the communication and interaction of all these strategies. Operation strategy plays crucial role in business organizations.

The following figure depicts the role of operation strategy and other core strategies in designing business strategies.

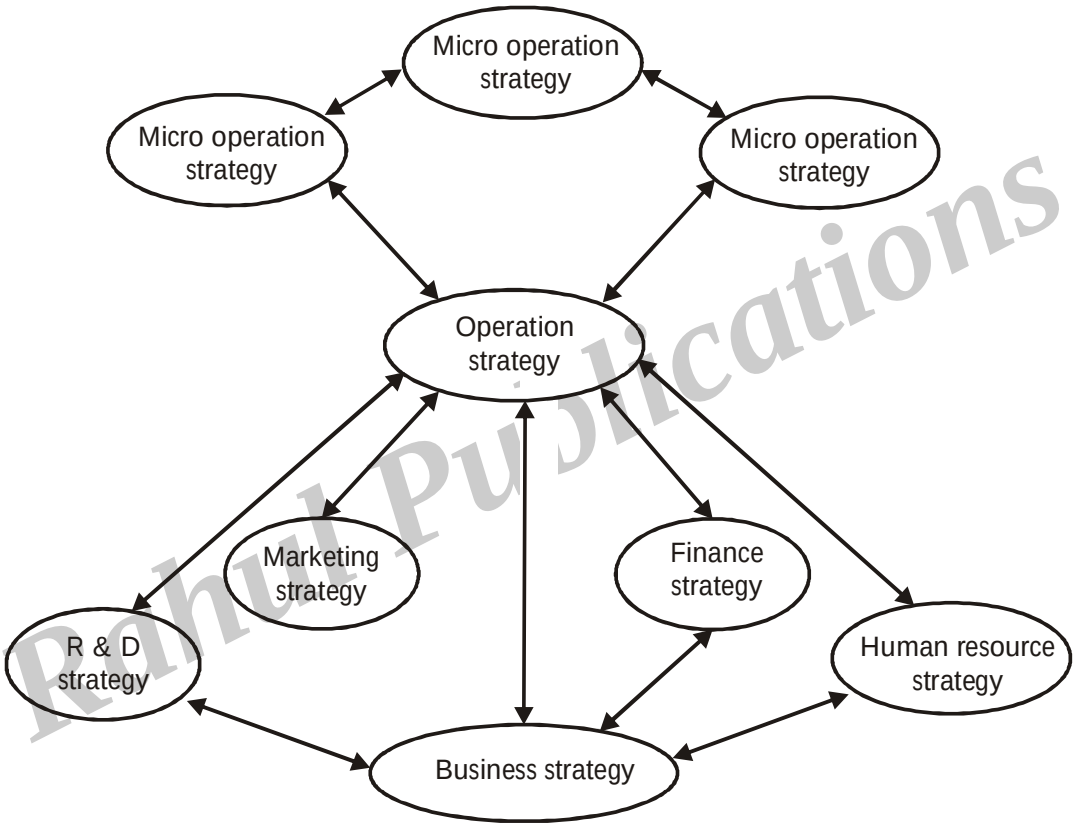


Fig.: Role of operation strategy and other core strategies

Thus, it is clear from the above figure that operations strategy is the essential part of business strategy. Operations strategy is interlinked with other strategies of the business. It works in coordination with other core strategies business to design and implement the business-level strategy.

Q26. Briefly explain how production function is related to other areas of functional management of the organization.

Ans : **(Oct.-22, Imp.)**

1. Production and Materials Management

The production programme (planning) based upon the forecasted demand spells out the requirement of materials (quantity and time of requirements). The success of production depends upon the smooth flow of

materials between the various work stations. The materials function to a greater extent contributes to the success of the production function by making available the materials and tools at the quantity required and at the required time.

2. Production and Maintenance

There is a direct relationship between production and maintenance function. The efficiency of the maintenance function enhances the production efficiency.

A good or effective maintenance is characterized by:

(a) Less break downs and hence less down time.

(b) Increase in equipment/machine availability.

(c) No stoppage of production.

(d) Higher utilization of machines/equipment's.

3. Production and Production Planning and Control (PPC):

Production planning and control can be defined as "the direction and co-ordination of firms resources towards attaining the prefixed goals". PPC helps to achieve uninterrupted flow of materials through production line by making available the materials at right time in required quantity. The production planning deals with activities such as process selection, process planning, loading, scheduling and sequencing. Production plan prepares the time table of production.

Manufacturing or production carries out the production as per the plan given by planning department of PPC. Everything will not be perfect and predictable. There are many contingencies/ obstacles like non availability of materials, unauthorized absenteeism machine breakdown rush orders etc. will try to deviate the output from the plan.

The control function will be so designed as to sense these deviations between planned and actual production. Thus, the production functions effectiveness depends on the accuracy of production planning and control function.

4. Production and Research and Development:

Research and Development department develops new products/services and improves the design of existing products in order to enhance their functional utility, customer appeal. Design department's output will be in the form of drawings.

1.5.4 Productivity

Q27. Define the term Productivity and Bringout its importance.

Ans : **(Jan.-18, Dec.-18, Feb.-16, Imp.)**

Meaning

i) Productivity refers to the output relative to the inputs. Stated more clearly, productivity refers to the amount of goods and services produced with the resource used.

ii) Productivity is measured with the help of a formula which runs as follows :

$$\text{Productivity} = \frac{\text{Quantity of goods and services produced}}{\text{Amount of resources used}}$$

iii) As the equation indicates, there are two variables in measuring productivity the amount of production and the amount of resources used. Productivity varies with the amount of production relative to the amount of resources used.

Importance

1. Increase production using the same (or) a smaller amount of resources.
2. Reduce the amount of resources used while keeping the same production (or) increasing it.
3. Allow the amount of resources used to increase as long as production increases more.
4. Allow production to decrease as long as the amount of resources used decreases more.
5. When productivity increases, the company can pay higher remuneration to its employees without boosting inflation. Increased earnings without corresponding increase inflation adds to the standard of living of people. Improving productivity also means getting more from given inputs.

6. Higher productivity does not mean adding more inputs but using the resources better. Improving productivity does not mean working harder; it means working smarter, not just doing things right but doing right things.
7. Productivity benefits the whole economy, besides contributing to the success of the organization.
8. Any economy is made up of multiple organizations and if all organizations prosper because of increased productivity, economy itself tends to benefit.

Q28. Discuss the various types of productivity. And Explain how overall productivity is measured.

Ans : **(Dec.-18)**

Types

1. Partial Productivity

Partial productivity is the ratio of output to one class of input among various factors of production. For example, Labour productivity, is the partial productivity measure, which measures the productivity of labour class. Similarly we can define other partial productivity as Material productivity, Capital productivity and so on.

2. Total Factor Productivity

Total factor productivity is the ratio of net output to the sum of associated labour and capital (factor) inputs. By net output mean that output minus intermediate goods and services purchased. The denominator of this ratio is made up of only the labour and capital input factors.

3. Total Productivity

Total productivity is the ratio of total output to the sum of all input factors. Thus, a total productivity measure reflects the joint impact of all the inputs in procuring the output.

In all the above definitions, both the output and input (inputs) are expressed in real or physical terms by being reduced to constant Rupee or any other monetary value of a reference period often referred as basic period. This reduction to base period is accomplished by dividing the values of output and input (inputs) by deflators or inflators, depending upon whether the prices of outputs and inputs have gone up or down respectively. This is done to avoid price variation.

Measurement

Productivity of any organization can be measured with the help of following formulae,

$$\text{Productivity} = \frac{\text{Total Output}}{\text{Total Input}}$$

Productivity measurement system includes few components which allows them to be applied to any type of organization such as mining, manufacturing, service, government, both profit oriented (or) non-profit oriented.

Q29. What are the Factors Affecting Productivity?

Ans : **(Aug.-16, Imp.)**

Economists site a variety of reasons for changes in productivity.

However some of the principle factors influencing productivity rate are:

1. Capital/labour ratio

It is a measure of whether enough investment is being made in plant, machinery, and tools to make effective use of labour hours.

2. Scarcity of some resources

Resources such as energy, water and number of metals will create productivity problems.

3. Work-force changes

Change in work-force effect productivity to a larger extent, because of the labour turnover.

4. Innovations and technology

This is the major cause of increasing productivity.

5. Regulatory effects

These impose substantial constraints on some firms, which lead to change in productivity.

6. Bargaining power

Bargaining power of organized labour to command wage increases excess of output increases has had a detrimental effect on productivity.

7. Managerial factors

Managerial factors are the ways an organization benefits from the unique planning and managerial skills of its manager.

8. Quality of work life

It is a term that describes the organizational culture, and the extent to which it motivates and satisfies employees.

Q30. Discuss the Strategies for Improving Productivity.

(OR)

Explain different strategies for improving overall productivity in an organization.

Ans : **(July-18, Imp.)**

There are several strategies for improving the productivity which are given below :

1. Increased output for the same input

In this strategy, the output is increased while keeping the input constant. Let us assume that in a steel plant, the layout of the existing shops is not proper.

By slightly altering the location of the billet-making section, i.e. bringing it closer to the furnace which produces hot metal, the scale formation at the top of ladles can be reduced to a greater extent. The molten metal is usually carried in ladles to the billet-making section. In the long run, this would give more yield in terms of tons of billet produced. In this exercise, there is no extra cost involved. The only task is the relocation of the billet-making facility by shifting it closer to the furnace which involves insignificant cost.

2. Decreased input for the same output

In this strategy, the input is decreased to produce the same output. Let us assume that there exists a substitute raw material to manufacture a product which has the required properties and it is available at a lower price. If we can identify such material and use it for manufacturing the product, then certainly it will reduce the input cost. In this exercise, the job of the purchase department is to identify an alternate substitute material. The process of identification does not involve any extra cost. So, naturally, the productivity ratio will increase because of the decreased input by way of using the cheaper raw material to produce the same output.

3. Proportionate increase in the output is more than the proportionate increase in the input

Consider the example of introducing a new product into the existing product mix of an organization. Let us assume that the existing facilities are not fully utilized. So, the R&D wing of the company has identified a new product which has a very good market and which can be manufactured with the surplus facilities of the organization. If the new product is taken up for production, then the following will result.

a) There will be an increase in the revenue of the organization by way of selling the new product in addition to the existing product mix.

b) There will be an increase in the material cost, and operation and maintenance cost of machineries because of producing the new product.

If we closely examine these two increases, we find that the proportionate increase in the revenue will be more than the proportionate increase in the input cost.

4. Proportionate decrease in the input is more than the proportionate decrease in the output

Let us consider the reverse case of the previous example, i.e. dropping an uneconomical product from the existing product mix. This will result in the following:

a) There will be a decrease in the revenue of the organization because of dropping a product from the existing product mix.

b) There will be a decrease in the material cost, and operation and maintenance cost of machineries because of dropping an existing product from the product mix.

If we closely examine these two decreases, we find that the proportionate decrease in the input cost will be more than the proportionate decrease in the revenue. Hence, there will be a net increase in the productivity ratio.

5. Increase in the output with decrease in the input

Let us assume that advanced automated technologies like, Robot, Automated Guided Vehicle System (AGVS), etc., are available in the market which can be employed in the organization of our interest. The outcome of these modern tools can be summarized as following.

a) There will be a drastic reduction in the operation cost. Initially, the cost of on equipment would be very high. But, in the long run, the reduction in the operation cost would break-even the high initial investment and offer more savings on the input.

b) These advanced facilities would help in producing more number of goods because they don't experience fatigue. The increased production will therefore yield more revenue.

In this example, there is an increase in the revenue while there is a decrease in the input in the long run. Hence, the productivity ratio will increase at a faster rate.

PROBLEMS

1. A furniture manufacturing company has provided the following data. Compare the labour, raw materials and supplies and total productivity of 2013 and 2014.

	Particulars	` in lacs	
		2013	2014
Output	Sales value of production	22	35
Input	Labour	10	15
	Raw materials and supplies	8	13
	Capital equipment depreciation	0.7	1.2
	Other	2.2	4.8

Sol : **(Feb.-16)**

Calculation of Partial Productivity Measure

$$\text{Partial productivities measure} = \frac{\text{Output}}{\text{Labour}}$$

(i) Labour

$$\text{Labour} = \frac{\text{Output}}{\text{Labour}}$$

$$\text{For the year 2013} = \frac{22,00,000}{10,00,000} = 2.2$$

$$\text{For the year 2014} = \frac{35,00,000}{15,00,000} = 2.33$$

(ii) Raw Material and Supplies

$$\text{Raw materials and supplies} = \frac{\text{Output}}{\text{Raw material and supplies}}$$

$$\text{For the year 2013} = \frac{22,00,000}{8,00,000}$$

$$= 2.75$$

$$\text{For the year 2014} = \frac{35,00,000}{13,00,000}$$

$$= 2.69$$

(iii) Calculation of Total Productivity Measure

$$\text{Total Productivity} = \frac{\text{Output}}{\text{Inputs}}$$

$$\text{For the year 2013} = \frac{22,00,000}{10,00,000 + 8,00,000 + 70,000 + 2,20,000}$$

$$= \frac{22,00,000}{20,90,000}$$

$$= 1.05$$

$$\text{For the year 2014} = \frac{35,00,000}{15,00,000 + 13,00,000 + 1,20,000 + 4,80,000}$$

$$= \frac{35,00,000}{34,00,000}$$

$$= 1.03$$

Comparison of Labour, Raw Materials and Supplies and Total Productivity of 2013 and 2014

Particulars	2013	2014
Labour	2.2	2.33
Raw material and supplies	2.75	2.69
Total productivity	1.05	1.03

2. A furniture company has provided the following data for the years 2014 and 2015. Compare the labour raw materials and total productivity.

	Particulars	2014(in `)	2015(in `)
Output	**Sales value of production**	**24,000**	**36,000**
Input	**Labour**	**12,000**	**15,000**
	Raw materials 10,000	**12,5000**	
	Capital equipment depreciation	**800**	**1,200**
	Others	**2,400**	**4,800**

Sol : **(Aug.-16)**

Calculation of Productivity Measures (Labour and Raw material)

$$\text{Partial productivities measure} = \frac{\text{Output}}{\text{Labour}}$$

(i) Labour

$$\text{Labour} = \frac{\text{Output}}{\text{Labour}}$$

$$\text{For the year 2014} = \frac{24,000}{12,000}$$

$$= 2$$

$$\text{For the year 2015} = \frac{36,000}{15,000}$$

$$= 2.4$$

(ii) Raw Material

$$\text{Raw Material} = \frac{\text{Output}}{\text{Raw material}}$$

$$\text{For the year 2014} = \frac{24,000}{10,000}$$

$$= 2.4$$

$$\text{For the year 2015} = \frac{36,000}{12,500}$$

$$= 2.88$$

(iii) Calculation of Total Productivity

$$\text{Total Productivity} = \frac{\text{Output}}{\text{Inputs}}$$

$$\text{For the year 2014} = \frac{24,000}{12,000 + 10,000 + 800 + 2,400}$$

$$= \frac{24,000}{25,200}$$

$$= 0.95$$

$$\text{For the year 2015} = \frac{36,000}{15,000 + 12,500 + 1,200 + 4,800}$$

$$= \frac{36,000}{33,500}$$

$$= 0.95$$

For the year 2015 $$= \frac{36,000}{15,000 + 12,500 + 1,200 + 4,800}$$

$$= \frac{36,000}{33,500}$$

$$= 1.07$$

Comparision of Labour, Raw Material and Total productivity of 2014 and 2015

Particulars	2014 (`)	**2015 (`)**
Labour	2	2.4
Raw material 2.4	2.88	
Total productivity	0.95	1.07

1.6 World Class Manufacturing

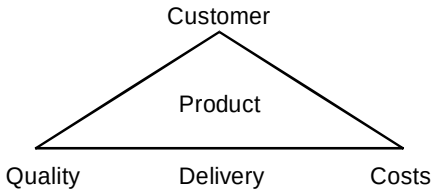
Q31. Explain the concept of World Class Manufacturing. What is its relevance for developing country like India.

Ans : **(Jan.-18, Imp.)**

Introduction

Every commercial organization is focused on making profit. Manufacturing companies are special within these enterprises because they make their products themselves.

The objectives of Manufacturing Companies are to satisfy the needs of the customer who wants:



i) Products of consistent high quality

ii) Delivery on time in full amount ordered

iii) Products at the lowest possible cost level.

World Class Manufacturing (WCM) is the collective term for the most effective methodologies and techniques to realize these objectives.

World Class Manufacturing is the result of many centuries' of production knowledge and ability. Starting with the guild structure in the Middle Ages, this knowledge and ability evolved via the manufacturing in the 18th century, scientific management/mass production, socio-technology and lean production in the twentieth century into the State-of-the-Art manufacturing companies in the beginning of the 21st Century World Class Manufacturing.

Characteristics

Thus the four main characteristics of World Class Manufacturing are successively:

1. Make losses visible
2. Improving in team format
3. Organizing process-oriented
4. Standardize working methods.

People who are directly involved in carrying out the processes of additional value are here the internal customers. All others should be supportive and derive their existence from their positive influence on the production process.

Principles

There are three main principles, which drive world-class manufacturing.

i) Implementation of just in time and lean management leads to reduction in wastage thereby reduction in cost.

ii) Implementation of total quality management leads to reduction of defects and encourages zero tolerance towards defects.

iv) Implementation of total preventive maintenance leads to any stoppage of production through mechanical failure.

Implementation

World class manufacturers tend to implement best practices and also invent new practices as to stay above the rest in the manufacturing sector. The main parameters which determine world-class manufacturers are quality, cost effective, flexibility and innovation.

World class manufacturers implement robust control techniques but there are five steps, which will make the system efficient. These five steps are as follows:

i) Reduction of set up time and in tuning of machinery: It is important that organizations are able to cut back time in setting up machinery and also tune machinery before production.

ii) Cellular Manufacturing: It is important that production processes are divided according to its nature, with similar nature combined together.

iii) Reduce WIP Material: It is normal tendency of manufacturing organization to maintain high levels of WIP material. Increased WIP leads to more cost and decreased WIP induces more focus on production and fast movement of goods.

iv) Postpone Product Mutation: To achieve a higher degree of customization many changes are made to final product. However, it is important that mutation conceived for the design stage implement only after final operation.

v) Removal the trivial many and focus on vital few: It is important for organization to focus on production of products which are lined with forecast demand as to match customer expectation.

Relevance of World Class Manufacturing for Developing India

1. It promotes professional integrity.
2. It contributes high rate of returns to shareholders.
3. It develops employees innovative spirit.
4. It is a financial supermarket, as it adopts diversification to maintain growth.
5. It maintain health relationships with individual households to satisfy their wants with efficiency and sensitivity.
6. The company should maintain its reputation as a leading housing finance from inorder to spread it globally.

The companies which are contributing world class manufacturing for the development of India are,

i) Bharat Forge

ii) Bajaj

iii) Tata in the auto sector to Larsen and Joubro

iv) Godrej and Boyce in specialist engineering.

v) Ballepur Industries in paper.

vi) Other Pharmaceuticals and Textiles.

Q32. Discuss the Role and Responsibilities of Production Managers in an Automobile Manufacturing Organization.

Ans : **(April-23, Imp.)**

1. Need to be Focused

In every organization, the Production Manager is responsible for producing the required quantity of the product in time in accordance with the delivery date. The quantity to be produced depends on the demand whereas the time by which the product should be completed is determined by delivering date.

2. Production Control

It is the duty of the production manager to use the resources at his disposal in the best possible manner as well as to regulate the operation in such a way that the desired delivery schedule is maintained. It is been done by routing, scheduling, and inspection during the production process.

3. Quality Control

The major responsibility of the production manager is to manufacture the goods and services within the desired specifications. Though the quality of the finished goods can be ensured by the inspection of finished goods it is better to employ measures, which minimize the likelihood of producing defective items.

4. Analysis & Selection of Production Method

There can be a number of ways in which manufacturing operations can be executed. The production manager should select the most efficient and economical method to perform the operation.

5. Plant Layout and Material Handling

The physical arrangement of manufacturing components and the equipment for handling the material during the production process has a considerable effect on the cost of production. The material handling system and the plant layout should be most efficient for the given situation.

Q33. What do you understand by manufacturing process technology? Explain the role of CAD in manufacturing.

Ans : **(April-23, Imp.)**

Computer-aided Manufacturing (CAM) is the term used to describe the use of computerized systems to control the operations at a manufacturing plant. These computerized systems assist manufacturers in various operations such as planning, transportation, management, and storage. CAM helps manufacturers improve their time to market capabilities, and create precise dimensions. In this post, you will understand how Computer-aided Manufacturing Services is transforming the landscape of manufacturing input. This is why it is referred as CAD-CAM. The functions of this combination software is divided into two main categories:

1. Manufacturing Planning

In this process, the computer delivers information for production planning as well as management. This may include:

i) Computer Aided Process Planning (CAPP)
ii) Computer Assisted NC Part Program-ming
iii) Computerized Machinability Data System
iv) Work Standards Development
v) Inventory and Production Planning

2. Manufacturing Control

In the process, the computer is used to manage and control the physical operations of the manufacturing plant. These may include:

i) Shop Floor Controlling
ii) Process Monitoring and Controlling
iii) Inventory Controlling
iv) Production Delivery Controlling

1.7 Sustainable Operations Management, Industry 4.0

Q34. Explain briefly about Sustainable Operations Management?

Ans : **(Imp.)**

Introduction

Operations Management functions with administering and efficiently utilizing man, machine and

money to deliver quality output. It primarily focuses on business profits. On the other hand, Sustainable Operations Management (SOM) applies the principle of sustainability to all strategic decisions of business operations. It advocates economic, social and environmental objectives too along with revenue generation.

SOM requires an organization to contribute towards the economic and social growth along with promoting environmental sustainability. An exhaustive study on sustainable operations management is carried out here discussing the concept, factors, ways to implement and the importance of sustainability in operations.

Sustainable Operations Management (SOM)

Sustainable Operations Management can be defined as the set of skills and concepts that help a company to carry out its business processes competitively without hindering or disturbing the social, economic or environmental factors.

The SOM approach aims at delivering the requirement of current generation without compromising the needs of the future. It ensures a balance between business revenue, environmental obligation and social well-being.

All functional process units of a business must be aligned with the principles of sustainability. Production units should be arranged in a way to promote reduction of energy use, gas emissions, liquid and solid wastes and ensure effective resource utilization. Integration of production optimization techniques, use of green energy and limited number of processes should be encouraged. Distribution and logistics, including packaging and transport mode should incorporate SOM techniques.

Q35. Explain the importance of factors Sustainable Operations Management.

Ans :

Importance

Sustainable Operations Management Practices contributes significantly to the internal and external territory of an organization. The importance of SOM primarily is reducing operating costs, improved employee and customer satisfaction and socio environmental enrichment.

The benefits of adopting SOM practices are,

i) Integrating SOM creates a wider scope enabling more deliverables for business. This can prompt them to revisit their business objectives and efficiency.

ii) It can help cost reduction by implementing energy-efficient measures in business processes.

iii) Profitability is the aim of every business entity. Sustainable practices in operations help efficiently manage resources without wastage and reduce costs, thereby increasing profit.

iv) Adopting sustainable practices help business to improve its image and goodwill. Society and public governance view the company with reputation as it caters to environmental protection and social commitment.

v) SOM provides greater employee satisfaction as they tend to be happier with clean and healthier workspace and feel engaged leading to a productive workforce.

vi) Employees of companies following SOM approach enjoy high morale and record lesser employee turnover.

vii) SOM integrated businesses exercise more social responsibility. Customers who are interested in social commitments are more attracted to companies following SOM practices.

Q36. How to implement Sustainable Operations Management?

Ans :

There are certain points to consider before integrating sustainable solutions to operations management. They are,

i) The Company need to understand the basic principles of balancing people, planet and purpose with business profits. This fundamental understanding will help adopting SOM with ease.

ii) The objectives of business need to be prioritised and well aligned to SOM after thoroughly analysing the existing requirements and demands.

iii) The company could rethink on their mission statement to confirm the long term perspective of its business

iv) It is always advisable to set fund allocation sanctioned towards SOM initiatives from management.

v) Taking inputs from all parties involved including employees, stakeholders, suppliers, partners and customers will help SOM implementation. Seeking feedback will enable them to think and recognise the potential merits of the company being more socially committed.

vi) Take expert advice if required to device strategic decisions to focus on sustainability goals.

Finally, the activities implemented under sustainable practices need to be monitored and measured to track the changes and outcomes. This can ensure that the business gives ample attention to social economic and environmental factors.

Q37. Explain briefly about Sustainable industry 4.0 in production and operations management.

Ans : **(Imp.)**

In today's industrial environment, where concepts of smart factories are consolidating their application in companies, it is still necessary to approach management decision making from a perspective that encompasses all aspects of sustainability without losing sight of the social return to which they must contribute. In order to obtain a reliable prediction, of the operation of a Sustainable Manufacturing System (SMS) and its Social Return (SR), this paper develops a methodology and procedures that allow predicting the system performance as a whole. This will allow us to assist management decision making in industries 4.0, supported by multi-criteria methods in knowledge management, simulation, value analysis and operational research by means of:

a) Study the economic, social and environ-mental impacts in the organization and management of the efficient operation of an SMS with the selection of strategies and alternatives in production chains to minimize and / or mitigate environmental and labor risks.

b) Encourage of industrial symbiosis or eco-industries networks that create opportunities increasing eco-efficiency and the positive social return of production systems.

This proposed methodology will facilitate changes in the structure of production systems in order to implement industry' 4.0 paradigms through facilitator technologies such as simulation and virtual reality. This framework will allow Small and Medium Enterprises (SMEs) and other companies to address the decision-making activities that improve the economic-functional efficiency, which will lead to reduce the environmental impact and increase the positive social return of certain production strategies, considering working conditions.

Short Questions and Answers

1. Define operations management.

Ans :

Meaning

Operations management is a modern discipline (of practise) which deals with the process of planning, designing, operating and managing the systems and subsystems of an organization for the achievement of organizational goals.

Definitions

i) **According to H.A. Harding,** "Production management is concerned with those processes which convert the inputs into outputs. The inputs are various resources like raw materials, men, machines, methods, etc. and the outputs are goods and services."

ii) **According to M.J.S. Harry,** the word production is often used to mean the same as manufacture. In order to go through a process of manufacturing itself, we need basically three things: someone to do the job, his equipment and the necessary materials. To run production, we require service activities which make sure that the manufacturing activity can go on and control to make sure that it goes in the right direction.

iii) **According to E.S. Buffa,** "Production management deals with decision-making related to production processes so that the resulting goods or service is produced according to specifications, - the amounts and by the schedule demanded and at minimum cost."

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2. Explain the objectives of operations management.

Ans :

Operation Management involves manage-ment of the entire process responsible for converting inputs into outputs**.** The following are the objectives of Operations Management.

i) To provide customer service

The main objective of any operating management systems is to utilize resources judiciously for the satisfaction of customer needs and wants. Therefore, customer satisfaction is a key objective of operations management. Operation management focuses on providing the right products at a right price at the right time. Hence, this objective will influence the operations manager's decisions to achieve the required customer service.

ii) Effective utilization of resources

Resources that are used in the business organization must be carefully utilized. Inefficient use of resources or inadequate customer service leads to commercial failure of an organization. Operations management is concerned essentially with the utilization of resources. It aims at obtaining maximum output from the available resources with minimum cost.

iii) To reduce cost of production

Operation management aims at reduction in the cost of production of goods and services. The cost per unit of the product has to be set properly and all efforts should be taken to control the actual cost to pre-determined cost of production. Cost can be classified in to fixed cost and variable cost. The variable cost changes with every level of production. This variable cost can be checked by means of inventory and labour control techniques.

3. Distinguish between production management and operations management.

Ans :

S.No.	Nature	Production Management	Operations Management
1.	**Meaning**	Production Management cannotes administration of the range of activities belonging to the creation of products	Operations Management refers to the part of management concerned with the production and delivery of goods services.
2.	**Decision Making**	Related to the respects of production.	Related to the business activities.
3.	**Found in**	Enterprises where production is undertaken.	Banks, Hospitals, Companies including production companies, agencies etc,.
4.	**Objectives**	To produce right quality goods in right quantity at right time and at least cost.	To utilize resources, to the extent possible so as to satisfy customer wants.

4. Flow shop

Ans :

According to Buffa, "Continuous flow production situations are those where the facilities are standardized as to routings and flow since inputs are standardized. Therefore a standard set of processes and sequences of the process can adopt".

Thus continuous or flow production refers to the manufacturing of large quantities of a single or at most a very few varieties of products with a standard set of processes and sequences. The mass production is carried on continuously for stock in anticipation of demand.

5. Job Shop Production System.

Ans :

Job or unit production involves the manufacturing of a single complete unit with the use of a group of operators and process as per the customer's order. This is a "special order" type of production. Each job or product is different from the other and no repetition is involved. The product is usually costly and non-standardised.

Customers do not make a demand for exactly the same product on a continuing basis and therefore production becomes intermittent. Each product is a class by itself and constitutes a separate job for the production process. Shipbuilding, electric power plant, dam construction, etc. are common examples of job production.

6. Distinguish between Job production and Batch production.

Ans :

S.No.	Characteristics	Job Production	Batch Production
1.	**Volume of production (quantity)**	One (or) few jobs	Limited number of small lots
2.	**Product variety**	Larger variety	Medium (or) few variety
3.	**Layout**	Process (or) functional layout	Process (or) functional layout
4.	**Set up time**	High	High and frequent
5.	**Manufacturing cycle time**	Large	Medium
6.	**Material flow**	Discontinuous non-uniform, travel long distances.	Discontinuous

7. What is a Corporate Strategy?

Ans :

This is formulated by top management to oversee the interests and operations of an organization made up of more than one line of business. The corporate level strategy of the family controlled Siyaram Poddar Companies is to continuously innovate in all its businesses with the right technology, relentlessly cut costs and focus on the overseas markets.

In formulating corporate level strategy, the company should decide where it wants to be in 10 or 15 years hence, in at least eight areas : Market standing, innovation, productivity, physical and financial resources, profitability, managerial performance and development, worker-performance and attitudes and social responsibility.

In general, organizations would be interested in improving their productivity by formulating proper corporate strategies.

8. Generic competitive strategies in detail.

Ans :

A company's competitive strategy consists of the business approaches and initiatives it undertakes to attract customers and fulfil their expectations, to withstand competitive pressures and to strengthen its market position. Competitive strategy has a narrower scope than business strategy. Competitive strategy deals exclusively with management's action plan for competing successfully and providing superior value to customers.

9. Productivity

Ans :

i) Productivity refers to the output relative to the inputs. Stated more clearly, productivity refers to the amount of goods and services produced with the resource used.

ii) Productivity is measured with the help of a formula which runs as follows :

$$\text{Productivity} = \frac{\text{Quantity of goods and services produced}}{\text{Amount of resources used}}$$

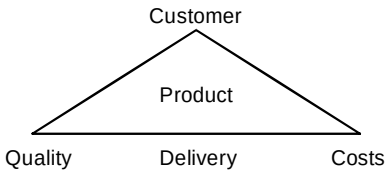
iii) As the equation indicates, there are two variables in measuring productivity the amount of production and the amount of resources used. Productivity varies with the amount of production relative to the amount of resources used.

10. World Class Manufacturing.

Ans :

Every commercial organization is focused on making profit. Manufacturing companies are special within these enterprises because they make their products themselves.

The objectives of Manufacturing Companies are to satisfy the needs of the customer who wants:



i) Products of consistent high quality

ii) Delivery on time in full amount ordered

iii) Products at the lowest possible cost level.

11. Conceptualizing production system as a transformation process. Explain atleast two each of manufacturing and services with inputs and outputs.

Ans :

A production system is a system where in inputs (i.e., material, labour, capital and equipments) are transformed into useful outputs (such as finished goods and/or services).Transformation process is almost used in each and every business. The transformation process usually makes use of all the available resources to change/ transform the inputs into outputs. Inputs can be raw material, ready to sell product and a customer.

The following table shows the transformation process in manufacturing and services.

Component	S.No.	Typical Systems	Inputs	Resources Utilized	Transformation Process	Output
Manufacturing	1.	Automobile	Steel layers, components of engine	Labour force, machinery instruments	Manufacturing car	Finest quality cars
	2.	Garments Factory	Fabric, threads, buttons	Sewing machine and tailors	Making readymade garment	Latest fashioned readymady garment
Services	1.	Hospital	Patients	Nurses, doctors, medicines, machines and tools	Health care	Healthy individuals
	2.	Restaurant	Hungry customers	Chef, eatables, waiters, culture (or) ambience	Well -cooked, well well served, good ambience	Customer satisfaction

12. Define production.

Ans :

i) Meaning of Production

Production may be defined as conversion of inputs-men, machine, materials, money, methods and management (6Ms) into output through a transformation process. Output may be goods produced or services rendered.

Production is a method employed for making or providing essential goods and services for consumers. It is a process that puts intangible inputs like ideas, creativity, research, knowledge, wisdom, etc. in use or action. It is a way that transforms (convert) tangible inputs like raw-materials, semi-finished goods and unassembled goods into finished goods or commodities.

ii) Meaning of System

System is an arrangement or assembly of inter-dependent processes (activities) that are based on some logic and function. It operates as a whole and is designed (build) with an intention to achieve (fulfill) some objective or do some work. Huge systems are often a collection (assembly) of smaller sub-systems.

iii) Definition of Production System

Production system may be defined as, 'The methods, procedure or arrangement which includes all functions required to accumulate (gather) the inputs, process or reprocess the inputs, and deliver the marketable output (goods).

13. Strategic Role of Operations Management.

Ans :

i) Strategy

A strategy is a way of doing something. It usually includes the formulation of a goal and a set of action plans for accomplishment of the goal.

ii) Strategic Management

Strategic management may be understood as the process of formulating, implementing and evaluating business strategies to achieve organizational objectives. A more comprehensive definition of strategic management is "that set of managerial decisions and actions that determines the long-term performance of a corporation. It involves environmental scanning, strategy formulation, strategy implementation, evaluation and control." The study of strategic management therefore emphasises monitoring and evaluating environmental opportunities and threats in the light of a corporation's strengths and weaknesses.

Choose the Correct Answers

1. The components of set up time to produce or build an item are: [c]
   (a) Process preparation time (b) Process tear down time
   (c) Learning time (d) All above
2. Which of these would an operations manager not be responsible for? [b]
   (a) Safety and maintenance (b) Sales and marketing
   (c) Selecting suppliers (d) Recruiting employees
3. Which of these Managers would be least likely to be considered in an operations management role within an organization? [c]
   (a) Production Manager (b) Reservations Manager
   (c) Financial Risk Manager (d) Quality Manager
4. Which of the following statement correctly explains the role of operations management? [d]
   (a) Sustain the company's operation (b) Protect the company's operation
   (c) Project the company's operation (d) All of the above
5. An operations strategy is created directly from the _____ strategy. [c]
   (a) Corporate strategy (b) Marketing strategy
   (c) Business strategy (d) Human resource strategy
6. Which of the following statement correctly explains the role of operations management? [d]
   (a) Sustain the company's operation (b) Protect the company's operation
   (c) Project the company's operation (d) All of the above
7. Which one of the following strategies specifies how the firm will employ its production capabilities to support its corporate strategy? [d]
   (a) Tactical (b) Operations
   (c) Manufacturing (d) Production
8. The role of a _____ manager is to sustain, protect, and project the company's operations side. [b]
   (a) Project Manager (b) Operations Manager
   (c) Finance Manager (d) Marketing Manager
9. Inputs include _____, energy and information. [d]
   (a) Human Resources (b) Capital and Material
   (c) Land (d) All Above
10. Transformations are the operations that _____ inputs into outputs [a]
   (a) Convert (b) Divert
   (c) Revert (d) All the Above

Fill in the Blanks

1. Intermittent process is classified into two types i.e., _____ and _____ .
2. Keeping a track on the production activities to make sure that the activities are performed as per the schedule is known as _____ .
3. The industries which follow _____ process are also known as process industries.
4. _____ is a step-by-step process for the conversion of raw material into value-added goods and services (finished goods).
5. _____ is the process in which different machine tools are used to cold work the metals into various shapes.
6. _____ involves all those sequential operations which are essential for achieving the product specifications.
7. The machining processes which make use of methods like electro-chemical processes are referred to as _____ .
8. The five stages in product life cycle are Introduction, Growth, Maturity, Saturation and _____.
9. _____ are also called as Automatic Screw cutting machines or auto-mats.
10. _____ is defined as a technique of joining two dissimilar or similar metals by the application of heat and pressure.

ANSWERS

1. Job Shop Process and Batch Process
2. Expediting
3. Continuous
4. Production
5. Machining
6. Process Design
7. Unconventional/ Non-traditional Machining
8. Decline
9. Automatic Machine Tools
10. Welding

Very Short Questions and Answers

1. Scope of operation management.

Ans :

i) Facility Location

Selecting appropriate location for the production

ii) Plant Layouts and Material Handling

Deciding upon the machines, equipment and necessary devices which could lead to effectual and desired production in the most economic way. Preparation of plan layout for the establishment of machines in the required sequence. Storage of material and handling it in most effective way to avoid the wastage and delivery at the work centers as and when required.

2. Production

Ans :

Production may be defined as conversion of inputs men, machine, materials, money, methods and management (6Ms) into output through a transformation process. Output may be goods produced or services rendered.

3. Batch Manufacturing.

Ans :

Batch production pertains to repetitive production. It refers to the production of goods, the quantity of which is known in advance. It is that form of production where identical products are produced in batches on the basis of demand of customers' or of expected demand for products.

4. Strategy

Ans :

A strategy is a way of doing something. It usually includes the formulation of a goal and a set of action plans for accomplishment of the goal.

5. Strategy Implementation

Ans :

Strategy Implementation is the translation of chosen strategy into organizational action so as to achieve strategic goals and objectives.

UNIT II

Product Design and Analysis: New Product Development, its Concepts, Steps of Product Design, Process Planning and Design, Selection of Process, Responsibilities of Process Planning Engineer, Steps in Process Planning. Process Design, Process Research, Pilot Plant Development, Capacity Planning, Enhanced Capacity using Optimization. Value Analysis, Value Engineering, Lean Production System.

2.1 Product Design and Analysis

Q1. Explain briefly about Product Design and Analysis.

Ans : **(April-23, Imp.)**

Meaning

Product Design is concerned with the form and function of a product. Form design involves the determination of what a product would look like, i.e., the shape and appearance of the product, what it will be made of (product structure) and how it will be made (process design). Functional design deals with what function the product will perform and how it performs.

Aspects

The various aspects in product design are:

1. Design for Function
2. Design for Making
3. Design for Selling

1. Design for Function

A product must perform the function which its customer expects it to do. If a product is designed by taking its functional features into account, then it will create satisfied customers, and will further lead to having more repeat customers. The factors which are to be considered for functional design are strength and wearability of the product and its components.

2. Design for Making

A product design that solves the functional problem smoothly, but is impossible to manufacture, is of no use. Attention must be given to materials, fastening devices etc., while designing a product. The hardness of the material specified at the design stage must be within the permitted range while machining. In some intricate design, to join components, we may require small size fasteners. If these are not available in the market, then the design may become infeasible at the manufacturing stage. Making use of standard parts is an important aspect of product design.

3. Design for Selling

A product that functions well and is easy to make, but is wanted by no one is of no avail. It makes no difference whether the product is a pen or a CNC machine, it has to sell itself to the customers. The features like, appearance and convenience, depending on the customers, needs, are to be considered. Product convenience can be improved using pre-determined motion-time systems.

So, engineers, designers and psychologists should work together to design a better product for selling.

The product design and analysis include the following aspects :

(i) Process planning and design

(ii) Value analysis

(iii) Standardization and simplification

(iv) Make or buy decision

(v) Ergonomic considerations in product design

(vi) Concurrent engineering®

Q2. Explain the Characteristics of good product Design.

(OR)

Describe the Characteristics of good product Design.

Ans : **(Imp.)**

A good product design must ensure the following:

(i) Function (or) Performance

The function or performance is what the customer expects the product to do to solve his/her problem or offer certain benefits leading to satisfaction. For example, a customer for a motor bike expects the bike to start with a few kicks on the kick peddle and also expects some other functional aspects such as pick-up, maximum speed, engine power and fuel consumption etc.

(ii) Appearance (or) Aesthetics

This includes the style, colour, look, feel, etc. which appeals to the human sense and adds value to the product.

(iii) Reliability

This refers to the length of time a product can be used before it fails. In other words, reliability is the probability that a product will function for a specific time period without failure.

(iv) Maintainability

It refers to the restoration of a product once it has failed. High degree of maintainability is desired so that the product can be restored (repaired) to be used within a short time after it breaks down. This is also known as serviceability.

(v) Availability

This refers to the continuity of service to the customer. A product is available for use when it is in an operational state. Availability is a combination of reliability and maintainability. High reliability and maintainability ensures high availability.

(vi) Producibility

This refers to the ease of manufacture with minimum cost (economic production). This is ensured in product design by proper specification of tolerances, use of materials that can be easily processed and also use of economical processes and equipments to produce the product quickly and at a cheaper cost.

(vii) Simplification

This refers to the elimination of the complex features so that the intended function is performed with reduced costs, higher quality or more customer satisfaction. A simplified design has fewer parts which can be manufactured and assembled with less time and cost.

(viii) Standardisation

It refers to the design activity that reduces variety among a group of products or parts. For example, group technology items have standardised design which calls for similar manufacturing process steps to be followed. Standard designs lead to variety reduction and results in economies of scale due to high volume of production of standard products. However, standardised designs may lead to reduced choices for customers.

(ix) Specification

A specification is a detailed description of a material, part or product, including physical measures such as dimensions, volume, weight, surface finish etc. These specifications indicate tolerances on physical measures which provide production department with precise information about the characteristics of products to be produced and the processes and production equipments to be used to achieve the specified tolerances (acceptable variations).

(x) Safety

The product must be safe to the user and should not cause any accident while using or should not cause any health hazard to the user. Safety in storage, handling and usage must be ensured by the designer and a proper package has to be provided to avoid damage during transportation and storage of the product. For example, a pharmaceutical product while used by the patient, should not cause some other side effect threatening the user.

Q3. Explain the Objectives and approaches of Product Design.

Ans : **(Feb.-12, Imp.)**

Objectives

The following are the objectives of product design are :

(i) The overall objective is profit generation in the long run.

(ii) To achieve the desired product quality.

(iii) To reduce the development time and cost to the minimum.

(iv) To reduce the cost of the product.

(v) To ensure producibility or manu-facturability (design for manufacturing and assembly).

Approaches

1. Designing for the customer

i) Designing for aesthetics and for the user is generally termed industrial design which is probably the most neglected area by manufacturers.

ii) In many products we use, parts are inaccessible, operation is too complicated or there is no logic to setting and controlling the function of the product.

iii) Sometimes worst conditions exist, metal edges are sharp and consumers cut their hands trying to reach for adjustment or repairs.

iv) Many products have too many features- far more than necessary and for instance many electronic products have too many features which the customers cannot fully make use of (operate).

v) One approach to getting the voice of the customer into the design specification of a product is quality function deployment (QFD).

vi) This approach uses interfunctional teams from marketing, design engineering and manufacturing to incorporate the features sought by the customers in the product at the stage of product design.

2. Designing for Manufacture and Assembly (DFMA)

i) Traditionally the attitude of designers has been "we design it, you build it" which is termed as "over-the-wall approach", where the designer is sitting on one side of the wall and throwing the design over the wall to the manufacturing engineers.

ii) The manufacturing engineers have to deal with the problems that arise because they were not involved in the design effort.

iii) This problem can be overcome by an approach known as concurrent engineering (or simultaneous engineering).

iv) Concurrent engineering means bringing design and manufacturing people together early in the design phase to simultaneously develop the product and processes for manufacturing the product.

v) Recently this concept has been enlarged to include manufacturing personnel, design personnel, marketing and purchasing personnel in loosely integrated cross-functional teams. In addition, the views of suppliers and customers are also sought frequently.

vi) This will result in product designs that will reflect customer wants as well as manufacturing capabilities in the design stage itself.

vii) Design for Manufacturing (DFM) and Design for Assembly (DFA) are related concepts in manufacturing.

viii) The term design for manufacturing is used to indicate the designing of products that are compatible with an organisation's capability. Design for assembly focuses on reducing the number of parts in a product or on assembly methods and sequence that will be employed.

(ix) Designing for manufacture includes the following guidelines:

(a) Designing for minimum number of parts.

(b) Developing modular design.

(c) Designing for minimum part variations, (i.e., communication or using standardised parts) and

(d) Designing parts for ease of fabrication.

3. Designing for ease of production

Manufacturability or producibility is a key concern for manufacturing products. Ease of fabrication and/or assembly is important for cost, productivity and quality. Designing products for ease of production is a key way for manufacturers to be competitive in the world market.

Standardisation refers to design activity that reduces variety among a group of products or parts. This will result in higher volume for each product or part model which can lead to lower production costs, higher product quality and lower inventory and higher ease of automation.

4. Designing for Quality

Building product quality into the product design is the first step in producing products of superior quality. This is known as "quality of design" which is followed by "quality of conformance." Quality of design refers to the quality specifications incorporated in the design. It consists of quality characteristics such as appearance, life, safety, maintenance and other features of the product.

(a) Robust design

(b) Design for production and

(c) Design for reliability

(a) Robust Design: Customers expect products to perform satisfactorily when used in all kinds of field conditions. Hence it is not enough if the products perform as intended when they are produced and used under ideal conditions. A robust design is one that will perform as intended even if undesirable conditions occur either in production or in the field.

(b) Design for production (i.e., for ease of manufacturer and assembly) was discussed in the previous section. This can reduce the sources of error and improve overall product quality. Modular design and designing for automation are two aspects of designing for ease of production.

(i) Modular design is the creation of products from some combination of basic, preexisting subsystems known as modules. In this approach, products are designed in easily segmented components or modules. This design offers flexibility to both production (manufacture and assembly) and marketing. The modular design concept gives consumers a range of product options and offers considerable advantages in manufacturing and product design.

(ii) Designing for Automation: In designing for automation, three broad issues affecting product design efforts come into play. They are: (i) wasteful or unnecessary processes should not be automated, (ii) simplify the design before automation, (iii) the process may be simplified to such an extent that automation may not be needed.

(c) Design for Reliability: Reliability is a measure of the ability of a product, part or system to perform its intended function under a prescribed set of conditions. It is the probability that an item will function as planned over a given time period. Reliability is always specified with respect to normal operating conditions which are taken into consideration while designing the product for reliability.

(i) Designing for Ergonomics

'Poorly designed products may cause work-related accidents resulting in injuries to users. Hence, comfort, safety and ease of use for the users are becoming more important quality dimensions that have to be considered in product design. Human factor engineering or Ergonomics applies knowledge of human capabilities and limitations to the design of products and processes.

(ii) Designing for Environmental Protection

This includes designing products which are environmental friendly known as green designs. Sometimes reaction to a social or environmental concern opens up a set of promising new design options.

A new approach called "universal design" is an example of product design in which an attempt is made to design products that are easily operable by disabled persons.

(iii) Designing for Recycling

This approach to product design focuses on designing products so that raw materials such as plastics can be retrieved once the product has finished its useful life and scrapped. Recycling means recovering materials for further use. Recycling is done to achieve cost savings, and also to meet environmental concerns and regulations. Designing for recycling facilitates the recovery of materials and components in used products for reuse.

(iv) Designing of Disassembly (DFD)

This involves designing products which can be more easily taken apart or disassembled. It includes fewer parts and less material and using snap-fits where possible instead of screws, bolts and nuts.

(v) Designing for Mass Customisation

It is a strategy of designing standardised products but incorporating some degree of customisation in the final product. Delayed differentiation and modular designs are two tactics used to make mass customisation possible.

Q4. Explain the Factors Influencing Product Design.

Ans :

Following are the factors influencing Product design.

(i) Customer Requirements

The designers must find out the exact requirements of the customers to ensure that the products suit the convenience of customers for use. The products must be designed to be used in all kinds of conditions.

(ii) Convenience of the Operator or User

The industrial products such as machines and tools should be so designed that they are convenient and comfortable to operate or use.

(iii) Trade off between Function and form

The design should combine both performance and aesthetics or appearance with a proper balance between the two.

(iv) Types of Materials Used

Discovery of new and better materials can improve the product design. Designers keep in touch with the latest developments taking place in the field of materials and components and make use of improved materials and components in their product designs.

(v) Work Methods and Equipments

Designers must keep abreast of improvements in work methods, processes and equipments and design the products to make use of the latest technology and manufacturing processes to achieve reduction in costs.

(vi) Cost/Price Ratio

In a competitive market, there is lot of pressure on designers to design products which are cost effective because cost and quality are inbuilt in the design. With a constraint on the upper limit on cost of producing products, the designer must ensure cost effective designs.

(vii) Product Quality

The product quality partly depends on quality of design and partly on quality of conformance. The quality policy of the firm provides the necessary guidelines for the designers regarding the extent to which quality should be built in the design stage itself by deciding the appropriate design specifications and tolerances.

(viii) Process Capability

The product design should take into consideration the quality of conformance, i.e., the degree to which quality of design is achieved in manufacturing. This depends on the process capability of the machines and equipments. However, the designer should have the knowledge of the capability of the manufacturing facilities and specify tolerances which can be achieved by the available machines and equipments.

(ix) Effect on Existing Products

New product designs while replacing existing product designs, must take into consideration the use of standard parts and components, existing manufacturing and distribution strategies and blending of new manufacturing technology with

the existing one so that the costs of implementing the changes are kept to the minimum.

(x) Packaging

Packaging is an essential part of a product and packaging design and product design go hand in hand with equal importance. Packaging design must take into account the objectives of packaging such as protection and promotion of the product. Attractive packaging enhances the sales appeal of products in case of consumer products (non-durable).

2.2 New Product Development

2.2.1 Concepts

Q5. Define New Product Development. What are the causes and factors for New Product Development?

(OR)

Explain the concept of new product development.

Ans : **(April-23, Imp.)**

Meaning

A product is produced so that it can directly (or) indirectly fulfil human wants. Each product at a certain point of time reaches its maturity stage is based on the competition, technology, culture, taste of customers etc. Organization can charge some parts (or) technology used to upgrade the product.

Causes

The major causes for this increased emphasis on developing new products are

(a) Increased competition

(b) Advances in technology.

(a) Increased Competition

The reasons for this increase in foreign competition are many, including

i) Advances in IT

ii) A trend to lower trade barriers and the creation of trade organization.

iii) The faster speed at which goods can be transported.

(b) Advances in Technology

Rapid advances in technology are causing many products to become obsolete more quickly. Computers are good example of products that have been significantly impacted by advances in technology.

Factors

1. The external appearance of a manufactured product must be so attractive that it should attract buyers to purchase it.
2. Internal parts of a product which influence performance, reliability and durability and even long term satisfaction of customer.
3. The quantity, type and difficulty of product's components influence the type of suppliers. The production process is influenced by the type of parts and capital investment and personal skills that are essential for a company. It is observed that most of the product's cost is ascertained by its design.

Q6. Explain the benefits of Introducing New Products.

Ans :

The benefits of introducing new product faster:

1. Greater Market Share

The firm with the ability to bring new products to market quickly has several advantages over their slower competitors.

2. Price Premiums

When a firm is the first to bring a new product to market, it has little or no competition, and can therefore charge premium prices.

3. Quick Reaction to Competition

To bring new products to market quickly is also in a much better position to respond quickly to a competitor's surprise announcement of the introduction of a new product.

4. Set Industry Standards

For revolutionary products, the first firm into the market often has the luxury of setting the standards for that industry.

Q7. Explain the Categories of New Products.

Ans :

New products can be grouped according to the degree of innovation associated with them in comparison to existing products. Within this framework, we define three broad categories of new products.

1. Incremental or Derivative Products

Incremental or derivative products are those products that have least amount of innovation and are typically hybrids or enhancements of existing products. These products are often cost-reduced versions of existing products or simply similar products with added features or functions.

Companies usually can bring incremental products to market quickly. However, this does not occur automatically. A minor design change in a product sometimes can significantly impact a firm's production process. Decision on proceeding with such changes in a product therefore must be made with careful considerations.

2. Next Generation or Platform Products

Next generation or platform products are the middle of these three categories of new products which often represent new 'system' solutions for the customer. They provide broad base for a product family that can be leveraged over several years and, therefore, require significantly more resources than do derivative or incremental products. Pentium, Pentium II, Pentium III, and Pentium 4 microprocessors an excellent example of products that fall into this category.

3. Breakthrough or Radical Products

Breakthrough or Radical Products are those products that are defined as new products. The development of these products typically requires substantial product design and process change. When successfully introduced, this type of product often creates an entirely new product category, which becomes a new core business for the firm. In doing, so it creates an opportunity for it to be the first to enter an entirely new market.

2.2.2 Steps of Product Design

Q8. What are the various steps involved in Product Design?

(OR)

Describe the phases of generic product development process.

(OR)

Explain the stpes in product design.

Ans : **(Dec.-19, May-19, Feb.-16, Aug.-15, Imp.)**

Following are the various steps involved in steps of product design.

1. Task Clarification

Task clarification is the first step involved in the product development process. In this step, the ideas which match with the strategy are recognised and the needs of customers are ascertained. This helps in identifying the functional pre-requisites of the product. The product idea should clearly display that it satisfies the needs of the consumers which the current products do not meet.

2. Generation of Concept

Based on the specifications or the features of product, the concept is generated. In this step, the companies determine the important problems and plan the functional structure of the product or service. This helps in creating proposals and solution principles which are integrated and developed into concept variants.

The concept must be assessed against the technical and economic information. If the results obtained are fair and acceptable, then it indicates that the concept has to move towards the screening stage.

3. Embodiment Design

After the completion of screening stage, the ideas are developed in their introductory arrangement and a preliminary analysis is performed. The effective introductory designs are selected, improved and assessed against the technical and economic data. With the improvement of introductory design, the configuration is completed.

A comprehensive examination of improved design must be done. The design is analysed for identifying errors, cost and manufacturability. The introductory or preliminary design and alternate designs are assessed on the basis of the important parameters for ascertaining the design support which needs analytical testing, experimentation and physical modelling.

4. Detailed Engineering Design

This stage deals with designing and building a comprehensive product definition involving its elements, materials, sizes, shapes etc. The product design is examined, experimented and the data is gathered for ascertaining whether the design fulfills the design objectives or not. The final design consists of drawings, specifications and other required documentations which acts as the basis of product and process development.

5. Physical Evaluation

After creating a detailed engineering design, physical evaluation is done. This is done by constructing a working prototype of the product, inspecting and by analysing to make sure that it denotes the solution.

If an organisation performs some tasks simultaneously by using the pros of cross functional thinking, then the duration of this stage can be minimized. Before conducting physical evaluation, computer simulations are done. The use of CAD systems helps the designers to observe any element, any scale or any cross section.

2.3 Process Planning and Design

Q9. Explain briefly about Process Planning and Design.

(OR)

What is process planning design?

Ans : **(Dec.-18)**

Meaning

Process planning is concerned with planning the conversion processes needed to convert the raw material into finished products. It consists of two parts:

(i) Process design

(ii) Operations design

(i) Process Design

Process design is concerned with the overall sequences of operations required to achieve the product specifications. It specifies the type of work stations to be used, the machines and equipments necessary to carry out the operations. The sequence of operations are determined by

(a) the nature of the product

(b) the materials used

(c) the quantities to be produced

(d) the existing physical layout of the plant

(ii) Operations design

Operations design is concerned with the design of the individual manufacturing operation. It examines the man-machine relationship in the manufacturing process. Operations design must specify how much labour and machine time is required to produce each unit of the product.

Framework

The process design is concerned with the following:

(i) Characteristics of the product or service offered to the customers.

(ii) Expected volume of output.

(iii) Kinds of equipments and machines available in the firm.

(iv) Whether equipments and machines should be of special purpose or general purpose.

(v) Cost of equipments and machines needed.

(vi) Kind of labour skills available, amount of labour available and their wage rates.

(vii) Expenditure to be incurred for manufacturing processes.

(viii) Whether the process should be capital-intensive or labour-intensive.

(ix) Make or buy decision.

(x) Method of handling materials economically.

Q10. What is process strategy? Explain the key aspects and types of process strategies.

Ans :

Meaning

- A process strategy is an organization's approach to process selection for the purpose of transforming resource inputs into goods and services (outputs).
- The objective of a process strategy is to find a way to produce goods and services that meet customer requirement and product specification (i.e., design specifications) within the constraints of cost and other managerial limitations.
- The process selected will have a long-term effect on efficiency and production as well as flexibility, cost, and quality of the goods produced.
- Hence it is necessary that a firm has a sound process strategy at the time of selecting the process.

Key Aspects

(i) Make (or) buy decisions

(ii) Capital intensity and

(iii) Process flexibility

(i) Make (or) Buy Decisions

Make or buy decisions refer to the extent to which a firm will produce goods or provide services in-house or go for outsourcing (buying or subcontracting).

(ii) Capital Intensity

Capital intensity refers to the mix of equipment and labour which will be used by the firm.

(iii) Process Flexibility

Process flexibility refers to the degree to which the system can be adjusted to changes in processing requirements due to such factors as changes in product or service design, changes in volume of products produced and changes in technology.

Strategies

Virtually every good or service is made by using some variation of one of three process strategies. They are:

(i) process focus

(ii) repetitive focus and

(iii) product focus.

Each of these three strategies are discussed below:

(i) Process Focus

Majority (about 75 per cent) of global production is devoted to low volume, high variety products in manufacturing facilities called job shops. Such facilities are organised around performing processes.

(ii) Repetitive Focus

A repetitive process is a product oriented production process that uses modules. It falls between product focus and process focus. It uses modules which are parts or components prepared often in a continuous or mass production process.

A good example of repetitive process is the assembly line which is used for assembling automobiles and household appliances and is less flexible than process-focused facility. Personal computer is an example of a repetitive process using modules in which the modules are assembled to get a custom product with the desired configuration.

(iii) Product Focus

It is a facility organised around products, a product oriented, high-volume low-variety process. It is also referred to as continuous process because it has very long continuous production run.

Examples of product focussed processes are steel, glass, paper, electric bulbs, chemicals and pharmaceutical products, bolts and nuts etc. Product- focussed facilities need standardisation and effective quality control. The specialised nature of the facility requires high fixed cost, but low variable costs reward high facility utilisation.

Q11. Compare and contrast Process focus, Repetitive focus and Product focus.

Ans :

Sl.No.	Process Focus	Sl.No.	Repetitive Focus	Sl.No.	Product Focus
1.	Small quantity and large variety of products are produced.	1.	Long runs, usually standardised products with options for customers are produced from modules.	1.	Large quantity and small variety of products are produced.
2.	General purpose machines and equipments are used.	2.	Special equipments used in assembly lines.	2.	Special purpose machines and equipments are used.
3.	Broadly skilled operators.	3.	Modestly trained operators.	3.	Broadly skilled operators.
4.	Many job instructions because of job changes.	4.	Repetitive operations reduce job instructions and-training.	4.	Few job instructions because jobs are standardised.
5.	High raw material inventory.	5.	Just-in-time procurement techniques are used.	5.	Low raw material inventories relative to value of output.
6.	High work-in-process compared to output.	6.	Just-in-time production techniques are used.	6.	Work-in-process inventory is low compared to output.
7.	Work flow is slow.	7.	Work flow is slow.	7.	Fast work flow.
8.	Finished goods are usually made to order arid not stored.	8.	Finished goods are made to frequent forecasts.	8.	Finished goods are usually mode to a forecast and stored.
9.	Production scheduling is complicated, concerned with trade-off between inventory availability, capacity and customer service.	9.	Production scheduling is based on building various models from a variety of modules to forecasts.	9.	Simple production scheduling, concerned with establishing a rate of output sufficient to meet demand forecast.
10.	Low fixed costs and high variable costs.	10.	Fixed costs are dependent on flexibility of the facility.	10.	Fixed costs tend to be high and variable costs low.

Q12. Discuss in detail the major factors affecting process design decisions.

(OR)

Describe the factors that affect process design.

Ans : **(Aug.-16, Feb-15, Imp.)**

1. Process Choice

The Process choice determines whether resources are organised around products or processes in order to implement the flow strategy. It depends on the volumes and degree of customisation to be provided.

The production manager has to choose from five basic process types:

(i) Job shop process

(ii) Batch process

(iii) Repetitive process

(iv) Continuous process

(v) Project process

(i) Job Shop Process

It is used in job shops when a low volume of high-variety goods are needed. Processing is intermittent, each job requires somewhat different processing requirements. A job shop is characterised by high customisation (made to order), high flexibility of equipment and skilled labour and low volume. A tool and die shop is an example of job shop, where job process is carried out to produce one-of-a kind of tools. Firms having job shops often carry out job works for other firms). A job shop uses a flexible flow strategy, with resources organised around the process.

(ii) Batch Process

Batch processing is used when a moderate volume of goods or services is required and also a moderate variety in products or services. A batch process differs from the job process with respect to volume and variety. In batch processing, volumes are higher because same or similar products or services are repeatedly provided, examples of products produced in batches include paint, ice cream, soft drinks, books and Magazines.

(iii) Repetitive Process

This is used when higher volumes of more standardised goods or services are needed. This type of process is characterised by slight flexibility of equipment (as products are standardised) and generally low labour skills. Products produced include automobiles, home appliances, television sets, computers, toys etc.

(iv) Continuous Process

This is used when a very highly standardised product is desired in high volumes. These systems have almost no variety in output and hence there is no need for equipment flexibility. A continuous process is the extreme end of high volume, standardised production with rigid line flows.

(v) Project Process

It is characterised by high degree of job customisation, the large scope for each project and need for substantial resources to complete the project.

2. Vertical Integration

Vertical integration is the amount of the production and distribution chain, from suppliers of components to the delivery of products/services to customers, which is brought under the ownership of a firm. The management decides the level or degree of integration by considering all the activities performed from the acquisition of raw materials to the delivery of finished products to customers.

(a) Backward integration which represents moving upstream toward the sources of raw materials and parts, for example a steel mill going for backward integration by owning iron ore and coal mines and a large fleet of transport vehicles to move these raw materials to the steel plant.

(b) Forward integration in which the firm acquires the channel of distribution.

Advantages

(i) Can sometimes increase market share and allow the firm enter foreign markets more easily.

(ii) Can achieve savings in production cost and produce higher quality goods.

(iii) Can achieve more timely delivery.

(iv) Better utilisation of all types of resources.

Disadvantages

(i) Not attractive for low volumes.

(ii) High capital investment and operating costs.

(iii) Less ability to react more quickly to changes in customer demands, competitive actions and new techniques.

3. Resource Flexibility

The choices that management makes concerning competitive priorities determine the degree of flexibility required of a firm's resources its employees, facilities and equipment. Production managers must decide whether to have flexible workforce which will provide reliable customer service and avoid capacity bottlenecks.

2.3.1 Selection of Process

Q13. Explain briefly about Selection of Process.

Ans :

Meaning

i) Process selection decisions determine the type of productive process to be used and the appropriate span of that process. For example, the managers of a fast-food restaurant may be required to decide whether to produce food strictly to customer order or to inventory.

ii) The managers must also decide whether to organize the process flow as a high-volume line flow or a low-volume batch-production process.

iii) Furthermore, they must decide whether to integrate forward towards the market and/or backward towards their suppliers.

iv) All these decisions help in defining the type of process which will be used to make the product.

v) Process selection is sometimes viewed as a layout problem or as a series of relatively low-level decisions.

vi) But, on the contrary, process selection is strategic in nature and is of utmost importance. Process decisions affect costs, quality, delivery and flexibility of operations.

Process Selection Decisions

Processes can be classified and selected according to product flow and the type of customer order. The customer order is generally of two types

1. Make-to-stock
2. Make-to-order.

1. Make-to-stock

Make-to-stock aims to produce products in advance and helps to have ready stock when demands occur. This is applicable for a product which has no specific customer at the time of manufacturing. For example, tooth paste, soap, etc.

2. Make-to-order

Make-to-order aims to manufacture products only on orders. For example, crane manufacturing, ship, boiler, etc.

2.3.2 Responsibilities of Process Planning Engineer

Q14. What are the Responsibilities of Process Planning Engineer?

Ans : **(Dec.-19, Imp.)**

The responsibilities of process planning engineer

i) Prepare various strategies for all planning activities for projects.

ii) Maintain all asset investment plans and ensure compliance to capital expenditure.

iii) Ensure accuracy for all operational requirements for projects and achieve all investment objectives.

iv) Evaluate all system capacity and analyze all production requirement and system deficiencies.

v) Provide support to all operations and extension requests.

vi) Manage work as per component technical resource for all Water System Plans and assist to prepare all capital plans and project requirements.

vii) Analyze all engineering activities for all internal and external departments.

viii) Prepare required presentation for all regulatory agencies.

ix) Develop required to enhance performance of planning projects.

x) Manage all communication and provide efficient feedback for all processes.

xi) Ensure optimal utilization of all common tools and processes.

xii) Prepare plans and schedule for all project delivery.

xiii) Recommend appropriate improvements and ensure optimal quality of all project schedules and evaluate reports.

xiv) Perform regular analysis of all schedule trends.

xv) Maintain an efficient performance of all schedule and analyze all software tools and assist in transmission and distribution of all various projects.

xvi) Administer all distribution and transmission system.

xvii) Manage all customer site and maintain product suite for all applications.

2.3.3 Steps in Process Planning

Q15. What are the various steps involved in process planning.

(OR)

Explain Steps in Process Planning.

Ans : **(Dec.-19, May-19)**

The steps in process planning are summarized below :

1. Analyze the part print to get an overall picture of what is wanted.
2. Make recommendations to or consult with product engineers on product design changes.
3. List the basic operations required to produce the part to the drawing or specifications.
4. Determine the most practical and economical manufacturing method and the form of tooling required for each operation.
5. Devise the best way to combine the operations and put them in sequence.
6. Specify the gauging required for the process.

2.3.4 Process Design

Q16. Define the following terms.

(i) Process

(ii) Process Design

Ans : **(April-23)**

(i) Process

A process is referred to a sequence of activities that aims at achieving efficient output i.e., for instance, adding value to the customer's goods.

Process plays a very significant role in the production system. Product and process are interrelated. Both product and process are required to carry out the activities of the production system. Thus, process, in my organization is a continuous functioning of the sequential activities in order to produce efficiently with greater productivity levels.

(ii) Process Design

Process design is concerned with the overall sequence of operations required to achieve the design specifications of the product. It specifies the types of work stations that are to be used, the machines and equipments necessary to carry out the processes to produce the product.

The choice of process technology (i.e., manual, mechanised or automated technology) and the process design is related to product design because the manufacturing processes must be capable of achieving the product quality (accuracy, tolerances etc.) specified in the product design and also the product must be designed for producibility.

2.3.5 Process Research, Pilot Plant Development, Capacity Planning, Enhanced Capacity using Optimization

Q17. Describe the various activities involved in process design.

(OR)

Explain about pilot plant development.

Ans : **(Oct.-20, Dec.-19)**

The following are the activities involved in process design are :

(i) Process Research

Process research phase is the first phase of process development. This phase can be clearly explained with the help of a product like casting of gear

blanks which are used in making gears useful for rotating the kilns in cement plants or sugar plants. It is necessary to conduct research relating to activities that take place while preparing castings of the gear blanks.

(ii) Pilot Plant Development

The idea of the processes in making the castings for gear blanks may be tested using a pilot plant. The given example is a well proven one. So, even without pilot development, one can go to commercial plant transfer stage. But, in a case, where the processes are new and requires prototyping of the facilities and try pilot run using the proto type version, one should use pilot development for the assumed combinations of the processes that have been designed during the process research phase.

(iii) Capacity Consideration

Based on the forecast of the demand of the product, the facilities which are to be used in different processes are to be designed so that the integrated output of the system matches with the forecasted demand of that product.

(iv) Commercial Plant Transfer

After having convinced about the integrated functioning of the processes using the pilot development phase, the process design may be transferred to commercial plant where the regular production can take place.

(v) Enhanced Capacity Using Optimization

Once the plant starts producing the product, over a period of time, the performance of the operations of the processes will be available for the integrated function of the plant. Based on such data, one can make an attempt to optimize the process design in the plant to increase the capacity. One may use some model/ process improvement based on the available data.

Q18. Write about process research and capacity planning.

(OR)

Explain about capacity planning.

Ans : **(Dec.-19, Oct.-20)**

(i) Process Research

Product design is the initial step of every business venture which occurs after the concept of a product is accepted. It has direct influence on plant layout and in-process materials flow. The product design process involves critical evaluation of various design features in terms of places of use, substitute materials and equipment alternatives for manufacturing the product are cautiously planned. Hence, the objective of product design and analysis is to ascertain and define products which are beneficial for manufacturers and distributors and satisfy human beings.

(ii) Capacity Planning

Capacity planning is a long-term strategic decision (also referred to as strategic capacity planning) that establishes a firm's overall level of resources. Capacity may be defined as the amount of resource inputs available relative to output requirements over a particular period of time.

Capacity decisions affect product lead time, customer responsiveness, operating costs and a firm's ability to compete. Inadequate capacity can result in loss of customers and limited growth. On the other hand excess capacity can result in under utilisation of machines, equipment and labour, excess inventory, higher costs and lesser profits. Therefore the major capacity decisions involved are,

(i) How much capacity to be installed

(ii) When to increase capacity

(iii) How much to increase

Long-range capacity planning decisions usually involve the following activities.

(i) Estimating the capacities of the current (existing) facilities.

(ii) Forecasting the long-range future capacity needs for all products and services offered by the firm.

(iii) Identifying and analysing sources of capacity to meet future capacity needs.

(iv) Developing capacity alternatives.

(v) Selecting from among the alternative sources of capacity.

2.4 VALUE ANALYSIS / VALUE ENGINEERING

Q19. What is Value Analysis? Explain its types.

(OR)

Explain briefly about Value Engineering.

Ans : **(Dec.-19, May-19, Jan.-18, Imp.)**

Value Analysis also called as value engineering, value analysis is an important activity that typically occurs jointly between purchasing and methods engineering.

This activity is aimed at modifying the specifications of materials, parts, and products to reduce their costs while reducing their original function. Focus is placed on the value of the product - what function is to be performed by the product - and how that value can be achieved at the lowest cost. Although value analysis is applied to all phases of the production process, primary attention is devoted to the materials and components going into the product.

Value engineering typically follows a rather close structured pattern of analysis. A value analysis team or committee takes a product, which has been designed or produced and attempts to define what function the product should fulfil. Once the function has been identified, the analysis committee examines the possible ways of performing the function at the lowest cost.

$$\text{Value} = \frac{\text{Function}}{\text{Cost}}$$

Types

(a) Use Value

It indicates the attributes of a product which are essential for its performance as engine, steering wheel and axle in a motor car without which car cannot run. Secondary use value refers to such devices as bonnet or the mudguard or the windscreen without which motor car can be driven but these are necessary for the protection of engine and other parts.

Auxiliary use value is essential for better control and operation as speed meter, electric horn etc in motor car.

(b) Esteem Value

Certain properties of a product do not increase its utility or performance but they make it esteemable which would induce customers to purchase the product. For example, a watch with gold cover has esteem value. A rich customer may prefer a watch with gold cover although a watch with a steel cover may serve the same purpose of keeping time.

(c) Cost Value

This value is measured in terms of cost involved. In case of a manufacturing concern it refers to the cost of production of the product produced and if some part of the product is purchased from outside, it means cost of purchase of that part.

(d) Exchange Value

Certain characteristics of a product facilitate its exchange for something else and what we get is the exchange value of that product. It is equivalent to its sale value. All these values play an important part in our personal lives, but in value analysis, we are mainly concerned with use value and to some extent to the esteem value.

Q20. Explain the evolution of value analysis. Enlist the situations where value analysis programme can be imple-mented.

Ans :

Evolution

Value engineering or value analysis had its birth during the World War II Lawrence D. Miles was responsible for developing the technique and naming it. Value analysis is defined as "an organized creative approach which has its objective, the efficient identification of unnecessary cost which provides neither quality nor use nor life nor appearance nor customer features." Value analysis focuses engineering, manufacturing and purchasing attention to one objective-equivalent performance at a lower cost.

Value analysis is concerned with the costs added due to inefficient or unnecessary specifications and features. It makes its contribution in the last stage of product cycle, namely, the maturity stage. At this stage, research and development no longer make positive contributions in terms of improving the efficiency of the functions of the product or adding new functions to it. Value is not inherent in a product, it is a relative term, and value can change with time and place. It can be measured only by comparison with other products which perform the same function.

Implemented

When one or more of the following indications are seen, then VA programme can be implemented.

1. Reduction in sales of company's products.
2. When price of company are higher than competitors.
3. Instant increase in cost of raw materials.
4. Development of new designs.
5. When there is disproportionate increase in cost of manufacturing compared to volume of production.
6. Trend of rate of return on investment continuously falls downwards.
7. When firm could not meet its delivery commitments.

Q21. Explain the steps to be followed for applying value engineering.

(OR)

Describe the various steps involved in value analysis.

(OR)

What is value engineering? What are the important phases of value engineering? Briefly explain each of them.

(OR)

What is Value Analysis ? Explain the objectives and steps in conducting Value Analysis.

Ans : **(Oct.-22, Aug.-21, May-19, Aug.-17)**

The basic steps of value engineering are listed below :

Step 1 : Identify the Product

First, identify the component for study. In future, any design change should add value and not make the product an obsolete one. Value Engineering can be applied to a product as a whole or to its subunits.

Step 2 : Collect Relevant Information

Information relevant to the following must be collected :

i) Technical specifications with drawings.

ii) Production processes, machine layout and instruction sheet.

iii) Time study details and manufacturing capacity.

iv) Complete cost data and marketing details.

v) Latest development in related products.

Step 3 : Define different Functions

Identify and define the primary, secondary and tertiary functions of the product or parts of interest. Also, specify the value content of each function and identify the high cost areas.

Step 4 : Different alternatives

Knowing the functions of each component part and its manufacturing details, generate the ideas and create different alternatives so as to increase the value of the product. Value Engineering should be done with brain storming sessions. All feasible and non-feasible suggestions are recorded without any criticism, rather, persons are encouraged to express their views freely.

Step 5 : Critically evaluate the alternatives

Different ideas recorded under Step 4 are compared, evaluated and critically assessed for their virtues, validity and feasibility as regards their financial and technical requirements. The ideas technically sound and involving lower costs are further developed.

Step 6 : Develop the best alternative

Detailed development plans are made for those ideas which emerged during step 5, and appear most suitable and promising. Development plans comprise drawing the sketches, building of models, conducting discussions with the purchase section, finance section, marketing divisions, etc.

Step 7: Implement the alternative

The best alternative is converted into a prototype manufacturing model which ultimately goes into operation and its results are recorded.

Objectives

i) Simply the product

ii) Reduce the cost of the product

iii) Use cheaper and better materials

iv) Modify and improve the product design so as to make it acceptable to the customer.

v) Use efficient processes

vi) Increase the utility of the product by economical means.

vii) Ensure greater return on investment

viii) Improve organizational efficiency.

2.4.1 Advantages and Application Areas

Q22. Explain advantages and application of value engineering.

Ans : **(Imp.)**

Advantages

Following are the main advantages of value analysis:

(i) It is a powerful tool for cost reduction because its basic objective is the identification of unnecessary costs in a product or service and efficiently eliminating them without impairing its quality and efficiency. Reduction in cost will make available more profit to a firm.

(ii) It is a scientific tool for increasing the productivity of a concern because it aims at exploring various alternatives for efficient use of all types of resources in employment and making available goods and services of the kind and quality most wanted by customers at lower and lower costs.

(iii) It helps to keep management abreast of the latest technology and other developments because value analysis aims at examining new methods and techniques of doing things with a view to reducing the cost and increasing the value of the items.

(iv) It ensures the fullest possible use of resources because it aims at eliminating all unnecessary costs.

(v) It promotes innovation and creativity. It induces the creative ability of the staff because it involves a creative approach for finding out unnecessary costs. Creativity develops new ideas which, in turn, make available the least expensive alternative to do the same function.

(vi) It creates proper atmosphere for increased efficiency because it aims at a continuing search for improvement in efficiency.

(vii) It is helpful in any drive for import substitution because it explores new methods and techniques of manufacturing indigenous goods which may serve the same purpose which imported goods serve. Thus, it is helpful in saving precious foreign exchange.

(viii) It can be applied at all stages from the initial design stage of an item right up to the final stage of its packing and despatch because it aims at identifying unnecessary costs at all levels with a view to eliminating them systematically.

(ix) Customers' needs are best served with the help of value analysis because it aims at production of the most suitable products.

(x) Value analysis helps in the implementation of the marketing concept because it lays emphasis on the constant linking of production function with the marketing function.

(xi) Management effectiveness can be measured with the help of value analysis because any saving in cost is treated as increased efficiency.

Application

(i) Capital Goods - Plant, equipment, machinery, tools, etc.

(ii) Raw and semi - processed material, including fuel,

(iii) Materials handling and transportation costs.

(iv) Purchased parts, components, sub-assemblies, etc.

(v) Maintenance, repairs, and operational items.

(vi) Finishing items such as paints, oils, varnishes, etc.

(vii) Packing materials and packing.

(viii) Printing and Stationery items.

(ix) Miscellaneous items of regular consumptions.

(x) Power, water supply, air, steam & other utilities (services).

Q23. Distinguish between value analysis and value engineering.

Ans : **(Feb.-17, Feb.-15)**

Sl.No.	Value Analysis	Sl.No.	Value Engineering
1.	Value analysis is the application of set of techniques to an existing product with a view to improve its value.	1.	Value Engineering is the application of same set of techniques to a new product at the design stage-project concept or preliminary design when no hardware are exists.
2.	Value Analysis is thus a remedial process.	2.	Value Engineering is thus a preventive process.
3.	Value Analysis is done after the birth of the product	3.	Value Engineering is an early stage process.
4.	Value Analysis is done to have between optimized commercial output.	4.	Value Engineering provides better engineering results.

Q24. How value engineering differ from cost reduction.

Ans : **(Dec.-18)**

Sl.No.	Value Engineering	Sl.No.	Cost Reduction
1.	Value engineering provides the way in which the given task can be performed effectively.	1.	Cost reduction is associated with reporting the benefits of actions in terms of cost savings.
2.	Value engineering applies specific techniques to improve the planned actions.	2.	Cost reduction applies specific systems to record and report the results of the actions.
3.	The members of value engineering team include engineers, architects and trained members in the respective field of action.	3.	The members of cost reduction team include auditors, accountants and trained members in the respective field of action.
4.	Value engineering provides the data to cost reduction program in terms of cost savings.	4.	Cost reduction records the performance of value engineering team in terms of cost reduction goals.
5.	Value engineering depends on cost reduction and auditing to validate and assess it's performance.	5.	Cost reduction depends on value engineering to the cost savings actions in bulk.

2.5 LEAN PRODUCTION SYSTEM

Q25. Explain briefly about Lean Production System.

Ans :

1. Lean manufacturing has emerged as an alternative to mass production techniques. It reflects a totally new approach to operation management and greatly contributes to the addressing of issues in a consumer driven market. In 1990, James Womack wrote a book called "The Machine that Changed the World". This book was a straight forward account of the history of automobile manufacturing combined with the study of Japanese, American and European automobile assembly plants.

2. He called the system that he described "Lean Manufacturing" It is an incredibly successful System that integrates the 'routine' work of producing and delivering products, services and information with 'problem identification and process improvement'. It is an extension of supply chain concept based on a systematic elimination of unproductive activities identified as wastes.

3. The concept involved in minimizing wastes; all manufacturing processes are either valueadded or non value added. The valor stream includes all activities required to bring a product from vendor's raw material into the hands of customers. Value added processes mold, transforms or otherwise change raw material into finished products. Non value added activities are often necessary, consume time and resources but add little or no value to the product. Such activities include transporting, material, storing material, conducting inspection etc.

4. To provide what the customer is asking for, you need to improve production efficiency. In the past, increasing production efficiency required employees to work harder or longer and machines to run faster. Such methods work in the short run but cause problems. Accident rates increase workers and equipment are overworked and overtaxed equipment and workers revolt.

5. The Lean concept refers to a collection of tools used to promote long-term profitability and growth by more with less. The essential element of Lean Manufacturing is aimed at the elimination of waste at every area of production including customer relations, product design, and supplier network and factory management. Its' goal is to incorporate less human effort , less inventory, less time to develop products and less space , to become highly responsive to customer demand, while producing top quality products in most efficient and economical manner possible.

   Total Productive Maintenance (TPM) is a Lean concept based on three simple ideas;

   i) Preventive maintenance schedules must be developed and adhered to,

   ii) Extensive maintenance history exists in a database and equipment failures may be predicted within reasonable time frames

   iii) Simpler maintenance tasks be delegated to those who know the equipment the best. Establishing a preventive maintenance schedule and Predictive Maintenance Systems are basic requirements of Lean Manufacturing. In addition, the operators should be responsible and have ownership

for all maintenance of the equipment they operate. As operators know their machines the best they would be the first to detect variations in operations; unusual sounds, vibrations smell etc. The specific tools of Lean Manufacturing such as

(a) Pull System,

(b) Kanban Cards,

(c) Kaizen

iv) Are artifacts of a general? Comprehe-nsive approach to managing collabo-rative work systems that allows frequent fine grained problem identification and improvement in overall organizational structure, coordinated mechanisms and task performance.

Q26. What are the objectives of lean productions system?

Ans : **(Imp.)**

i) The lean methodology is a management philosophy that was born with the Toyota Production System.

ii) The tools used in this process seek to eliminate waste, that is, to exclude what is of no value to the customer.

iii) However, for this methodology to work, it is not enough for the company's managers and engineers to know the Lean system's advantages.

iv) The working class also has the same need to understand the objectives of lean manufacturing that is behind the numerous practices and tools today applied in the industrial environment.

Key Objectives of Lean Manufacturing

1. Continuous Improvement
2. Cost Reduction
3. Production Agility
4. Improvements in the Work Environment
5. Elimination of Waste

1. Continuous Improvement

i) One of the main objectives of lean manufacturing is continuous improvement. This concept is related to the practice of constantly improving a company's processes.

ii) Lean manufacturing does not reduce waste in the same way as an external consultancy, which assesses the scenario, makes a diagnosis, proposes changes in the company, and ends its work.

iii) Lean is a philosophy that must be incorporated into the company's organizational culture. This helps create processes to identify opportunities to wipe waste continuously.

iv) It aims to achieve better and better results continuously. Then, after a process has been improved, this new process is reassessed again after some time in search of new improvements. This cycle is endless.

2. Cost Reduction

i) Before allowing a greater profit, reducing production costs should be considered an opportunity to differentiate.

ii) Lean production decreases costs within its operations, not only in production but also in office and administrative expenditures.

iii) It allows the organization to produce more without having to invest more resources.

iv) It is not difficult to understand that lean will improve your company's profitability. It will also enable greater and more stable revenues through better customer service and loyalty.

v) The elimination of waste generates productivity gains and, therefore, cost reduction.

vi) One of the biggest benefits of cost reduction is offering more competitive prices to customers.

3. Production Agility

i) By improving production agility, a manufacturer can serve a larger market without having to expand its structure.

ii) Supporting the concept of level production, the idea is to meet the demands of customers' orders.

iii) Thus, the company remains active daily with all stages in synergy, producing at a constant pace.

iv) The more agile a factory, the greater its production capacity.

i) It is very important to note, however, that this objective is not an end in itself. In lean, production is increased when it is known that there is a demand to absorb it.

i) Otherwise, it would not be reducing waste, but increasing it.

i) Also Read: Benefits and Principles of Lean Data Management

4. Improvements in the Work Environment

i) Lean manufacturing should not be confused with the practices that increase productivity at the expense of the employee's quality of life.

ii) In addition to the obvious ethical and human issue, ensuring a good work environment fights waste, reducing turnover, and removing workers due to illnesses and accidents.

5. Elimination of Waste

i) Lean manufacturing seeks to eliminate everything that the end consumer does not perceive as value.

ii) By minimizing inventories and streamlining processes, the industry gains in agility and optimization of production time. In practice, lean manufacturing is applied by eliminating 8 wastes.

iii) **Defects:** Problems that bring losses to the industry and to customers, when production has flaws that need to be repaired and cause a disruption in the production process, or a direct financial loss.

iv) **Overproduction:** Quantities produced that go beyond what is necessary.

v) **Waiting:**Materials, equipment, information, and people who are limited to the previous steps, which generate a loss of time or delay in processes.

vi) **Transportation:** Unnecessary displace-ment of materials, either internally or externally.

vii) **Excess processing:** Steps or processes that are not necessary and do not add value to the product.

viii) **Inventory:** Raw material accumulated in exaggeration, due to internal information exchange errors, or problems with supplier deliveries.

ix) **Unused Talent:** Superficial exploitation of the potential of each employee.

x) **Motion:** Collaborators who need to move around unnecessarily, due to demands of the production process or idealized workstations without taking into account the production stages.

Q27. Explain why process design lags behind product design.

Ans : **(Oct.-22)**

i) A process may be defined as "a series of steps, actions, or operations used in making something or bringing about a desired result: a manufacturing process"

ii) Similarly, a design process can be defined as a sequence of creative problem finding, analyzing, and solving steps used by the designer to develop an appropriate design solution for the given client, which is an organizational framework used by designers during the process of product design.

iii) The product described refers to the concept in a broad sense, which refers to the sum of the products formed with a certain purpose and to meet the needs of targeted people as well as nonphysical services.

Short Questions and Answers

1. Characteristics of good product Design.

Ans :

A good product design must ensure the following:

(i) Function (or) Performance

The function or performance is what the customer expects the product to do to solve his/her problem or offer certain benefits leading to satisfaction. For example, a customer for a motor bike expects the bike to start with a few kicks on the kick peddle and also expects some other functional aspects such as pick-up, maximum speed, engine power and fuel consumption etc.

(ii) Appearance (or) Aesthetics

This includes the style, colour, look, feel, etc. which appeals to the human sense and adds value to the product.

2. Objectives of product design.

Ans :

(i) The overall objective is profit generation in the long run.

(ii) To achieve the desired product quality.

(iii) To reduce the development time and cost to the minimum.

(iv) To reduce the cost of the product.

(v) To ensure producibility or manu-facturability (design for manufacturing and assembly).

3. Explain the benefits of Introducing New Products.

Ans :

The benefits of introducing new product faster:

i) Greater Market Share

The firm with the ability to bring new products to market quickly has several advantages over their slower competitors.

ii) Price Premiums

When a firm is the first to bring a new product to market, it has little or no competition, and can therefore charge premium prices.

iii) Quick Reaction to Competition

To bring new products to market quickly is also in a much better position to respond quickly to a competitor's surprise announcement of the introduction of a new product.

4. What is process strategy?

Ans :

- A process strategy is an organization's approach to process selection for the purpose of transforming resource inputs into goods and services (outputs).
- The objective of a process strategy is to find a way to produce goods and services that meet customer requirement and product specification (i.e., design specifications) within the constraints of cost and other managerial limitations.
- The process selected will have a long-term effect on efficiency and production as well as flexibility, cost, and quality of the goods produced.

5. What are the various steps involved in process planning.

Ans :

The steps in process planning are summarized below :

i) Analyze the part print to get an overall picture of what is wanted.

ii) Make recommendations to or consult with product engineers on product design changes.

iii) List the basic operations required to produce the part to the drawing or specifications.

iv) Determine the most practical and economical manufacturing method and the form of tooling required for each operation.

6. What is Value Analysis?

Ans :

Value Analysis also called as value engineering, value analysis is an important activity that typically occurs jointly between purchasing and methods engineering.

This activity is aimed at modifying the specifications of materials, parts, and products to reduce their costs while reducing their original function. Focus is placed on the value of the product - what function is to be performed by the product - and how that value can be achieved at the lowest cost. Although value

analysis is applied to all phases of the production process, primary attention is devoted to the materials and components going into the product.

7. Advantages of value analysis

Ans :

(i) It is a powerful tool for cost reduction because its basic objective is the identification of unnecessary costs in a product or service and efficiently eliminating them without impairing its quality and efficiency. Reduction in cost will make available more profit to a firm.

(ii) It is a scientific tool for increasing the productivity of a concern because it aims at exploring various alternatives for efficient use of all types of resources in employment and making available goods and services of the kind and quality most wanted by customers at lower and lower costs.

(iii) It helps to keep management abreast of the latest technology and other developments because value analysis aims at examining new methods and techniques of doing things with a view to reducing the cost and increasing the value of the items.

8. Distinguish between value analysis and value engineering.

Ans :

Sl.No.	Value Analysis	Sl.No.	Value Engineering
1.	Value analysis is the application of set of techniques to an existing product with a view to improve its value.	1.	Value Engineering is the application of same set of techniques to a new product at the design stage-project concept or preliminary design when no hardware are exists.
2.	Value Analysis is thus a remedial process.	2.	Value Engineering is thus a preventive process.
3.	Value Analysis is done after the birth of the product	3.	Value Engineering is an early stage process.

9. What are the Responsibilities of Process Planning Engineer?

Ans :

The responsibilities of process planning engineer

i) Prepare various strategies for all planning activities for projects.

ii) Maintain all asset investment plans and ensure compliance to capital expenditure.

iii) Ensure accuracy for all operational requirements for projects and achieve all investment objectives.

iv) Evaluate all system capacity and analyze all production requirement and system deficiencies.

v) Provide support to all operations and extension requests.

10. What are the attributes of a product design?

Ans :

i) Product forms a part of firm's marketing mix.

ii) Product forms the basis for the firm's marketing program.

iii) The perception about the product differ from person to person. The expectations of management, consumers and society with respect to product differ from one another.

iv) Product refers to both goods (tangible form) and services (intangible form).

v) Marketer's objectives can be achieved through production, sales, development and modifications of the product.

Choose the Correct Answers

1. The cost reduction technique in comparison to the worth of a product is known as [b]

   (a) Reverse engineering (b) Value engineering

   (c) Material engineering (d) Quality engineering

2. Value analysis examines the [d]

   (a) Design of every component (b) Method of manufacturing

   (c) Material used (d) All of the above

3. Value analysis is normally applied to [b]

   (a) New products (b) Old products

   (c) Future products (d) Both (a) and (b)

4. Value can be defined as the combination of _____ which ensures the ultimate economy and satisfaction of the customer. [a]

   (a) Efficiency, quality, service and price (b) Efficiency, quality, service and size

   (c) Economy, quality, service and price (d) Efficiency, material, service and price

5. Value is the cost directly proportionate to [b]

   (a) Price (b) Function

   (c) Product Material (d) All of the above

6. Most important benefit to the consumer from efficient production system is: [c]

   (a) He can save money

   (b) He will have product of his choice easily available

   (c) He gets increased use value in the product

   (d) He can get the product on credit.

7. Two important functions that are to be done by Production department are: [c]

   (a) Forecasting (b) Costing

   (c) Scheduling and loading (d) Inspecting

8. Production planning deals with: [a]

   (a) What production facilities is required and how these facilities should be laid out in space available

   (b) What to produce and when to produce and where to sell

   (c) What should be the demand for the product in future?

   (d) What is the life of the product?

9. In Process Planning we plan: [c]

(a) Different machines required

(b) Different operations required

(c) We plan the flow of material in each department

(d) We design the product.

10. In Operation Planning: [a]

(a) The planner plans each operation to be done at work centers and the sequence of operations

(b) Decide the tools to be used to perform the operations

(c) Decide the machine to be used to perform the operation

(d) Decide the materials to be used to produce the product.

Fill in the Blanks

1. _____ deals with the estimation of both the long and short term capacity requirements of a concern.
2. The term _____ means searching to determine i.e., to discover things for oneself.
3. _____ is a process that follows capacity planning and uses medium range forecast.
4. A _____ decides the quantity of each finished product which needs to be completed in each time period.
5. _____ is the process of determining the processing sequence of all the jobs at each work centre or machine.
6. _____ is a process of organizing the production line in such a way that the production flows from one workstation to other without any delay.
7. _____ refers to the physical arrangement of plant and different parts of plant.
8. _____ is a function of deciding the place where the plant must be located for maximizing the operating economy and its effectiveness.
9. _____ is a production management function which deals with the routine problem of maintaining the physical plant in good working condition.
10. Breakdown maintenance is usually seen in _____.

ANSWERS

1. Capacity planning
2. Heuristic
3. Aggregate planning
4. Master Production Schedule
5. Sequencing
6. Line balancing
7. Layout
8. Plant location
9. Maintenance
10. Small factories

Very Short Questions and Answers

1. Define New Product Development.

Ans :

A product is produced so that it can directly (or) indirectly fulfil human wants. Each product at a certain point of time reaches its maturity stage is based on the competition, technology, culture, taste of customers etc. Organization can charge some parts (or) technology used to upgrade the product.

2. Make (or) Buy Decisions

Ans :

Make or buy decisions refer to the extent to which a firm will produce goods or provide services in-house or go for outsourcing (buying or subcontracting).

3. Process Flexibility

Ans :

Process flexibility refers to the degree to which the system can be adjusted to changes in processing requirements due to such factors as changes in product or service design, changes in volume of products produced and changes in technology.

4. Process Design

Ans :

Process design is concerned with the overall sequence of operations required to achieve the design specifications of the product. It specifies the types of work stations that are to be used, the machines and equipments necessary to carry out the processes to produce the product.

5. Make-to-stock

Ans :

Make-to-stock aims to produce products in advance and helps to have ready stock when demands occur. This is applicable for a product which has no specific customer at the time of manufacturing. For example, tooth paste, soap, etc.

UNIT III

Plant Location and Plant Layout: Factors Influencing Plant Location, Break-even Analysis. Single Facility Location Problem, Multi facility Location Problems, Model for Multi Facility Location Problem, Model to Determine X-Coordinates of New Facilities, Model to Determine Y- Coordinate.

Plant Layout - Plant Layout: Introduction, Classification of Layout, Advantages and Limitations of Product Layout, Advantages and Limitations of Group Technology Layout, Layout Design Procedures.

3.1 PLANT LOCATION

Q1. What is meant by Plant Location? Explain the need of plant location.

(OR)

What do you understand by the concept of Plant Location?

(OR)

What is facility location? Explain the need of plant location.

Ans : **(Feb.-17, Aug.-16)**

Meaning

i) Plant location may be understood as the function of determining where the plant should be located for maximum operating economy, and effectiveness.

ii) The selection of a place for locating a plant is one of the problems, perhaps the most important, which is faced by an entrepreneur while launching a new enterprise.

iii) A selection on pure economic considerations will ensure an easy and regular supply of raw materials, labour force, efficient plant layout, proper utilisation of production capacity and reduced cost of production.

iv) An ideal location may not, by itself, guarantee success; but it certainly contributes to the smooth and efficient working of an organisation.

v) A bad location, on the other hand, is a severe handicap for any enterprise and it finally bankrupts it. it is, therefore, very essential that utmost care should be exercised in the initial stages to select a proper place.

Need

The need for the selection of the location may arise under any of the following conditions:

(a) When the business is newly started;

(b) The existing business unit has outgrown its original facilities and expansion is not possible; hence a new location has to be found;

(c) The volume of business or the extent of market necessitates the establishment of branches;

(d) A lease expires and the landlord does not renew the lease;

(e) When a company thinks that there is a possibility of reducing manufacturing cost by shifting from one location to another location; and

(f) Other social or economic reasons; for instance, inadequate labour supply, shifting of the market etc.

3.1.1 Factors Influencing Plant Location

Q2. Enumerate and explain the major factors governing plant location.

(OR)

What are the factors influencing the plant location?

(OR)

Explain the factors influencing the choice of plant location.

(OR)

What are the factors that influence the choice of location of a production unit?

Ans : **(Dec.-19, Feb.-17, Aug.-16)**

i) Proximity of the plant to the market.

ii) Easy accessibility of plant to labour, raw material and cost.

iii) The land for plant should be suitable enough to fulfill the present and future expansion needs. In addition to this, cost of land and development land should be considered.

iv) The infrastructure facilities such as water, electricity, banking and finance should be available at optimum level.

v) Provision for the disposal of waste, overflow treatment etc.

vi) The union activities and political influences should also be considered.

vii) Climatic and seasonal conditions such as rainfall, temperature, humidity, dust count, etc must be considered.

viii) Availability of fire fighting facilities, surety, police force etc.

ix) Demographic considerations such as trained manpower, educational institutions, living standard, income level, population etc.

x) Access to residential and official accommodation or rental basis.

xi) Assistance from government, grant, subsidy and tax structure.

xii) Features of soil such as capacity to bear load, drainage capacity etc.

xiii) Existence of complementary and competing industries.

3.2 BREAK-EVEN ANALYSIS

Q3. Explain briefly about Break-even Analysis.

(OR)

Discuss about break even chart graphically.

Ans : **(May-19, Aug.-17)**

Break even analysis implies that at some point in the operations, total revenue equals total cost. Break even analysis is concerned with finding the point at which revenues and costs agree exactly. It is called 'Break-even Point'. The fig. portrays the Break Even Chart :

Break even point is the volume of output at which neither a profit is made nor a loss is incurred. The Break Even Point (BEP) in units can be calculated by using the relation :

$$BEP = \frac{\text{Fixed Cost}}{\text{Contribution per unit}} = \frac{\text{Fixed Cost}}{\text{Selling Price - Variable Cost per unit}}$$

$$= \frac{F}{S - V} \text{ units}$$

The Break Even Point (BEP) in Rs. can be calculated by using the relation :

$$BEP = \frac{\text{Fixed Cost}}{\text{PV Ratio}} = \frac{\text{Fixed Cost}}{\left\{\frac{\text{Sales} - \text{Variable Cost}}{\text{Sales}}\right\}}$$

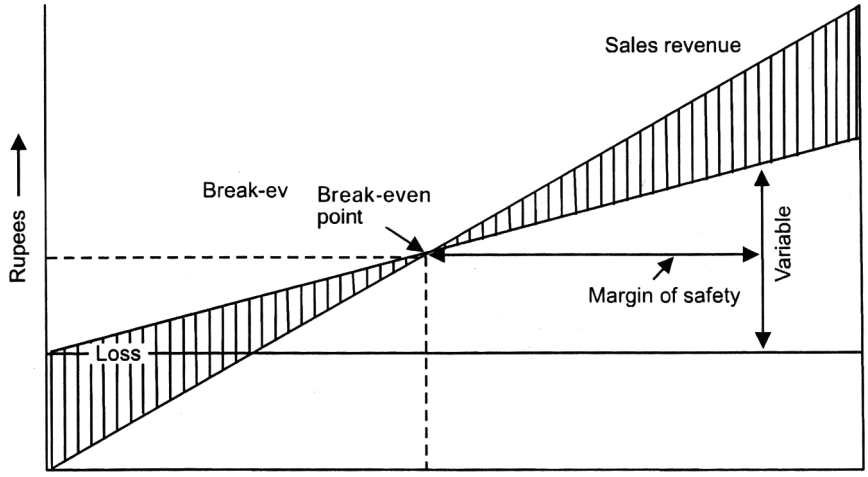


Fig. : Units of output or percentage of capacity

Plotting the break even chart for each location can make economic comparisons of locations. This will be helpful in identifying the range of production volume over which location can be selected.

PROBLEMS

1. Potential location A, B and C have the cost structures shown for producing a product expected to sell at Rs. 100 per unit. Find the most economical location for an expected volume of 2,000 units/year. Also determine the range of annual volume of production for which each of the locations A, B and C would be most economical.

Location	Fixed Cost	Variable Cost per Unit (Rs)
A	25,000	50
B	50,000	25
C	80,000	15

Sol :

(a) To determine the most economical location for an expected annual volume of production of 2,000 units, calculate the total cost of production at each of the location for the annual production volume Q = 2,000 nos.

$$\text{Total Cost} = \begin{pmatrix}\text{Fixed cost}\\ \text{per annum}\end{pmatrix} + \begin{pmatrix}\text{Variable cost}\\ \text{per unit}\end{pmatrix} + \begin{pmatrix}\text{Quantity}\\ \text{produced}\end{pmatrix}$$

Total cost at location A, $TC_A = (FC)_A + (V.C)_A \times Q$

$TC_A = 25,000 + 50 \times 2000$

$= 25,000 + 1,00,000 = \text{Rs. } 1,25,000$

Similarly,

Total cost at location B, $TC_B = 50,000 + 25 \times 2,000$

$= 50,000 + 50,000 = \text{Rs. } 1,00,000$

Total cost at location C, $TC_C = 80,000 + 15 \times 2,000$

$= 80,000 + 30,000 = \text{Rs. } 1,10,000$

2. Location A would result in fixed costs of 3,00,000 variable costs of 63 per unit and revenues of 68 per unit.

Annual fixed costs at location B are 8,00,000 with variable costs of 32 per unit and revenue of 68 per unit. Sales volume is estimated to be 25,000 units / year. Which location is most attractive.

Sol :

Total cost of production at location A = Fixed cost + Variable cost per unit × Sales value

= 3,00,000 + 63 × 25,000

= 3,00,000 + 15,75,000 = 18,75,000

Total cost of production at location B = 8,00,000 + 32 × 25,000

= 8,00,000 + 8,00,000 = 16,00,000

Total revenue at location A = 68 × 25,000 = 17,00,000

Total revenue at location B = 68 × 25,000 = 17,00,000

Total profit at location A = 17,00,000 – 18,75,000

= –1,75,000 (i.e., loss of 1,75,000)

Total profit at location B = 17,00,000 – 16,00,000 = 1,00,000

Since location 'B' gives a profit of 1,00,000 as compared to a loss of 1,75,000 at location A, location B is the best choice.

3. XYZ Company is considering an additional facility. The company is heavily dependent on water transportation. Therefore it has narrowed its choice of location to three port facilities in Mumbai, Karwar and Machilipatnam. On the basis of the following data, which location is preferable ?

Relevant Factors	Mumbai	Karwar	Machilipatnam
Variable cost per unit	` 18	` 20	` 19.50
Fixed cost per year	` 15 lakhs	` 30 lakhs	` 40 lakhs
Price per unit	` 300	` 300	` 300
Volume (unit/year)	3 lakhs	2.5 lakhs	3.25 lakhs

Sol : **(Dec.-18)**

The most economical port location among the three (i.e., Mumbai, Karwar, Machilipatnam) can be determined by calculating the total cost incurred at each location in an year.

Total cost = [Fixed Cost Per Year] + [Variable Cost Per Year] × [Volume (Units/Year)]

OR

TC = FC + (VC + Volume)

(i) Total cost incurred at location Mumbai

TC = FC + (VC + Volume)

= 15,00,000 + [18 × 3,00,000]

= 15,00,000 + 54,00,000

= ` 69,00,000

(ii) Total cost incurred at location Karwar

TC = 30,00,000 + [20 × 2,50,000]

= 30,00,000 + 50,00,000

= ` 80,00,000

(iii) Total cost incurred at location Machilipatnam

TC = 40,00,000 + [19.50 × 3,25,000]

= 40,00,000 + 63,37,500

= ` 1,03,37,500

If we compare the total costs incurred at the three locations.

$TC_{(Mumbai)} < TC_{(Karwar)} < TC_{Machilipatnam}$

The location Mumbai is said to be the most economical one among the three as it incur less cost compared to the other locations. Therefore, location 'Mumbai' is preferable.

4. From the following data, you are required to calculate :

(i) The amount of fixed expenses

(ii) The number of units to break-even

(iii) The number of units to earn a profit of ` 40,000

The selling price per unit can be assumed at ` 100.

The company sold in two successive periods 7,000 units and 9,000 units and has incurred a loss of ` 10,000 and earned ` 10,000 as profit respectively.

Sol : **(May-19)**

Sales	Project-I	Project-II
Profit/Loss (–)	` 7,00,000 (–) ` 10,000	` 9,00,000 (+) ` 10,000

Since

1 Unit = 100

7000 Units = ` 7,00,000

9000 Units = ` 9,00,000

Thus, for an additional sales of ` 2,00,000, there is an additional contribution of ` 20,000 which has wiped off the loss of ` 10,000 of period-I and earned a profit of ` 10,000 in period-II.

$$\text{P/V Ratio} = \frac{\text{Changes in Contribution}}{\text{Changes in Sales}} \times 100$$

$$= \frac{20,000}{2,00,000} \times 100 = 10\%$$

$$\text{Contribution of period-I} = 7,00,000 \times \frac{10}{100} = ` 70,000$$

Loss of period-I (given) = ` 10,000

(i) Fixed Cost = Contribution $\pm$ Profit / Loss

or

Contribution = Fixed Cost $\pm$ Profit / Loss

Fixed Cost = ` 70,000 + ` 10,000

= ` 80,000

(ii) $$\text{Break-even Point} = \frac{\text{Fixed Cost}}{\text{P/V Ratio}} = \frac{80,000}{\frac{10}{100}}$$

$$= \frac{80,000 \times 100}{10} = ` 8,00,000$$

$$\text{Number of units of break-even} = \frac{\text{Break-even Sales}}{\text{Selling Price per Unit}}$$

$$= \frac{8,00,000}{100} = 8,000 \text{ units}$$

(iii) Number of units required to earn a profit of ` 40,000

$$= \frac{\text{Fixed Cost + Desired Profit}}{\text{P/V Ratio}}$$

$$= \frac{80,000 + 40,000}{10\%}$$

$$= \frac{1,20,000 \times 100}{10} = ` 12,00,000$$

5. A company is making a loss of ` 40,000 and relevant information is as follows :

Sales ` 1,20,000; Variable Costs ` 60,000; Fixed costs ` 1,00,000.

Loss can be made good either by increasing the sales price or by increasing sales volume.

What are Break-even sales if,

(i) Present sales level is maintained and the selling price in increased.

(ii) If present selling price is maintained and the sales volume is increased. What would be sales if a profit of ` 1,00,000 is required ?

Sol : **(May-19)**

Given that,

Sales = ` 1,20,000

Variable costs = ` 60,000

Fixed costs = ` 1,00,000

Loss = ` 40,000

Calculation of Break Even Sales

$$\text{BEP (in sales)} = \frac{\text{Fixed Cost}}{\text{Contribution}} \times \text{Sales}$$

Contribution = Sales – Variable Cost

Contribution = 1,20,000 – 60,000

= 60,000

$$\text{BEP (in Sales)} = \frac{1,00,000}{60,000} \times 1,20,000$$

= 2,00,000

(i) Break even sales if present sals level is maintained and the selling price is increased.

(ii) Break even sales if present selling price is maintained and sales volume is increased.

Note :

Question No. (i) and (ii) cannot be solved because.

- Number of units and sales price per unit is not given in the problem.
- In Question No. (i), to what extent selling price is to be increased is not mentioned.
- In Question No. (ii), to what extent sales volume is to be increased is not mentioned.

(iii) **Sales if a Profit of 21,00,000 is Required**

$$\text{Sales at Desired Profit} = \frac{\text{Fixed Cost + Desired Profit}}{\text{Selling Price – Variable Cost}} \times \text{Sales}$$

$$= \frac{1,00,000 + 1,00,000}{1,20,000 - 60,000} \times 1,20,000$$

$$= \frac{2,00,000}{60,000} \times 1,20,000$$

= 4,00,000

6. The following are the potential sites for setting up of Ice factory. Using the following details, decide which site can be picked up for setting up of Ice factory.

Annual demand is 3,000 units

Selling price per unit is ` 300/-

Sites	Fixed cost (`)	Variable cost (`)
Mumbai	**50,000**	**135**
Ahemadabad	**1,00,000**	**110**
Bangalore	**1,20,000**	**120**

Sol : **(Dec.-19)**

Given that,

Annual demand = 3,000 units

Selling price per nit = ` 300

Mumbai

Fixed cost per annum = ` 50,000

Variable cost per unit = ` 135

Ahemadabad

Fixed cost per annum = ` 1,00,000

Variable cost per unit = ` 110

Bangalore

Fixed cost per annum = ` 1,20,000

Variable cost per unit = ` 120

For each site, calculating total cost by using the following formula,

Total cost = Fixed cost + (Variable cost per unit × Volume)

(or)

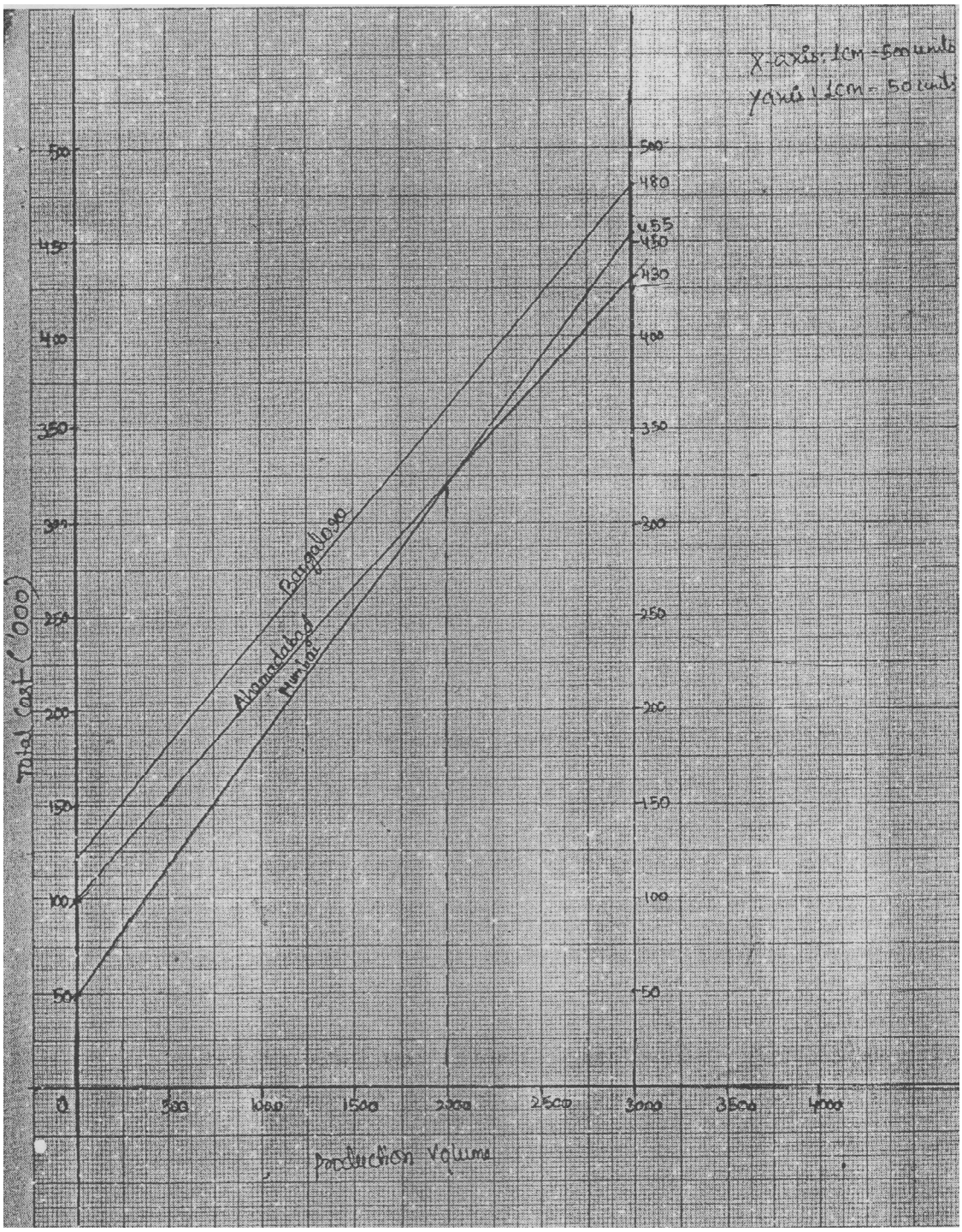
TC = FC + (VC + V)

Annual demand or Volume = 3,000 units (Given)

Sites	Total Cost (TC)
Mumbai	50,000 + (135 × 3,000) = 4,55,000
Ahemadabad	1,00,000 + (110 + 3,000) = 4,30,000
Bangalore	1,20,000 = (120 × 3,000) = 4,80,000

It is clear from the above table that the cost of Ahemadabad is minimum. Therefore, Ahemadabad must be selected for locating the plant.

Using the information given in the above table, a more generalized graph can be drawn. This graph act as a ready made chart to find out different ranges of production volumes based on which best site can be selected.



Range	Desirable Site
$O \leq Q \leq 2,000$	Mumbai
$2,000 \leq Q \leq 3,000$	Ahemababad
$3,000 \leq Q$	Bangalore

7. From the following data, you are required to calculate:

(i) The amount of fixed expenses.

(ii) The number of units to break even.

(iii) The number of units to earn a profit of Rs. 40,000. The selling price per unit can be assumed at Rs. 100. The company sold in two successive periods 7,000 units and 9,000 units and has incurred a loss of Rs. 10,000 and earned Rs. 10,000 as profit respectively.

Ans : **(April-23)**

(a) Computation of Fixed cost

Operating Income = Contribution margin – Fixed Cost

Contribution margin (%) = Change in Profit / Change in sale

= (20,000 / 20,000) 100 = 100%

Contribution margin Per unit = Selling price per unit × Contribution margin ratio

= Rs. 10 × 100% = Rs. 10

Contribution margin at 7000 units sold

Contribution margin = 7000 units × Rs. 10 = Rs. 70000

Operating loss = Rs. 10,000

Rs. 70000 = Fixed cost – Rs. 10,000

Fixed cost = Rs. 8000

Fixed cost 9000 units sold

Contribution margin = 9000 units × Rs. 10 = Rs. 90,000

Net income Rs. 10000

Fixed cost = Rs.80,000

b) Break even point

Fixed cost / Contribution margin per unit

= Rs. 80000 / Rs. 100 = 8000 units

c) Targeted Profit = Rs. 40,000

Required sales = (Fixed cost + Targeted Profit) / Contribution margin Per unit

= (Rs.80,000 + Rs. 40,000) / Rs. 100 = 12,000 units.

8. A company is making a loss of Rs. 40,000 and relevant information is as follows: Sales Rs. 1,20,000; Variable Costs Rs. 60,000; Fixed costs Rs. 1,00,000. Loss can be made good either by increasing the sales price or by increasing sales volume. What are Break even sales if

(i) Present sales level is maintained and the selling price is increased.

(ii) If present selling price is maintained and the sales volume is increased. What would be sales if a profit of Rs. 1,00,000 is required?

Ans : **(April-23)**

Break even point = $\frac{\text{Contribution}}{\text{Fixed Cost}}$

Sales	1,20,000
Variable Costs	60,000
Contribution	60,000
Fixed Cost	100,000
Net profit(Loss)	– 40.000

Sales Level Is maintained and selling price

a) Increased

So no changes in variable cost

Sales need to be increased by 40,000 that is 1,20,000 – 40,000 = 1,60,000

Sales	1,60,000
Variable Costs	60,000
Contribution	1,00,000
Fixed Cost	1,00,000
Net profit (Loss)	0

Selling price maintained and sales volume

b) Increased

Sales = 1,20,000

Variable Costs = 60,000

Variable Cost 50%

Variable cost is 50% of sales

Contribution % is 50% of sales

Contribution required for break even is 1,00,000

Sales = 1,00,000/50% = 2,00,000

Sales	2,00,000	100%
Variable Costs	1,00,000	50%
Contribution	1,00,000	50%
Fixed Cost	1,00,000	
Net profit (Loss)	0	

Breakeven sales = 2,00,000

Selling price maintained and sales volume increased and targeted profit 1,00,000

Sales = (1,00,000 + 1,00,000)/50% = 4,00,000

Sales	4,00,000	100%
Variable Costs	2,00,000	50%
Contribution	2,00,000	50%
Fixed Cost	1,00,000	
Net profit(Loss)	1,00,000	

Sales for 1,00,000 profits = 4,00,000

3.3 Single Facility Location Problem

Q4. Explain about Single Facility Location Problem.

Ans :

Meaning

The single new facility location problem is one of the easiest method to solve facility location problems. Its main objective is to locate a single new facility with respect to existing facilities in such a way that the cost of transporting material between new facility and existing facilities get minimized.

Examples

Some of the examples of single new facility location problem are,

- For existing markets, locating new warehouses
- For providing better service to existing markets
- For serving cluster of towns in order to construct regional airports etc.

Generally, we follow rectilinear distance for such decision. The rectilinear distance between any two points whose coordinates are (X_1, Y_1) and (X_2, Y_2) is given by the following formula.

$$d_{12} = |X_1 - X_2| + |Y_1 - Y_2|$$

PROBLEMS

9. A group company has plants in six different locations, whose co-ordinates in kilo-meter are: (100, 200), (200, 200), (200, 500), (300, 500), (400, 300) and (500, 100). The company wants locate a centralized raw material warehouse, from which the quantity of materials transported to the plants 1, 2, 3, 4, 5 and 6, in tones are 1000, 1200, 800, 2000, 1800 and 900, respectively. Find the optimal location for the warehouse.

Sol :

The data of the problem are shown below.

Plant	1	2	3	4	5	6
Coordinates	100, 200	200, 200	200, 500	300, 500	400, 300	500, 100
Weight (tons)	1000	1200	800	2000	1800	900

Determination of X coordinate of the warehouse

The details of the calculation of the X-coordinate of the warehouse are shown below.

Existing Facility	X Coordinate	Weight	Σ Weight
1	100	1000	1000
2	200	1200	2200
3	200	800	3000
4	300	2000	5000
5	400	1800	6800
6	500	900	7700
Σ Weight = 7700			

$$\frac{\Sigma \text{ Weight}}{2} = \frac{7770}{2} = 3850$$

Optimal X coordinate of the warehouse (X*) = 300

Determination of Y coordinate of the warehouse

The workings to determine the Y coordinate of the warehouse are shown below.

Existing Facility	Y Coordinate	Weight	Σ Weight
6	100	900	900
1	200	1000	1900
2	200	1200	3100
5	300	1800	4900
3	500	800	5700
4	500	2000	7700
Σ Weight = 7700			

$$\frac{\sum \text{Weight}}{2} = \frac{7700}{2} = 3850$$

Optimal Y coordinate of the warehouse (Y*) = 300

(X*, Y*) of the warehouse = (300, 300)

10. An organization has seven plants in seven different locations, whose co-ordinates in kilometer are: (100, 300), (200, 500), (300, 600), (600, 400), (500, 300), (300, 200) and (200, 100). The company wants locate another plant, from which the quantity of materials transported to the plants in tones are 1000, 2500, 1000, 2700, 1500, 1200 and 1800, respectively. Find the optimal location for the new plant.

Sol :

The data of the problem are shown below.

Plant	1	2	3	4	5	6	7
Coordinates	100, 300	200, 500	300, 600	600, 400	500, 300	300, 200	200, 100
Weight (tons)	1000	2500	1000	2700	1500	1200	1800

Determination of X coordinate of the new plant : The details of the calculation of the X-coordinate of the new plant are shown below.

Existing Facility	X Coordinate	Weight	Σ Weight
1	100	1000	1000
2	200	2500	3500
7	200	1800	5300
3	300	1000	6300
6	300	1200	7500
5	500	1500	9000
4	600	2700	11700
Σ Weight = 11700			

$$\frac{\Sigma \text{ weight}}{2} = \frac{11700}{2} = 5850$$

Optimal X coordinate of the new plant (X) = 300

Determination of Y coordinate the new plant

The workings to determine the Y coordinate of the new plant are shown below.

Existing Facility	Y Coordinate	Weight	Σ Weight
7	100	1800	1800
6	200	1200	3000
1	300	1000	4000
5	300	1500	5500
4	400	2700	8200
2	500	2500	10700
3	600	1000	11700
Σ Weight = 11700			

$$\frac{\Sigma \text{ weight}}{2} = \frac{11700}{2} = 5850$$

Optimal Y coordinate of the new plant (Y*) = 400

(X*, Y*) of the new plant = (300, 400)

11. A new computer peripherals unit is to be set up. The unit will supply computer parts to five existing computer assembly units located as shown in the following table

Location	Coordinates	Volume Per Day
A	**200, 400**	**180**
B	**400, 250**	**150**
C	**300, 100**	**300**
D	**150, 300**	**200**
E	**180, 210**	**250**

Determine the new location by centroid method

Sol

Given

Location	Volume Per Day	Co-ordinates (km)	
		X_1	Y_1
A	180	200	400
B	150	400	250
C	300	300	100
D	200	150	300
E	250	180	210

Location	Volume Per Day	Coordinates (Km)		Weighted	Volume of
		X_1	Y_1	$V \times X_1$	$V \times Y_1$
A	180	200	400	36,000	72,000
B	150	400	250	60,000	37,500
C	300	300	100	90,000	30,000
D	200	150	300	30,000	60,000
E	250	180	210	45,000	52,500
Total	**1,080**	**1,230**	**1,260**	**2,61,000**	**2,52,000**

The coordinates of the location of the new facility are given as,

$$\bar{X} = \frac{\Sigma v_1 x_1}{\Sigma v_1} = \frac{2,61,000}{1,080} = 242$$

$$\bar{Y} = \frac{\Sigma v_1 x_1}{\Sigma v_1} = \frac{2,52,000}{1,080} = 233.3$$

The new location should be at (242, 233.3) km from the manufacturing company.

12. A particular utility provider is trying to find the best location for a solid waste disposal station. At present four locations / are located at the following coordinate locations: Station I (4,12), Station II (6, 5), Station III (11, 8) and Station IV (1, 13).

The number of loads hauled monthly from these four stations to the master stations will be 400, 250, 300 and 450 units, respectively. Find out the best location for the master station and give its coordinates.

Sol : **(Aug.-21)**

Determination of X-Coordinate of the Master Station

Existing Station	X-Coordinate	Weight (Units)	Σ Cumulative Weight (Units)
IV	1	450	450
I	4	400	850
II	6	250	1100
III	11	300	1400

Σ Weight (units) = 1400

$$\frac{\Sigma \text{ Weight}}{2} = \frac{1400}{2} = 700$$

The median location corresponding to the cumulative weight is 700 $\left(\text{i.e.,}\frac{1400}{2} = 700\right)$. Since the cumulative weight first exceeds 850 at X = 4, optimal X coordinate of the master station is X = 4.

Determination of X-Coordinate of the Master Station

Existing Station	Y-Coordinate	Weight (Units)	Σ Cumulative Weight (Units)
II	5	250	250
III	8	300	550
I	12	400	950
IV	13	450	1400

Σ Weight (units) = 1400

$$\frac{\Sigma \text{ Weight}}{2} = \frac{1400}{2} = 700$$

The median location corresponding to the cumulative weight is 700 $\left(\text{i.e.,}\frac{1400}{2} = 700\right)$. Since the cumulative weight first exceeds 950 at Y = 12, optimal Y coordinate of the master station is Y = 12.

∴ Optimal (X, Y) of the master station = (4, 12).

3.4 Multi facility Location Problems

Q5. What is Multi facility Location Problems? Explain its formulation.

Ans : **(April-23)**

Meaning

The multi-facility location problem is used to locate several new facilities with respect to existing facilities in such a way that the cost of transporting material from new facilities to existing facilities get minimized.

Formulation

The multifacility location problem is formulated as follows:

Let,

m be the number of existing facilities which are located at known distinct points P_1, P_2, P_3, ..., P_m in the X–Y plane, and

n be the number of new facilities which are to be located at points X_1 X_2, X_3, ..., X_n in the X-Y Plane.

$d(X_j, P_i)$ be the distance between the locations of the new facility j and the existing facility i.

$d(X_j X_k)$ be the distance between the locations of the new facilities j and k.

w_{ji} be the annual cost per unit distance between the new facility j and the existing facility i.

V_{jk} be the annual cost per unit distance between the new facilities j and k.

If the new facilities are located at $X_1 X_2, X_3,..., X_n$, then the total transportation cost is as given below.

$$f(X_1, X_2, ..., X_n) = \sum_{i \le j < k < n} v_{jk}\, d(X_j, X_k) + \sum_{j=1}^{n}\sum_{i=1}^{m} w_{ji}\, d(X_j, P_i) \quad ...(1)$$

The objective of the multifacility location problem is the selection of $X_1^*, X_2^*, ..., X_n^*$ of the new facilities such that total annual cost is minimized.

The objective function consists of two cost components: (i) total cost due to transportation between the new facilities, (ii) total cost due to transportation between the new facilities and the existing facilities. If all the terms of v_{jk} are zero, then the first component of the objective function will be zero and the modified objective function is as stated in the following.

$$f(X_1 X_2, X_3, X_{„}) = \sum_{j=1}^{n}\sum_{i=1}^{m} w_{ji}\, d(X_j, P_i) \quad (2)$$

i.e.

$$f(X_j) = \sum_{j=1}^{n} f_j(X_j)$$

where

$$f_j(X_j) = \sum_{j=1}^{n} w_{ji}\, d(X_j, P_i)$$

This corresponds to the location of a single new facility in which location of any new facility will not have effect on the location of another new facility. Hence, determining location for the new facilities can be treated as n single facility location problems. Here, the data for the existing facilities will be associated with each of the new facilities to determine the location for each of the new facilities. The single facility location procedure is to be repeated n times to determine the locations of a new facilities.

3.4.1 Model for Multi facility Location Problem

3.4.1.1 Model to Determine X, Y Coordinates of New Facilities

Q6. Explain the Model for Multi facility Location Problem.

Ans :

Let us assume the rectilinear distance between all the facilities.

X_j = (X_j, y_j) is the location of the jth new facility.

P_i = (a_i, b_j) is the location of the ith existing facility.

$d(X_j, X_k)$ = the distance between new facilities j and k.

$d(X_j, P_i)$ = the distance between the new facility j and the existing facility i.

Therefore,

$$d(X_j, X_k) = |x_j - x_k| + |yj - y_k| \quad (3)$$

$$d(X_j, P_i) = |x_j - a_i| + |y_j - b_i| \quad (4)$$

By substituting Eqs. (3) and (4) in Eq. (1), we get the following.

$$f(X_1, X_2, ..., X_n) = f_1(x_1, x_2, x_n) + f_2(y_1, y_2, ..., y_n) \quad (5)$$

where,

$$f_1(x_1, x_2, ..., x_n) = \sum_{1 \le j < k \le n} v_{jk} |x_j - x_k| + \sum_{j=1}^{n} \sum_{i=1}^{m} w_{ji} |x_j - a_i| \quad (6)$$

$$f_2(y_1, y_2, ...y_n) = \sum_{1 \le j < k \le n} v_{jk} |y_j - y_k| + \sum_{j=1}^{n} \sum_{i=1}^{m} w_{ji} |y_j - b_i| \quad (7)$$

The functions f_1 and f_2 represent the total cost of transportation in X direction and Y direction, respectively.

The objective is to minimize $f(X_1 X_2, ..., X_n)$. Therefore,

$$\min f(X_1, X_2, ..., X_n) = \min (f_1(x_1, x_2, ..., x_n) + f_2(y_1, y_2, ..., y_n)\}$$

$$= \min f_1(x_1, x_2, ..., x_n) + \min f_2(y1, y_2, ..., y_n)$$

So, if we can establish a technique to find optimal X-coordinates of the new facilities, the same technique can be used to find optimal /-coordinates of the new facilities.

Now, let us develop a linear programming model to determine the optimal X-coordinates of the new facilities.

Consider the function, Minimize $f_1(x_1, x_2, ..., x_n)$.

Minimize $f_1(x_x, x_2, ..., x_n) = \min \left\{ \sum_{1 \le j < k \le n} v_{jk} |x_j - x_k| + \sum_{j=1}^{n} \sum_{i=1}^{m} w_{ji} |x_j - a_i| \right\}$ as given in Eq. (6).

In the above function, both the components are in absolute form which are known to be non-linear. So, these are to be transformed into linear form.

Q7. Explain the model to determine X and Y co-ordinates of new facilities.

Ans :

1. Model to Determine X Co-ordinate of New Facilities

Based on the above transformation technique, Eq. (6) is transformed as follows: (Eq. (6) is reproduced here for quick reference).

$$\text{Minimise} \sum_{1 \le j < k \le n} v_{jk} (p_{jk} + q_{jk}) + \sum_{j=1}^{n} \sum_{i=1}^{m} w_{ji} (r_{ji} + s_{ji})$$

Subject to

$$x_j - x_k - p_{jk} + q_{jk} = 0, \quad 1 \le j < k \le n$$

$$x_j - a_i - r_{ji} + s_{ji} = 0, \; i = 1, 1, 2, ..., m$$

$$j = 1, 2, ..., n$$

$$y_j \ge 0,$$

$$r_{ji}, s_{ji} \geq 0, i = 1, 2, \ldots, n$$

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

x_j is unrestricted in sign, $j = 1, 2, \ldots, n$

$$p_{jk}, q_{jk} = 0,\ 1 \leq j < k \leq n$$

$$r_{ji}, s_{ji} = 0,\ i = 1, 2, \ldots, m$$

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

The unrestricted nature can be avoided by the following assumption.

If we have any coordinate of the existing facilities in the second or third or fourth quadrants, then we have to suitably alter the coordinates such that the points $P_1 P_2, P_3, \ldots, P_m$ lie in the first quadrant. Then, we can have the constraint $x_j \geq 0$ for all j instead of unrestricted nature in sign for x_js.

One can notice that except the last two sets of multiplicative constraints, the model is in linear form.

In the above model, for any basic feasible solution, if p_{jk} is in the basic feasible solution, q_{jk} will not be in the basic feasible solution and vice versa; likewise, if r_{ji} is in the basic feasible solution, s_{ji} will not be in the basic feasible solution and vice versa. The coefficients of the variables p_{jk} is –1 times the coefficients of the variable q_{jk}. So the two variables are linearly dependent. Likewise, r_{ji} and s_{ji} are linearly dependent. But a basis consists of linearly independent vectors (variables). Hence, the p_{jk} and q_{jk} will not be available in the basis simultaneously. Similarly, r_{jk} and s_{ji} will not be available in the basis simultaneously.

Based on the above discussion, the last two multiplicative constraint sets can be deleted from the model.

So, the final model to determine the X-coordinates of the new facilities is given below :

$$\text{Minimise} \quad \sum_{1 \leq j < k \leq n} v_{jk} (p_{jk} + q_{jk}) + \sum_{j=1}^{n} \sum_{i=1}^{m} w_{ji} (r_{ji} + s_{ji})$$

Subject to

$$x_j - x_k - p_{jk} + q_{jk} = 0,\ 1 \leq j < k \leq n$$

$$x_j - a_i - r_{ji} + s_{ji} = 0,\ i = 1, 2, \ldots, m$$

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

$$p_{jk}, q_{jk} \geq 0,\ 1 \leq j < k \leq n$$

$$r_{ji}, s_{ji} \geq 0,\ i = 1, 2, \ldots, m$$

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

$$x_j \geq 0^*,\ j = 1, 2, \ldots, n.$$

(If all $P_1, P_2, P_3, \ldots, P_m$ are in the first quadrant; even if they are not in the first quadrant, one can suitably modify them such that all are in the first quadrant.)

2. Model to Determine Y Co-ordinate of New Facilities

Consider the function which is given in Eq. (7)

$$f_2 (y_1, y_2, \ldots, y_n) = \sum_{1 \leq j < k \leq n} v_{jk} \left| y_j - y_k \right| + \sum_{j=1}^{n} \sum_{i=1}^{m} w_{ji} \left| y_j - b_i \right| \qquad \ldots(7)$$

Use y_j, y_k, p_{jk} and q_{jk} as data set for transforming the first term of the function 7 into linear form.

Similarly, assume y_j, b_i, r_{ji} and s_{ji} as data set for transforming the second term of the Eq. (7) into linear form. Based on these guidelines, a model to determine the Y-coordinates of the new facilities is given below.

Minimize $$\sum_{1\le j<k\le n} v_{jk}\left(p_{jk}+q_{jk}\right)+\sum_{j=1}^{n}\sum_{i=1}^{m} w_{ji}\left(r_{ji}+s_{ji}\right)$$

Subject to

$$y_j - y_k - p_{jk} + q_{jk} = 0,\ 1 \le j < k \le n$$

$$y_j - b_i - r_{ji} + s_{ji} = 0,\ i = 1,2,....,m$$

$$j = 1, 2, ..., n$$

$$p_{jk}, q_{jk} \ge 0,\ 1 \le j < k \le n$$

$$r_{ji},\ s_{ji} \ge 0,\ i = 1,2, ..., m$$

$$j = 1, 2, ..., n$$

y_j is unrestricted in sign, $j = 1, 2, ..., n$

$$p_{jk}\ q_{jk} = 0,\ 1 \le j < k \le n$$

$$r_{ji}\ s_{ji} = 0,\ i = 1, 2, ..., m$$

$$j = 1, 2,...., n$$

The unrestricted nature can be avoided by the following assumption.

If we have any coordinate of the existing facilities in the second or third or fourth quadrants, then we have to suitably alter the coordinates such that the points P_1, P_2, P_3, ..., P_m lie in the first quadrant. Then, we can have the constraint $y_j \ge 0$ for all j instead of unrestricted nature in sign for y_js.

One can notice that except the last two sets of multiplicative constraints, the model is in linear form.

As explained in the earlier model, the last two sets of multiplicative constraints can be ignored. So, the final model to determine the y-coordinates of the new facilities is given below :

Minimise $$\sum_{1\le j<k\le n} v_{jk}\left(p_{jk}+q_{jk}\right)+\sum_{j=1}^{n}\sum_{i=1}^{m} w_{ji}\left(r_{ji}+s_{ji}\right)$$

Subject to

$$y_j - y_k - p_{jk} + q_{jk} = 0,\ 1 \le j < k \le n$$

$$y_j - b_i - r_{ji} + s_{ji} = 0,\ i = 1, 2,...., m$$

$$j = 1, 2, ..., n$$

$$p_{jk}, q_{jk} \ge 0,\ 1 \le j < k \le n$$

$$r_{ji}, s_{ji} \ge 0,\ i = 1,2,....,m$$

$$j = 1, 2, ..., n$$

$$y_j \ge 0,\ j = 1, 2, ... n$$

13. For the location of an engineering plant three sites A, B and C are under consideration. The costs of various factors and other relevant aspects in respect of each site are listed below. It is required to make the final selection of the site.

Factors	Site A	Site B	Site C
Cost of land including	50,000	49,000	45,000
development of land in Rs.000			
Buildings in Rs.000	45,000	42,000	48,000
Labour charges Rs.	4,00,000	2,50,000	3,20,000
Power in Rs.	1,00,000	90,000	1,00,000
Water in Rs.	50,000	10,000	30,000
Cost of raw materials and other	10,000	8,000	8,500
supplies in Rs.			
Freight incoming in Rs.	3,00,000	5,00,000	5,20,000
Freight outgoing in Rs.	2,00,000	3,50,000	4,00,000
Local taxes in Rs.	50,000	Nil	30,000
Other factors			
Cost of living	Very high	Low	Moderate
Housing facilities	Excellent	Poor	Good
Community' facilities	Excellent	Poor	Good
Community attitude	Good	Encouraging	Indifferent

Use composite measure method approach in evaluating the site and justify your choice the site.

Ans : **(Oct.-22)**

The observation of quantitative factors reveals that site B avails substantial cost advantage over site A and site C. But in view of the qualitative factors site A is preferable.

The above mentioned illustration is the most simplified version of the decision. In reality, the ascertainment of various costs largely depends on the types of production, scale of production, type of factory building, selection of plant and machines, plant layout, provisions of plant services and so on. It is also relatively difficult to quantify the qualitative considerations. However, the scientific analysis helps in arriving at good decisions.

3.5 PLANT LAYOUT

3.5.1 Introduction

Q8. Define the term Plant Layout. Explain the characteristics of an ideal plant layout.

(OR)

What is facility layout?

Ans : **(May-19, Feb.-12)**

Meaning

A plant layout refers to the arrangement of machinery, equipment and other industrial facilities – such as receiving and shipping departments, tool rooms, maintenance rooms and employee amenities - for the purpose of achieving the quickest and smoothest production at the least cost. The subject of plant layout not only covers the initial layout of machines and other facilities but encompasses improvement in, or revision of, the existing layout in the light of subsequent developments in the methods of production.

Characteristics

Following are the characteristics of an ideal facility/plant layout:

1. It must ensure that production takes place smoothly.
2. It must make optimum use of available space.
3. It must have enough space between machines to ensure smooth flow of materials and workers.
4. It must facilitate minimum handling of product from one operation to another operation.
5. It must provide facilities like water, ventilation, rest room etc., in order to protect the health of workers.
6. It must be able to bring change in the policies of management.
7. It must have convenient location for store to ensure easy access.
8. It must facilitate workers coordination.

Q9. Explain the objectives of plant layout.

(OR)

Discuss the objectives of a good layout.

(May-19, Feb.-12)

(OR)

What are the objectives of plant layout?

Ans : **(Aug.-21)**

The objectives of a good plant layout are :

i) Provide enough production capacity
ii) Reduce material handling costs
iii) Reduce congestion that impedes the movement of people or material
iv) Reduce hazards to personnel
v) Utilize labour efficiently
vi) Increase employee morale
vii) Reduce accidents
viii) Utilize available space efficiently and effectively
ix) Provide for volume and produce flexibility
x) Provide ease of supervision
xi) Facilitate co-ordination and face-to-face communication where appropriate
xii) Provide for employee safety and health
xiii) Allow ease of maintenance
xiv) Allow high machine/equipment utilisation
xv) Improve productivity.

Q10. What are the principles of plant layout?

Ans : **(May-19)**

The Principles of Plant Layout are :

(i) Principle of Minimum Travel

Men and materials should travel the shortest distance between operations so as to avoid waste of labour and time and minimise the cost of materials handling.

(ii) Principle of Sequence

Machinery and operations should be arranged in a sequential order. This principle is best achieved in product layout, and efforts should be made to have it adopted in the process layout.

(iii) Principle of Usage

Every foot of available space should be effectively utilised. This principle should receive top consideration in towns and cities where land is costly.

(iv) Principle of Compactness

There should be a harmonious fusion of all the relevant factors so that the final layout looks well integrated and compact.

(v) Principle of Safety and Satisfaction

The layout should contain built in provisions for safety for the workmen. It should also be planned on the basis of the comfort and convenience of the workmen so that they feel satisfied.

(vi) Principle of Flexibility

The layout should permit revisions with the least difficulty and at minimum cost.

(vii) Principle of Minimum Investment

The layout should result in savings in fixed capital investment, not by ©voiding installation of the necessary facilities but by an intensive use of available facilities.

Q11. Discuss the factors influencing the layout.

(OR)

Explain the factors influencing the plant layout.

(OR)

How does the choice of the layout affect the operational performance of an organization?

(OR)

What are the factors influencing plant layout?

Ans : **(Dec.-19, Dec.-18, Jan.-18, Imp)**

The following are the various factors influencing plant layout are :

1. Materials

i) Plant layout is mainly influenced by the availability of material i.e., some arrangement must be down for the purpose of storing and moving the raw material into the plant until they gets converted into finished products.

ii) It is advisable for the factories to purchase raw materials economically at the time of its availability which needs to be stored and processed at the production centre either mechanically or chemically.

iii) The storage and materials movement needs appropriate storage rooms and equipment handling mechanisms through which materials are not only stored but can be efficiently handled at various work centres for their processing.

2. Product

i) A layout is designed with the ultimate purpose of producing a product. The type of product – that is, whether the product is heavy or light, big or small, liquid or solid - and the position in relation to the plant location influence the layout.

ii) In a majority of cases, the product moves from work station to work station. In some cases, as in the manufacture of locomotives and in ship-building, the product is stationary; but machinery and men are moved to the product.

iii) Thus, the position of the product in relation to the other factors of production deserves consideration in planning a layout.

iv) In the same way, the size of the product should be considered in planning the layout of a plant.

v) The requirements of a labout meant for a heavy product are different from the requirements of that for a light product.

vi) Again, the layout requirements for assembling a watch are different from those for the assembly.

3. Worker

i) The layout designer should also consider the type, position and requirements of employees. If women workers are employed, the layout must be planned after keeping in mind their particular requirements.

ii) The position of employees, that is, whether they remain stationary or moving, also influences the layout.

4. Machinery

i) The type of product, the volume of its production, the type of process and management policy determines the size and type of the machinery to be installed which, in turn, influences the plant

layout. Production is the combination and manipulation of men, materials and machines.

ii) These elements may be combined in various ratios and in various ways in the course of the production activity.

iii) The ratio in which these elements are used depends on their relative costs and on the production processes selected. Before laying out a plant, it is necessary to determine which of these elements are to be stationary or fixed as to location in the plant and which will be mobile during the process of production.

iv) Various alternatives are available in determining which factor to move:

(a) To move the product and the workers from work station to work station;

(b) To move the product .from work station to work station, keeping the machines and workers stationary; or

(c) To move the worker and the machine to the product, which is held at the location. The layout or arrangement of machines should be planned to suit the alternative used in a plant.

5. Type of Industry

The type of industry and the method of the manufacturing process exercise a significant influence on plant layout. Industries in this context may be broadly classified into four types:

(a) Synthetic;

(b) Analytical;

(c) Conditioning; and

(d) Extractive.

6. Location

i) The site selected for the location of a plant influences its layout in more than one way. First, the size and the terrain of the site determine the type of building which, in turn, influences the layout.

ii) Second, the location of the plant determines the mode of transportation, depending upon the distances from the source of raw materials and market to the plant.

iii) In some cases, railroads are used, in some others trucks are pressed into service. In a few cases, water loading and unloading facilities are required.

iv) The layout plan should provide for the exact type of transportation required. Third, a plant location may be determined in part by the fuel requirements of the concern.

v) The plant layout must provide for. the storage of this fuel, whether it be coal, oil or gas. Also, the layout must consider the requirements of power generation.

vi) Fourth, the demand for future expansion influences the plant layout. If a village site is selected, expansion may be effected by adding one more wing to the existing single-storey construction.

vii) If an urban site is selected, expansion may be effected by adding more storeys to the present structures.

7. Managerial Policies

Management policies significantly influence plant layout. The following are such managerial policies:

(a) The volume of production and provision for expansion;

(b) The extent of automation;

(c) Making or buying a particular component;

(d) Desire for rapid delivery of goods to customers;

(e) Purchasing policy;

(f) Personnel policies.

3.5.2 Classification of Layout

Q12. Mention different types of layouts.

Ans :

A layout essentially refers to the arranging the grouping of machines which are meant to produce goods. Grouping is done on different lines. The choice of a particular line depends on several factors. The methods of grouping or the types of layout are:

(i) Process Layout

Refer to Unit-III, Q.No. 13.

(ii) Product Layout

Refer to Unit-III, Q.No. 14.

(iii) Fixed position layout or static layout

Refer to Unit-III, Q.No. 16.

(iv) Cellular manufacturing (CM) layout or Group Technology Layout

Refer to Unit-III, Q.No. 17.

(v) Combination layout or Hybrid Labout

Refer to Unit-III, Q.No. 18.

3.5.2.1 Process Layout

Q13. What is Process Layout? Explain the advantages and disadvantages of Process Layout.

Ans : **(Imp.)**

- Process Layout is also called the functional layout, layout for job lot manufacture or batch production layout, the process layout involves a grouping together of like machines in one department.
- For example, machines performing drilling operations are fixed in the drilling department machines performing casting operations are grouped in the casting department, and so on.
- In this way, there would be a heating department, a painting department, a machining department and the like, where similar machines are installed in the plants which follow the process layout.
- The process arrangement is signified by the grouping together of like machines based upon their operational characteristics.
- A quantity of raw material is issued to a machine which performs first operation. This machine may be situated anywhere in the factory.
- For the next operation, a different machine may be required, which may be situated in another part of the factory. The material should be transported to this other machine for treatment.
- Thus, material would move long distances and along crisscrossing paths. At one stage, the material may be taken to a separate building, say, for heat treatment, and then brought back for grinding. If machines in one department are engaged, the partly finished product awaiting operations may be taken to the store and later reissued for production.
- Partly finished goods would be waiting for treatment in every department, like commuters waiting for buses in a city.

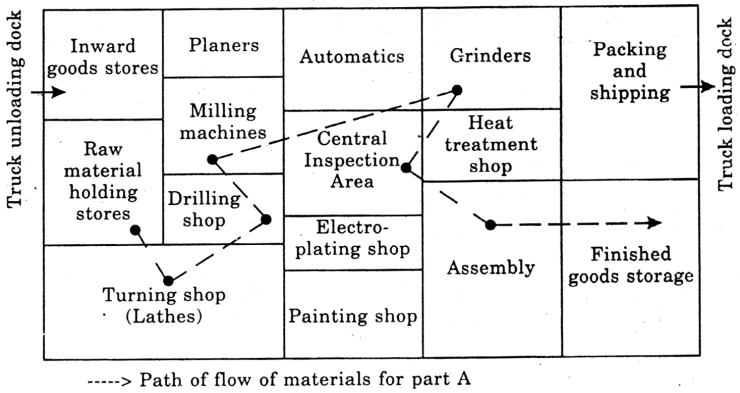


Fig. : Process Layout or Functional Layout or Job Shop Layout

Advantages

1. Reduced investment of machines as they are general purpose machines.
2. Greater flexibility in the production.
3. Better and more efficient supervision is possible through specialisation.
4. There is greater scope for expansion as the capacities of different lines can be easily increased.
5. This type of layout results in better utilisation of men and machines.
6. It is easier to handle breakdown of equipment by transferring work to another machine or station.
7. There is full utilisation of equipment.
8. The investment of equipment would be comparatively lower.
9. There is greater incentive to individual worker to increase his performance.

Disadvantages

1. There is difficulty in the movement of materials. Mechanical devices for handling materials cannot be conveniently used.
2. This type of layout requires more floor space.
3. There is difficulty in production control.
4. Production time is more as work-in-progress has to travel from place to place in search of machines.
5. There is accumulation of work-in-progress at different places.

3.5.2.2 Product Layout

3.5.2.2.1 Advantages and Limitations of Product Layout

Q14. What is Product Layout? Explain the advantages and disadvantages of Product Layout.

(OR)

"Plant layout involves, besides grouping of machinery an arrangement of other facilities also". Discuss.

(OR)

Explain about Product layout with its advantages and limitations.

Ans : **(Oct.-20)**

Meaning

Product layout is also called the straight-line layout (or) layout for serialised manufacture, the *product layout* involves the arrangement of machines in one line, depending upon the sequence of operations. Material are fed into the first machine and finished products come out of the last machine. In between, partly finished goods travel automatically, from machine to machine, the output of one machine becoming the input for the next. It is a feast for the eyes to watch the way sugarcane, fed at one and of the mill, comes out as sugar the other end. Similarly, in paper mill, bamboos are fed into the machine at one end and paper comes out at the other end.

In product layout, if there are more than one line of production, there are as many lines of machines. The emphasis here, therefore, is on special purpose machines in contrast to general purpose machines, which are installed in the process layout. Consequently, the investment on machines in a straight line layout is higher than the investment on machines in a functional layout.

The grouping of machines should be done, on product line, keeping in mind the following principles:

(i) All the machine tools or other items of equipment must be placed at the point demanded by the sequence of operations.

(ii) There should be no points where one line crosses another line;

(iii) Materials may be fed where they are required for assembly, but, not necessarily all at one point; and

(iv) All the operations, including assembly, testing and packing should be included in the line.

The product layout may be advantageously followed in plants manufacturing standardised products on a mass scale such as chemical, paper, sugar, rubber, refineries and cement industries.

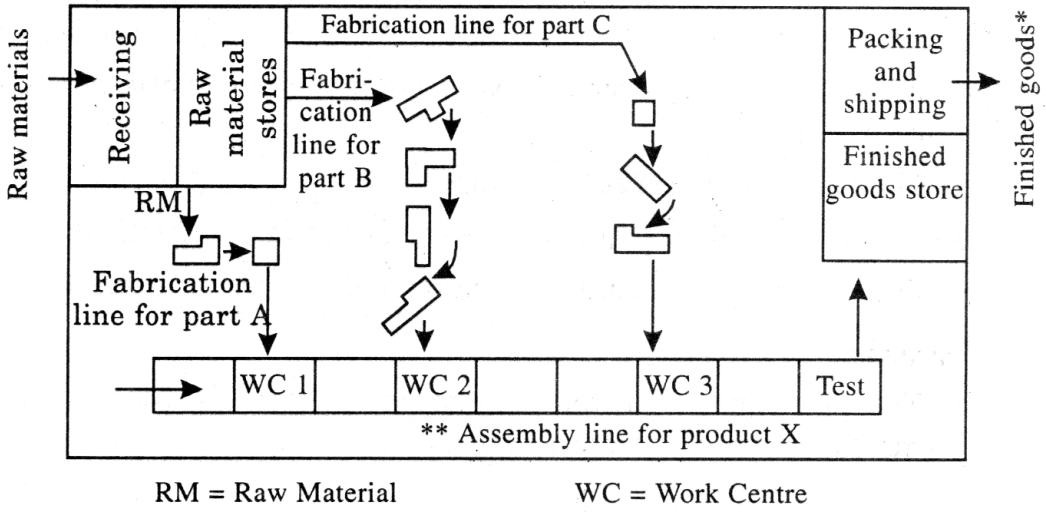


Fig. : Line Layout or Product Layout

Advantages

1. There is mechanisation of materials handling and consequently reduction in materials handling cost.
2. This type of layout avoids production bottlenecks.
3. There is economy in manufacturing time.
4. This type of layout facilitates better production control.
5. This type of layout requires less floor area per unit of production.
6. Work-in-progress is reduced and investment thereon is minimised.
7. Early detection of mistakes or badly produced item is possible.
8. There is greater incentive to a group of workers to raise their level of performance.

Disadvantages

1. Product layout is known for its inflexibility.
2. This type of layout is also expensive.
3. There is difficulty of supervision.
4. Expansion is also difficult.
5. Any breakdown of equipment along a production line can disrupt the whole system.

Q15. Bringout the comparison between product layout and process layout.

(OR)

Distinguish between product layout and process layout.

Ans : **(Feb.-17, Aug.-16, Aug.-15, Feb.-12, July-11)**

Product Layout		Process Layout	
1.	Mechanisation, of materials handling and consequent reduction in materials handling cost	1.	Reduction in the investment on machines as they are general purpose machines.
2.	Avoidance of bottlenecks.	2.	Greater flexibility in production.
3.	Economy in manufacturing time.	3.	Better and more efficient supervision possible through specialisation.
4.	Better production control.	4.	Better scope for expansion.
5.	Less floor area required per unit of production.	5.	Better utilisation of men and machines.
6.	Minimum investment in work-in-progress.	6.	Easier to handle breakdowns of equipment by transferring work to another machine or station.
7.	Early detection of mistakes or badly	7.	Full utilisation of the plant, produced items.
8.	Greater incentive to a group of workers to raise their performance.	8.	Greater incentive to individual workers to raise the level of their performance.

3.5.2.3 Fixed Position Layout

Q16. Write in detail about Fixed Position Layout. Highlight its advantages and limitations.

(OR)

What is fixed job layout? Where do you come across it?

Ans : **(Aug.-21, Aug.-16)**

Meaning

- Fixed position layout deals with the transfer of productional resources such as men, machines and equipments towards the productional site which is fixed or stable.
- In fixed position layout, the material or primary producational requirements will be in fixed location and the tools, machinery, men and other materials will be transferred to this location.
- It is desirable to transfer the men and machines to the product as the cost incurred on transferring them will be less when compared to the cost incurred on transferring the bulky product.
- Fixed position layout is also called as state layout or fixed location layout. The figure given below depicts the fixed position layout.
- Fixed position layout is widely find its applications in the manufacturing of heavy products like locomotives, ships, boilers, air crafts and generators.

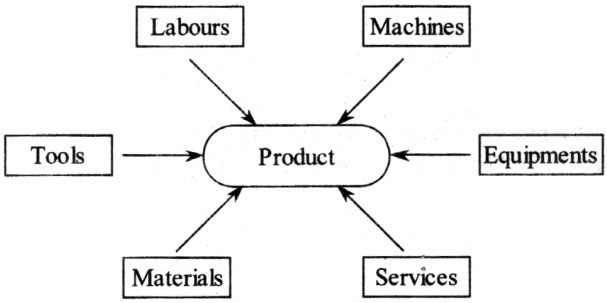


Fig. : Fixed Position Layout

For example, during the construction of building, men, cement, sand, bricks, steel, wood and others are taken to the construction site which is fixed. Similarly, in hospitals also, the doctors, nurses (workers), medicines and other (materials) will be given to a patient (product) [whose position is fixed]. The layout may be temporarily or permanently located.

Advantages

The following are the advantages of fixed position layout,

1. It is widely used for producing differentiated products by effectively utilising the production resources.
2. It involves low investment than the product and process layouts as the productional site is fixed.
3. Fixed position layout helps the workers to associate themselves with the product.
4. As production or workcentres are operating independently, total production time can be reduced by effective scheduling.
5. Continuity of operations and sense of responsibility can be ensured by performing tasks in groups.

Disadvantages

Some of the disadvantages of fixed position layout are,

1. The transfer of machines and equipment to the production centre consumes lot of time and can be very much expensive.
2. It is very difficult and expensive to position the material, object or machines.
3. Highly skilled workers are needed for carrying out the operations of fixed position layout.
4. The machines and equipments are not utilized effectively due to handling and positioning constraints.

3.5.2.4 Group Technology Layout

3.5.2.4.1 Advantages and limitations of Group Technology Layout

Q17. Describe briefly about Group Technology Layout. Explain Advantages and limitations of Group Technology Layout.

(OR)

Explain about Group Technology Layout with its advantages and limitations.

(OR)

Discuss briefly about cellular manufacturing layout with merits and limitations.

(OR)

What do you understand by Cellular layout? What are its merits?

(Oct.-22, Dec.-19, Dec.-18, Feb.-17, Aug.-15, Imp)

(OR)

Write about advantages and disadvantages of group technology.

Ans : **(Dec.-19)**

In cellular manufacturing (CM), machines are grouped into cells, and the cells functions somewhat like a product layout within a larger shop or process layout. Each cell in the CM layout is formed to produce a single parts family – a few parts, all with common characteristics, which usually means that they require the same machines and have similar machine settings.

The flow of parts with in cells, as shown in fig., can take many forms. For example, in cell #1 and #2, the parts in the part family flow through the same machines in a product focused, line flow fashion. But in the cells #3 and #4, parts take different routes through the cells because of the differences between the designs of the two parts.

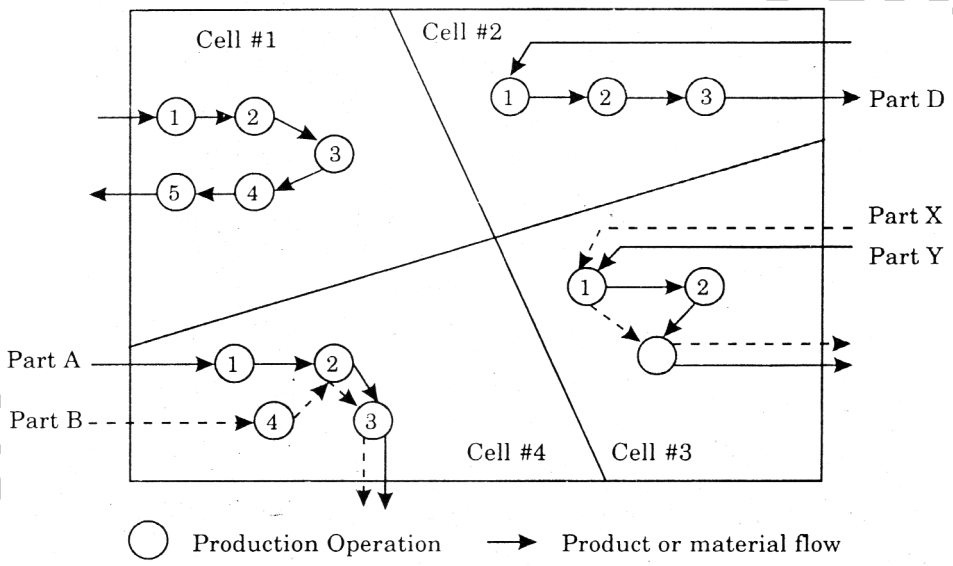


Fig. : Cellular Manufacturing Layout or Group Technology Layout

Advantages

The following are the advantages of cellular manufacturing layout,

1. It helps in reducing the work in process inventories thereby causing a sharp decline in the materials handling.
2. It helps in increasing the overall performance by reducing production costs and by achieving on-time delivery of products to customers.
3. It is associated with less tooling changes thereby facilitating quick production set ups.
4. It establishes simple production planning which reduces its flow time.
5. It increases the responsibilities of the operator and ensures the visual control.

Disadvantages

The following are the disadvantages of cellular manufacturing layout,

1. Involves less manufacturing flexibility.
2. Increases the machines down time as machines are grouped as cells which may not be functional throughout the production process.
3. Duplicate parts of equipment is used as it is very difficult for transferring the parts between the cells causing the rise in productional inefficiencies.

3.5.2.5 Combine Layout

Q18. Expalin the concept of Combine layout.

Ans :

i) The application of the principles of product layout, process layout or fixed location layout in their strict meanings is difficult to come across.

ii) A combination of the product and process layouts, with an emphasis on either, is noticed in most industrial establishments.

iii) Plants are never laid out in either pure form. It is possible to have both types of layout in an efficiently combined form if the products manufactured are somewhat similar and not complex.

iv) In plants involving the fabrication of parts and assembly, fabrication tends to employ the process layout, while the assembly areas often employ the product layout.

v) In soap manufacturing plants, the machinery manufacturing soap is arranged on the product-line principle; but ancillary services, such as heating, the manufacturing of glycerine, the power-house, the water treatment plant are arranged on a functional basis.

Figure illustrates the combined layout. The departments are arranged according to the type of processes but the products flow through on a product layout.

To extend the logic of the combined layout, we may refer to the application of the fixed location principle in every industrial establishment.

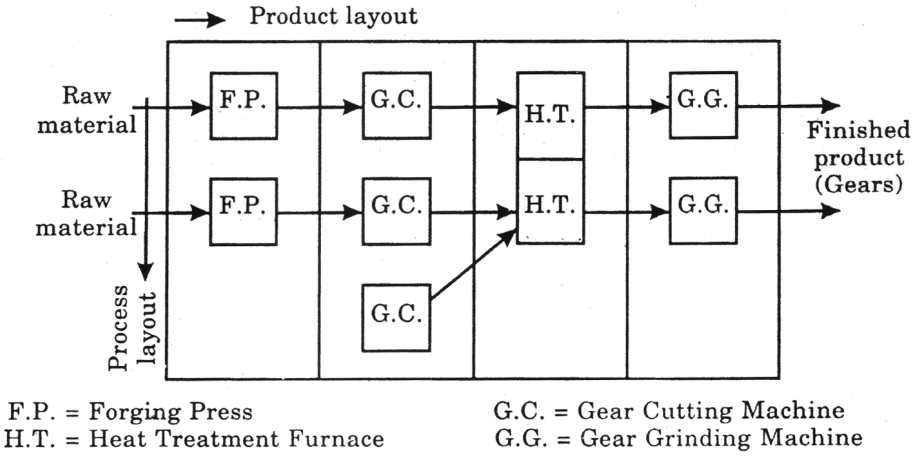


Fig. : Combination Layout or Hybrid Layout for Gear Manufacturing

In the final analysis, the combination that produces the desired volume of products at the least total cost is preferred. Marketing is concerned with maximising income, industrial engineering is concerned with minimising cost, and management is gambling that there is a sufficient differences in its favour.

Q19. Bring out the reasons with examples for layout revision.

Ans : **(Dec.-18)**

Plant layout should be dynamic in nature which can be easily changed on continuous basis. Layout should be such that the changes can be implemented and developments can be made without any difficulty. The revision of plant layout involve activities like introduction of new machinery or equipment, modifications in material handling devices, enhancement of manufacturing process, etc. Revision of layout is possible only when savings from revision are more than the cost incurred while carrying out such revision.

Revision of plant layout has become necessary due to following reasons,

1. Increase in production capacity requires revision of layout.

   Example: Xiaomi has increased its production capacity by 50% with introduction of new facility.

2. Introduction of new product which may be related or unrelated to product which is already being produced.

   Example: Nokia was established as paper mill later on engaged in production of tires, cables, electronics and mobile phones.

3. Technological advancement in materials, processes, product design, etc, which may or may not require change.

   Example: 3G/4G broadband is a good example of technological advancements through which small businesses can easily reach target markets with less costs of operation.

3.6 LAYOUT DESIGN PROCEDURES

Q20. What are the steps to be followed in designing a layout?

(OR)

Brief on layout design procedure.

Ans : **(May-19)**

Design the layout of a plant is a specialised activity and should be carried out systematically. The various steps to be followed in the layout design are :

Steps

1. Statement of specific objectives, scope and factors to be considered.
2. Collection of basic data on sales forecasts, production volumes, production schedules, part lists, operations to be performed and their sequences, work measurement, existing layouts, building drawings.
3. Preparation of various kinds of charts such as flow process charts, flow diagram, string diagram, templates etc.
4. Designing the production process.
5. Planning the material flow pattern and developing the overall materials handling plan.
6. Calculation of requirement of work centres and equipments.
7. Planning individual work centres.
8. Selection of materials handling equipments.
9. Determining storage requirements.

10. Planning of auxiliary and service facilities.
11. Determination of routing, space requirements for each work station, service department, employee facilities etc.
12. Draw building specifications to fit the requirements of the layout.
13. Preparation of floor plan indicating location of doors, windows, stair case, lifts etc.
14. Preparation of tentative or drafts layout plans.
15. Preparation of detailed layout drawing and get approval of the top management.
16. Preparation of work schedule for the installation of layout.

Q21. Discuss the probable errors in plant selection decision.

Ans : **(April-23)**

Facility location is critical for business continuity and success of the organization. So it is important to avoid mistakes while making selection for a location. Errors in selection can be divided into two broad categories behavioral and non-behavioral. Behavioral errors are decision made by executives of the company where personal factors are considered before success of location, for example, movement of personal establishment from hometown to new location facility. Non-behavioral errors include lack of proper investigative practice and analysis, ignoring critical factors and characteristics of the industry.

Location Strategy

The goal of an organization is customer delight for that it needs access to the customers at minimum possible cost. This is achieved by developing location strategy. Location strategy helps the company in determining product offering, market, demand forecast in different markets, best location to access customers and best manufacturing and service location.

Q22. What is REL chart? Illustrate its application with example.

Ans : **(Oct.-22)**

(i) Relationship charts are used in facility management and it locates the departments based on the relationship existing between them.

(ii) Relationship charts (REL diagram) a method for portraying the example and degree of interdepartmental development of things inside a production line.

(iii) REL or cross graphs are utilized to gather data about connections between industrial facility divisions, distinguishing the quantities of things every day moved from every office and which office gets them.

Short Question & Answers

1. What do you understand by Cellular layout? What are its merits?

Ans :

In cellular manufacturing (CM), machines are grouped into cells, and the cells functions somewhat like a product layout within a larger shop or process layout. Each cell in the CM layout is formed to produce a single parts family – a few parts, all with common characteristics, which usually means that they require the same machines and have similar machine settings.

Advantages

The following are the advantages of cellular manufacturing layout,

(i) It helps in reducing the work in process inventories thereby causing a sharp decline in the materials handling.

(ii) It helps in increasing the overall performance by reducing production costs and by achieving on-time delivery of products to customers.

2. What are the factors influencing the plant location?

Ans :

(i) Proximity of the plant to the market.

(ii) Easy accessibility of plant to labour, raw material and cost.

(iii) The land for plant should be suitable enough to fulfill the present and future expansion needs. In addition to this, cost of land and development land should be considered.

(iv) The infrastructure facilities such as water, electricity, banking and finance should be available at optimum level.

(v) Provision for the disposal of waste, overflow treatment etc.

(vi) The union activities and political influences should also be considered.

(vii) Climatic and seasonal conditions such as rainfall, temperature, humidity, dust count, etc must be considered.

3. Define Break-even chart.

Ans :

Break even analysis implies that at some point in the operations, total revenue equals total cost. Break even analysis is concerned with finding the point at which revenues and costs agree exactly. It is called 'Break-even Point'. The fig. portrays the Break Even Chart :

Break even point is the volume of output at which neither a profit is made nor a loss is incurred. The Break Even Point (BEP) in units can be calculated by using the relation :

$$BEP = \frac{\text{Fixed Cost}}{\text{Contribution per unit}} = \frac{\text{Fixed Cost}}{\text{Selling Price - Variable Cost per unit}} = \frac{F}{S - V} \text{ units}$$

The Break Even Point (BEP) in Rs. can be calculated by using the relation :

$$BEP = \frac{\text{Fixed Cost}}{\text{PV Ratio}} = \frac{\text{Fixed Cost}}{\left\{\frac{\text{Sales} - \text{Variable Cost}}{\text{Sales}}\right\}}$$

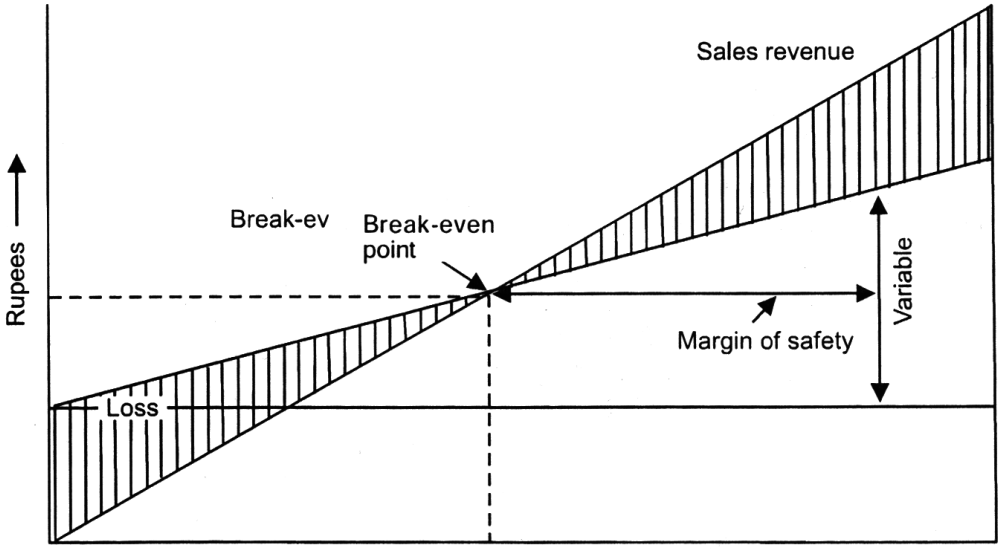


Fig. : Units of output or percentage of capacity

Plotting the break even chart for each location can make economic comparisons of locations. This will be helpful in identifying the range of production volume over which location can be selected.

4. What is meant by Plant Location?

Ans :

Plant location may be understood as the function of determining where the plant should be located for maximum operating economy, and effectiveness. The selection of a place for locating a plant is one of the problems, perhaps the most important, which is faced by an entrepreneur while launching a new enterprise. A selection on pure economic considerations will ensure an easy and regular supply of raw materials, labour force, efficient plant layout, proper utilisation of production capacity and reduced cost of production. An ideal location may not, by itself, guarantee success; but it certainly contributes to the smooth and efficient working of an organisation. A bad location, on the other hand, is a severe handicap for any enterprise and it finally bankrupts it. it is, therefore, very essential that utmost care should be exercised in the initial stages to select a proper place.

5. Single Facility Location Problem.

Ans :

The single new facility location problem is one of the easiest method to solve facility location problems. Its main objective is to locate a single new facility with respect to existing facilities in such a way that the cost of transporting material between new facility and existing facilities get minimized.

Some of the examples of single new facility location problem are,

- For existing markets, locating new warehouses
- For providing better service to existing markets
- For serving cluster of towns in order to construct regional airports etc.

Generally, we follow rectilinear distance for such decision. The rectilinear distance between any two points whose coordinates are (X_1, Y_1) and (X_2, Y_2) is given by the following formula.

$$d_{12} = |X_1 - X_2| + |Y_1 - Y_2|$$

6. Define the term Plant Layout.

Ans :

A plant layout refers to the arrangement of machinery, equipment and other industrial facilities – such as receiving and shipping departments, tool rooms, maintenance rooms and employee amenities - for the purpose of achieving the quickest and smoothest production at the least cost. The subject of plant layout not only covers the initial layout of machines and other facilities but encompasses improvement in, or revision of, the existing layout in the light of subsequent developments in the methods of production. In other words, a plant layout is a floor plan for determining and arranging the desired machinery and equipment of a plant, whether established or contemplated, in the one best place to permit the quickest flow of material at the lowest cost and with the least amount of handling in processing the product from the receipt of the raw materials to the shipment of the finished products.

A more simple, clear and comprehensive definition is given by knowles and Thomson. They say that a plant layout involves:

(i) "Planning and arranging manufacturing machinery, equipment, and services for the first time in completely new plants;

(ii) The improvements in layouts already in use in order to introduce new methods and improvements in manufacturing procedures.

7. Objectives of plant layout

Ans :

The objectives of a good plant layout are :

(i) Provide enough production capacity

(ii) Reduce material handling costs

(iii) Reduce congestion that impedes the movement of people or material

(iv) Reduce hazards to personnel

(v) Utilize labour efficiently

(vi) Increase employee morale

(vii) Reduce accidents

(viii) Utilize available space efficiently and effectively

(ix) Provide for volume and produce flexibility

(x) Provide ease of supervision

(xi) Facilitate co-ordination and face-to-face communication where appropriate

(xii) Provide for employee safety and health

(xiii) Allow ease of maintenance

(xiv) Allow high machine/equipment utilisation

(xv) Improve productivity.

8. Distinguish between product layout and process layout.

Ans :

Sl.No.	Product Layout	Process Layout
1.	Mechanisation, of materials handling and consequent reduction in materials handling cost	Reduction in the investment on machines as they are general purpose machines.
2.	Avoidance of bottlenecks.	Greater flexibility in production.
3.	Economy in manufacturing time.	Better and more efficient supervision possible through specialisation.
4.	Better production control.	Better scope for expansion.
5.	Less floor area required per unit of production.	Better utilisation of men and machines.
6.	Minimum investment in work-in-progress.	Easier to handle breakdowns of equipment by transferring work to another machine or station.
7.	Early detection of mistakes or badly	Full utilisation of the plant, produced items.
8.	Greater incentive to a group of workers to raise their performance.	Greater incentive to individual workers to raise the level of their performance.

9. Combine Layout

Ans :

The application of the principles of product layout, process layout or fixed location layout in their strict meanings is difficult to come across. A combination of the product and process layouts, with an emphasis on either, is noticed in most industrial establishments. Plants are never laid out in either pure form. It is possible to have both types of layout in an efficiently combined form if the products manufactured are somewhat similar and not complex.

In plants involving the fabrication of parts and assembly, fabrication tends to employ the process layout, while the assembly areas often employ the product layout. In soap manufacturing plants, the machinery manufacturing soap is arranged on the product-line principle; but ancillary services, such as heating, the manufacturing of glycerine, the power-house, the water treatment plant are arranged on a functional basis.

10. Bring out the reasons with examples for layout revision.

Ans :

Plant layout should be dynamic in nature which can be easily changed on continuous basis. Layout should be such that the changes can be implemented and developments can be made without any difficulty. The revision of plant layout involve activities like introduction of new machinery or equipment, modifications in material handling devices, enhancement of manufacturing process, etc. Revision of layout is possible only when savings from revision are more than the cost incurred while carrying out such revision.

Revision of plant layout has become necessary due to following reasons,

(i) Increase in production capacity requires revision of layout.

Example: Xiaomi has increased its production capacity by 50% with introduction of new facility.

(ii) Introduction of new product which may be related or unrelated to product which is already being produced.

Example: Nokia was established as paper mill later on engaged in production of tires, cables, electronics and mobile phones.

(iii) Technological advancement in materials, processes, product design, etc, which may or may not require change.

Example: 3G/4G broadband is a good example of technological advancements through which small businesses can easily reach target markets with less costs of operation.

Choose the Correct Answers

1. Which of the following explain the need for facility location selection? [d]
   (a) When the existing business unit has outgrown its original facilities and expansion is not possible.
   (b) When a business is newly started.
   (c) When the lease expires and the landlord does not renew the lease.
   (d) All of these.
2. Which of the following is the first step in making a correct location choice? [b]
   (a) Develop location alternatives
   (b) Decide the criteria for evaluating location alternatives
   (c) Evaluate the alternatives
   (d) Make a decision and select the location
3. Which of the following technique emphasises transportation cost in the determination of facility location? [c]
   (a) Location rating factor technique (b) Transportation technique
   (c) Centre-of-gravity technique (d) Both (b) and (c)
4. Transportation cost mainly depends on which of the following factors? [d]
   (a) Distance (b) Weight of merchandise
   (c) Time required for transportation (d) All of the above
5. In which of the following site selection techniques, a weightage between '0' to '1' is provided to factors that influence its location decision? [a]
   (a) Location rating factor technique (b) Transportation technique
   (c) Centre-of-gravity technique (d) None of these
6. Which of the following does not cause to production delay? [d]
   (a) Shortage of space
   (b) Long distance movement of materials
   (c) Spoiled work
   (d) Minimum material handling
7. Process layout is also known as _____. [d]
   (a) Functional layout (b) Batch production layout
   (c) Straight line layout (d) Both (a) and (b)
8. Which of the following facility layout is best suited for the intermittent type of production, which is a method of manufacturing several different products using the same production line? [b]
   (a) Product layout (b) Process layout
   (c) Fixed position layout (d) Cellular manufacturing layout

9. In which of the following layout type, materials are fed into the first machine and finished products come out of the last machine? [d]

(a) Product layout (b) Process layout

(c) Fixed position layout (d) Cellular manufacturing layout

10. Which of the following is not an advantage of using product layout? [c]

(a) Minimum material handling cost (b) Minimum inspection requirement

(c) Specialised supervision requirement (d) None of these

Fill in the Blanks

1. _____ analysis implies that at some point in the operations, total revenue equals total cost.
2. A _____ refers to the arrangement of machinery, equipment and other industrial facilities
3. Plant layout is mainly influenced by the availability of _____.
4. _____ policies significantly influence plant layout.
5. A _____ essentially refers to the arranging the grouping of machines which are meant to produce goods.
6. Process Layout is also called the _____.
7. Product layout is also called the _____.
8. _____ layout is widely find its applications in the manufacturing of heavy products like locomotives, ships, boilers, air crafts and generators.
9. _____ layout helps the workers to associate themselves with the product.
10. The _____ location problem is one of the easiest method to solve facility location problems.

ANSWERS

1. Break even
2. Plant layout
3. Material
4. Management
5. Layout
6. Functional layout
7. Straight-line layout
8. Fixed position
9. Fixed position
10. Single new facility

Very Short Questions and Answers

1. Plant Location.

Ans :

Plant location may be understood as the function of determining where the plant should be located for maximum operating economy, and effectiveness.

2. Examples of single new facility location problem .

Ans :

i) For existing markets, locating new warehouses

ii) For providing better service to existing markets

iii) For serving cluster of towns in order to construct regional airports etc.

3. Multi facility Location Problems?

Ans :

The multi-facility location problem is used to locate several new facilities with respect to existing facilities in such a way that the cost of transporting material from new facilities to existing facilities get minimized.

4. Objectives of plant layout.

Ans :

i) Provide enough production capacity

ii) Reduce material handling costs

iii) Reduce congestion that impedes the movement of people or material

iv) Reduce hazards to personnel

5. Classification of Layout.

Ans :

The methods of grouping or the types of layout are:

i) Product layout or functional layout or job shop layout

ii) Product layout or line processing layout or flow-line layout

iii) Fixed position layout or static layout

iv) Cellular manufacturing (CM) layout or Group Technology Layout

v) Combination layout or Hybrid Labour

UNIT IV

Scheduling: Introduction, Johnson's Algorithm, Extension of Johnson's rule. Job Shop Scheduling: Introduction, Types of Schedules, Schedule Generation, heuristic Procedures, Priority Dispatching Rules. Two Jobs and m Machines Scheduling. Quality control concepts.

4.1 SCHEDULING

4.1.1 Introduction

Q1. Define Scheduling. State its scope.

(OR)

Write short notes on Scheduling. Explain the scope of scheduling.

Ans : **(Dec.-19)**

Meaning

i) Scheduling pertains to establishing the time of the use of specific resources within an organization.

ii) It relates to the use of equipment, machines, facilities and human activities.

iii) Scheduling is necessary in every organization regardless of the nature of its activities.

For example, in manufacturing organizations, production must be scheduled, which means developing schedules for workers, machines, equipments, maintenance etc.

iv) In service organizations such as hospitals, admission, surgery, nursing assignments and support services such as cleaning, maintenance, security, meal preparation etc., must be scheduled.

v) In educational institutions, classrooms, instruction and students must be scheduled.

vi) Scheduling, means organising a production line to produce products in time efficiently with least use of time and maximum utilisation of resources (especially men and machines).

Scope

The scope of scheduling includes,

1. Combines the important elements for the optimal maintenance of jobs i.e., helps in integrating labour, tools materials, parts, information, engineering data authorizations and statutory permissions.
2. Future demand for service is matched with the available resources after considering the leave, training, skills and competencies possessed by the individuals.
3. Prepares the "weekly schedule" which represents that the planned work order could be achieved by the effective utilization of the available resources.
4. Prepare the alternative assignment strategies according to which specific jobs have to be allocated to the specific individuals.
5. Ensuring that the supervisors are able to receive and understand the preset job packages for all types of scheduled jobs.

Q2. Elaborate the objectives and principles of Scheduling.

Ans :

Objectives

The following are the objectives of scheduling are:-

i) To prevent unbalanced use of time among departments and work centres or to evenly load all machines in the production line.

ii) To utilise machines and labour in such a way that the output is produced within the established

lead time so as to, deliver the products/services in time and complete production in the shortest cycle time possible at minimum total cost of production.

iii) To reduce idle time of labour and machines, which might be caused due to waiting for materials, waiting for movement, waiting for inspection and waiting for want of work.

iv) To fix up delivery dates for various manufacturing activities and for the finished products.

v) To increase the efficiency of production or productivity.

Principles of Scheduling

The principles of scheduling are as follows,

i) Principle of Optimum Tasks Size

If the size of tasks are uniform and small then (or equal size) scheduling attains maximum efficiency.

ii) Principle of Optimum Production Plan

If the work is planned and all the plant has equal or even load then scheduling attains maximum efficiency.

iii) Principle of Optimum Operation Sequence

If the work is planned then all the work centres will follows the same sequence which increases the efficiency of operations.

Q3. What are the essential elements of Scheduling?

Ans :

i) Demand Forecasts/Customer's Firm Orders

Determine the delivery dates for finished products.

ii) Aggregate Scheduling

Tentative schedule based on demand for quarterly or monthly requirements. Enables employment of available resources in meeting the demand by adjusting the capacity. Needs rough-cut capacity planning.

iii) Production Plan

Showing output levels planned, resource requirements, and capacity limitations and inventory levels.

iv) Master Production Schedule

Dates committed and desired quantity to be produced on a daily, weekly, monthly or quarterly basis.

v) Priority Planning

Master schedule is exploded into components and parts that are required to produce the product.

vi) Capacity Planning

Regulates loading of specific jobs on specific work centres or machines for specific periods of time.

vii) Facility Loading or Machine Loading

Loading work centres/Machines after deciding which job to be assigned to which work centre/ machine *i.e.*, actual assignment of jobs to machines taking into consideration priority sequencing and machine utilisation.

viii) Evaluation of Workload

To balance the workload on various work centres /machines when resources are scarce or limited. Excess load in one work centre or machine has to be transferred to other work centre or machine having spare capacity.

ix) Sequencing

Priority sequencing of jobs is done to maximise workflow through work- centres or machines to minimise delay and cost of production.

Q4. Explain the various activities involved in scheduling.

Ans :

The process of scheduling involves mainly three activities, namely routing, loading and dispatching.

1. Routing

i) Routing can be described as the specifications of the workflow. It explains the sequence of operations and processes to be followed in order to produce a particular product.

ii) Routing determines what work is to be done, where and how it is to be done. The operations manager develops routing sheets (hard copy) or routing files (electronic copy for computerized organizations) that provide detailed information about the sequence in which a product is manufactured.

iii) The routing sheets may also provide information such as the list of operations to be performed by an operator and the skills required to perform these jobs. The production requirements of a product and the layout structure are the important considerations for drawing up routing sheets.

2. Loading

i) Loading can be defined as "assigning specific jobs to each work center for the planning period." For loading, the capacity limitations of each work center have to be considered in order to assign jobs to the work centers. In general, operations managers load jobs onto a work center upto its standard capacity.

ii) When the capacity limitation is not critical, the activity of loading aims at minimizing costs by reducing machine idle time, the amount of inventory, etc.

iii) Loading also includes the task of sequencing the jobs so that the machine idle times are minimized and the jobs are completed within the least time possible.

3. Dispatching

i) Once the production task is routed and the work centers are loaded, the activity 'dispatching' takes place. Dispatching is the final act of releasing job orders to the workers to go ahead with the production process. In this activity, an operations manager releases job orders in accordance with the planned sequence.

ii) Then the manager controls the production processes to ensure the effective implementation of the schedule in order to achieve the objectives specified in the master production schedule.

iii) Both manufacturing and service firms use the following dispatching rules (also called priority rules) in scheduling their production activities:

4. Earliest Due Date

Firms that follow this rule prioritize their jobs according to their earliest due date. Firm lists the earliest due dates of all the jobs and dispatching is done in such a way that the one with the earliest due date is dispatched first, the next earliest job second, and so on.

5. Longest Processing Time

Jobs that have the longest processing time are loaded first into the work center in this method. These types of jobs are given priority because they are considered more valuable to organiza-tions.

6. Shortest Processing Time

Some firms prioritize their work centers' jobs on the basis of the shortest processing time of jobs. Under this rule, the job which has the shortest processing time is given the highest priority. Firms use this rule when they want to maximize the number of completed jobs and keep a lower number of jobs in waiting.

7. First in First serve

Firms that use this rule, process their jobs in the order of their arrival. Jobs are not prioritized according to their relative importance because all jobs are treated as equally important. This rule is used by organizations' that lay emphasis on providing fair customer service. For instance, petrol filling stations schedule their services in such a way that the first customer is served first (irrespective of the volume of petrol to be filled).

8. Slack Time Remaining (STR)

In this method, the operations manager calculates the slack time of each job, i.e., the difference between the time remaining in the due date and the processing time required. Jobs with the shortest slack time are dispatched first.

Q5. Explain the advantages and disa-dvantages of scheduling.

Ans :

Advantages

1. It helps in understanding the project.
2. It continuously record the references, deliverables of the project, their time frames and related importance and occurrence.
3. The sequential order and timing of several work packages and activities can be clearly observed.
4. Corrective actions carnbe taken against delays which affects the project time.

5. Scheduling helps in identifying the critical activities and the critical sequential order of activities in advance.

6. Scheduling helps in transforming resources temporarily from non-critical activities to critical activities, hence effectively utilize the allocation of resources.

Disadvantages

The following are the disadvantages of scheduling,

1. Scheduling leads to frequent employee absenteeism and increased inefficiency of labour due to the lack of relevant skills and experience among them.

2. Resource constraints in scheduling leading to the decline in capacity causing supply delay of materials.

4.2 JOHNSON'S ALGORITHM

Q6. State Johnson's Rule.

(OR)

Explain briefly about Johnson's Algorithm.

(OR)

Explain briefly about Thumb Rules.

(OR)

Write the johnson's Algorithm for solving 'n' jobs through Two Machines.

(OR)

Explain the following terms in context of a job sequencing problem.

Ans : **(April-23, Dec.-19, April-19, Feb.-16)**

The task here is to sequence or determine the order of 'n' jobs to be processed on two machines in such a way, that the total elapsed time is kept minimum. The procedure for solving this type of problem was developed by Johnson and Bellman.

This type of problem can be described as,

i) Only two machines X and F are involved.

ii) Each job is processed in the order XY.

iii) Expected processing times $X_1, X_2, \ldots\ldots, X_n$ and $Y_1, Y_2, \ldots\ldots, Y_n$ of jobs 1, 2, ..., n on machines X and Y respectively are known.

Steps of Johnson's Rule

1. Select the least processing time occurring in the list $X_1, X_2, \ldots, X_n$ and $Y_1, Y_2, \ldots, Y_n$ of jobs 1, 2, ..., n on machines X and Y respectively.

2. a) If the least time is X_r, place the r_{th} job in the beginning of the sequence.

   b) If the least time is Y_S, place the S^{th} job at the end of the sequence.

   Note

   i) If there is a tie for minimum i.e., $X_r = Y_s$, then place r^{th} job in the starting of the sequence and 5^{th} job at the end of the sequence.

   ii) If there is a tie among X_r's, look for the corresponding times in machine Y. The job with minimum time in Y's among ties is placed first in the sequence and the next job is placed after this in the sequence.

   iii) If there is a tie among Y_r's, look for the corresponding times in machine X. The job with minimum time in corresponding X's among ties is placed last in the sequence and the next job is placed before this in the sequence.

3. The remaining (n –1) jobs are sequenced by repeating steps 1 and 2 by eliminating the processing times of the assigned jobs on both the machines.

4. The process is continued by placing the jobs next to first or next to last and so on till the optimum sequence is obtained.

5. The total elapsed time and idle times for the optimum sequence are computed using the following formulae,

   (a) Total Elapsed Time

   Time required between starting the first job in the optimum sequence on machine X and completing the last job in the optimum sequence on machine Y.

   (b) Idle Time on Machine X

   It is defined as the time when the last job on the optimum sequence is completed on machine Y.

   (OR)

   Time when the last job on the optimum sequence is completed on machine X.

Methodology to Calculate idle Time on Machines and Total Elapsed Time

Step 1

After sequencing is done, table formulation is done based on the process time.

Step 2

To find idle time on machine-1 for N-jobs.

Idle time on machine-1 is given by.

$$\left(\text{Total elpased time}\right) - \begin{pmatrix}\text{Time when the last job in a}\\ \text{sequence finishes on}\\ \text{machine } M_1\end{pmatrix}$$

Step 3

To determine idel time on machine -2 for N-jobs

Idle time on machine-2 is given by,

$$\begin{pmatrix}\text{Time at which the first}\\ \text{job in a sequence starts on}\\ \text{machine } M_2\end{pmatrix} + \sum_{k=2}^{n}\begin{pmatrix}\text{Time when the } k^{th} \text{ job}\\ \text{in a sequence}\\ \text{starts on machine } M_2\end{pmatrix} - \begin{pmatrix}\text{Time when the } (k-1)^{th}\\ \text{job in a sequence finishes}\\ \text{on machine } M_2\end{pmatrix}$$

Step 4

Total Elapsed Time

Total elapsed time = Time when the n^{th} job in a sequence finishes on machine M_2

$$= \sum_{k=1}^{n} M_{2k} + \sum_{k=1}^{n} I_{2k}$$

Where,

M_{2k} = Time consumed to process k^{th} job on machine M_2.

I_{2k} = time in which machine M_2 remains idle before starting work in k^{th} job and after processing $(k-1)^{th}$ job.

PROBLEMS

1. Seven jobs are to be processed on two machines A and B in the order AB. Each machine can process only one job at a time. The processing times (in hours) are as follows,

Job	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Machine A	**10**	**12**	**13**	**7**	**14**	**5**	**16**
Machine B	**15**	**11**	**8**	**9**	**6**	**7**	**18**

Suggest optimum sequence of processing the jobs and the total elapsed time. Also compute the idle time for both the machines.

Sol :

Job	1	2	3	4	5	6	7
Machine A	10	12	13	7	14	5	16
Machine B	15	11	8	9	6	7	18

Step 1

The smallest processing time is 5 hour for job 6 on machine-A. Hence, this job 6 must be placed at the beginning of the sequence.

J_6						

Step 2

The next smallest processing time in the remaining list is '6' hours which is for job-5 on Machine-B. Hence, the job-5 must be placed at the end of the sequence.

J_6						J_5

Step 3

The next smallest processing time in the reduced list is '7' hours, for job-4 on Machine-A. Job 4 is placed next to job 6 in the sequence.

J_6	J_4					J_5

Step 4

The next smallest processing time in the remaining list is 8 for job-'3' on Machine- 'B'. Hence, the job-3 must be placed before job 5 at the end of sequence.

J_6	J_4				J_3	J_5

Step 5

When the above procedure is continued, the following optimal sequence is attained.

J_6	J_4	J_1	J_7	J_2	J_3	J_5

Computation of Idle Time

Jobs Sequence	Machine-A				Machine-B			
	In Time	Processing Time	Out Time	Idle Time	In Time	Processing Time	Out Time	Idle Time
J_6	0	5	5	0	5	7	12	5
J_4	5	7	12	0	12	9	21	0
J_1	12	10	22	0	22	15	37	1
J_7	22	16	38	0	38	16	54	1
J_2	38	12	50	0	54	11	65	0
J_3	50	13	63	0	65	8	73	0
J_5	63	14	77	0 + 6	77	6	83	4
				= 6				= 11

$\therefore$ Total elapsed time = 83 hours

Idle time for machine A = 6 hours (77^{th} – 83^{rd} hour)

Idle time for machine B = 11 hours.

2. In a factory, there are six jobs to perform, each of which should go through two machines A and B, in the order AB. The processing timings in hours for the jobs are given below. You are required to determine, the sequence for performing the jobs that would minimise the total elapsed time, T. What is the value of T?

Jobs	1	2	3	4	5	6
Machine A	7	4	2	5	9	8
Machine B	3	8	6	6	4	1

Sol :

Step 1

The smallest processing time is one hour for job 6 on machine –B. Hence, this job 6 must be placed at the end of the sequence.

					6

Step-2

The next smallest processing time in the remaining list is 2 for job '3' on machine 'A'. Hence, the job 3, must -be placed first in the sequence.

3					6

Step-3

The next least processing time in the reduced list is '3', which is for job-1 and on machine B. Hence, it must be placed before job 6 at the end of sequence.

3				1	6

Step-5

When the above procedure is continued, the following optimal sequence is attained.

3	2	4	5	1	6

Computation of Idle Time

Task Sequence	Machine-A				Machine-B			
	In Time	Processing Time	Out Time	Idle Time	In Time	Processing Time	Out Time	Idle Time
3	0	2	2	0	2	6	8	2
2	2	4	6	0	8	8	16	0
4	6	5	11	0	16	6	22	0
5	11	9	20	0	22	4	26	0
1	20	7	27	0	27	3	30	1
6	27	8	35	0+1	35	1	36	5
				1				8

∴ Hence, the total elapsed time i.e., 'T' = 36 hour

The idle time for Machine A = 36 – 35 = 1 hour

The idle time for Machine B = 8 hours.

3. There are five jobs, each of which must go through the two machines A and B in the order AB. Processing times (in hours) are given below,

Job	1	2	3	4	5
Time for A	5	1	9	3	10
Time for B	2	6	7	8	4

Determine a sequence for five jobs that will minimize the elapsed time. Calculate the total idle time for the machines in this period.

Sol :

Select the smallest processing time i.e., 1 for job 2 of machine 'A' and place it in the beginning of the sequence.

2				

The next smallest processing time is 2 for job 1 of machine 'B'. So, place it at the end of sequence.

2				1

The next smallest processing time is 3 for job 4 of machine 'A'.

2	4			1

Next smallest processing time is 4 for job 5 of machine 'B'

2	4		5	1

Finally job 3 is left it is placed in the left over space.

2	4	3	5	1

The sequence of jobs that minimizes total elapsed time to complete the jobs on time is

$2 \rightarrow 4 \rightarrow 3 \rightarrow 5 \rightarrow 1$

Calculation of Total Elapsed Time and Total Idle Time

Jobs	Machine-A				Machine-B			
	In Time	Process Time	Out Time	Idle Time	In Time	Process Time	Out Time	Idle Time
2	0	1	1	0	1	6	7	1
4	1	3	4	0	7	8	15	0
3	4	9	13	0	15	7	22	0
5	13	10	23	0	23	4	27	1
1	23	5	28	0 + 2	28	2	30	1
				2				3

The minimum elapsed time is 30 hours.

Total idle time for Machine 'A' is 2 hours.

Total idle time for machine 'B' is 3 hours.

5 hours

4. There are seven jobs that must be processed in two operations A and B All seven jobs must go through A and B in that sequence A first, then B.The time Required for processing the job in each of the process A and B is indicated below:

Job	Time for process A (hours)	Time for process B(hours)
1	9	6
2	8	5
3	7	7
4	6	3
5	1	2
6	2	6
7	4	7

a) Determine the optimal order in which the jobs should be sequenced through the process.

b) What is the total time for all seven jobs?

Sol : **(Oct.-22)**

The sequence of Jobs that minimize total elapsed time to complete the Jobs on time is

5	6	7	3	1	2	4

Calculation of total elapsed time and total Idle time

Jobs	Machine A				Mechine B			
	In Time	Process Time	Out Time	Idle Time	In Time	Process Time	Out Time	Idle Time
5	0	1	1	0	1	2	3	1
6	1	2	3	0	3	6	9	0
7	3	4	7	0	9	4	13	0
3	7	7	14	0	13	7	20	0
1	14	9	23	0	20	6	26	0
2	23	8	31	0	26	5	31	0
4	31	6	37	0+3	37	3	40	6
				3				7

The minimum elapsed time is 40 hours.

Total idle time for Machine A is 3 hours

Total idle time for Machine B is 7 hours.

10 hours

4.2.1 Extension of Johnson's Rule

Q7. How is sequencing for 'n' Jobs on three Machines.

(OR)

Write the algorithm for 'n' jobjs on 3 machines.

Ans :

If the problems are of A'jobs on three machines, first it must be converted into *N* jobs on two machines. Inorder to convect the following procedure is followed,

Optimal solution for sequencing problems involving N jobs on three machines can be obtained by extending the Johnson's rule. To adopt this method, either or both of the following conditions should be satisfied. If not adopt CDs method.

Step 1

Consider three machines A, B and C on which 'N' jobs have to be performed in the order ABC.

Condition 1

The minimum of the times for different jobs on machine A is at least equal to the maximum of the times of different jobs on machine B.

i.e., $\boxed{\min A_i \geq \max B_i}$

Condition 2

The minimum of the times for different jobs on machine *C* is at least equal to the maximum of the times of different jobs on machine *B.*

i.e., $\boxed{\min C_i \geq \max B_i}$

Step 2

Replace the given problem with the equivalent problem involving N jobs and two fictitious (imaginary) machines and H with processing times as follows,

$G_1 = A_1 + B$. (i.e., i = 1, 2, ..., n) and

$H_1 = B_1 + C$ (i.e., i = 1, 2, ..., n)

Step 3

For problem obtained in step 2, apply the method of Johnson's rule adopted for sequencing 'N' jobs through two machines.

Step 4

Identify the smallest processing times among G_1's and H_1's.

Step 5

If the smallest time is on machine G, place the job in the beginning of the sequence. If the smallest time is on machine H, place the job to the last in the sequence.

Step 6

Delete the assigned job from processing time, repeat steps 4 and 5 for the remaining jobs till all the jobs are assigned.

Step 7

The sequence so obtained is optimal sequence for the original problem and compute total elapsed time and idle time using this sequence for each machine.

Methodology to Find the Idle and Elapsed Time

Step 1

Determine table formation based on process time.

Step 2

To find idle time on machine-1 for N-jobs.

Idle time on machine-1 is given by,

[Total elapsed time] – [Time when the last job in a sequence finishes on machine-1]

Step 3

To find idle time on machine 2 for N-jobs.

Idle time on machine 2 is given by,

[Time at which the first job in sequence starts on machine-2] + $\sum_{k=2}^{n}$[Time when the k^{th} job in a sequence starts on machine - 2 – Time when the $(k-l)^{th}$ job in a sequence finishes k - 2 on machine - 2] + [Time at which the last job in a sequence finishes on machine - Time at which the last job in a sequence finishes on machine-2]

Step 4

To find idle time on machine-3 for N jobs

Idle time on machine-3 is given by,

[Time when the first job in a sequence starts on machine-3] + $\sum_{k=2}^{n}$ [Time when the k^{th} job in a sequence starts on machine-3 – Time when the $(k-l)^{th}$ job in a sequence finishes on machine-3]

Step 5

Total elapsed time is given by,

Time when the last job on last machine in the sequence finishes.

PROBLEMS

5. A shoe manufacturer has to process 6 items through three stages of production i.e., cutting, pasting and curing. The time taken for each of these items at the different stages are given below in hours.

Item	A	B	C	D	E	F
Cutting	4	1.5	3.5	1	2.5	0.5
Pasting	1.5	2	2.5	1	0.5	3
Curing	4	3.5	3	4.5	5	4.5

Find an order in whihc these items can be processed in minimum time.

Sol :

Item	A	B	C	D	E	F
Cutting	4	1.5	3.5	1	2.5	0.5
Pasting	1.5	2	2.5	1	0.5	3
Curing	4	3.5	3	4.5	5	4.5

Johnson's Rule (Extension)

Step 1

Check the condition

Condition 1

Min(Cutting) $\geq$ Max (Pasting)

$0.5 \not\geq 3$

$\therefore$ Condition not satisfied

Condition 2

Min(Curing) $\geq$ Max (Pasting)

$3 \geq 3$

$\therefore$ Condition satisfied

Condition 2 is satisfied. So proceed to step 2.

Step 2

Create two fictitious machines,

G and H

G = Cutting + Pasting

H = Pasting + Curing

Jobs / Fictitious	A	B	C	D	E	F
G	5.5	3.5	6	2	3	3.5
H	5.5	5.5	5.5	5.5	5.5	7.5

Processing Time Table

Step 3

Apply Johnson's rule to the above table and get the optimal sequence.

Step 4

Select the least processing. If this occurs in machine G, then place it in the beginning of the sequence, otherwise place it at the end. Repeat the same process for the remaining jobs.

The smallest prossing time = 2 minutes for job D on machine G. Since this time is on first machine place job D at the beginning of the sequence.

Sequence	D					

Delete job D from processing time table.

Jobs / Fictitious	A	B	C	E	F
G	5.5	3.5	6	3	3.5
H	5.5	5.5	5.5	5.5	7.5

Processing Time Table

In the above table, the smallest processing time = 3min i.e., for job E on machine G. Since, it is on first machine, place the job E in the beginning after D.

Sequence	D	E				

Delete job E from processing time table. Continue the same process for all jobs.

Hence,

Optimal sequence	D	E	B	F	A	C

Computation of Times

Job Sequence	Cutting				Pasting				Curing			
	In Time	Process Time	Out Time	Idle Time	In Time	Process Time	Out Time	Idle Time	In Time	Process Time	Out Time	Idle Time
D	0	1	1	0	1	1	2	1	2	4.5	6.5	2
E	1	2.5	3.5	0	3.5	0.5	4	1.5	6.5	5	11.5	0
B	3.5	1.5	5	0	5	2	7	1	11.5	3.5	15	0
F	5	0.5	5.5	0	7	3	10	0	15	4.5	19.5	0
A	5.5	4	9.5	0	10	1.5	11.5	0	19.5	4	23.5	0
C	9.5	3.5	13	0+13.5	13	2.5	15.5	1.5+11	23.5	3	26.5	0
				13.5				16				2

Note

Idle time of machine (cutting) for Job C is 13.5 (26.5 – 13)

Additional idle time for machine (pasting) for Job C is 11(i.e., 26.5 – 15.5).

Total elaspsed time = 26.5 minutes.

Idle times for machines

Cutting = 13.5 minutes i.e., 0 + (26.5 – 13)

Pasting = 16 minutes i.e., 1.5 + (26.5 – 15.5)

Optimal sequence is given by

D	E	B	F	A	C

6. You are given the following data regarding the processing times of some jobs on three machines I, II and III. The order of processing is I-II-III. Determine the sequence that minimizes the total elapsed time (T) required to complete the jobs. Also evaluate T and the idle time of II and III.

Jobs	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Processing Times in House Machine I	**3**	**8**	**7**	**4**	**9**	**8**	**7**
Machine II	**4**	**3**	**2**	**5**	**1**	**4**	**3**
Machine III	**6**	**7**	**5**	**11**	**5**	**6**	**12**

Sol : **(Aug.-12)**

Johnson's Rule (Extension)

Step 1

Check the condition

Condition 1

$Min_1 \geq Max_{11}$

$3 \not\geq 5$ condition not satisfied

Condition 2

$Min_{III} \geq Max_{II}$

5 = 5 condition satisfied

Since condition 2 has been satisfied, go to step 2.

Step 2

Create two fictitious machines G and H.

G = Machine I + Machine II

H = Machine II + Machine III

	A	**B**	**C**	**D**	**E**	**F**	**G**
G	7	11	9	9	10	12	10
H	10	10	7	16	6	10	15

Step 3

The jobs are sequenced using Johnson's rule

Sequence I

						E

Sequence II	A					C	E
Sequence III	A	D				C	E
Optimal sequence	A	D	G	F	B	C	E

Computation of Times

Job	Machine I				Machine II				Machine III			
	In Time	Process Time	Out Time	Idle Time	In Time	Process Time	Out Time	Idle Time	In Time	Process Time	Out Time	Idle Time
A	0	3	3	0	3	4	7	3	7	6	13	7
D	3	4	7	0	7	5	12	0	13	11	24	0
G	7	7	14	0	14	3	17	2	24	12	36	0
F	14	8	22	0	22	4	26	5	36	6	42	0
B	22	8	30	0	30	3	33	4	42	7	49	0
C	20	7	37	0	37	2	39	4	49	5	54	0
E	37	9	46	0 + 13	46	1	47	7+12	54	5	59	0
Total				13				37				7

Note

Total elapsed time = 59 minutes

Idle Time

Machine I = 13 minutes (i.e., 59 – 46)

Machine II = 37 minutes [(i.e., 7 + (59 – 47))]

Machine III = 7 minutes

Total idle time = 57 minutes

7. Consider the following three machines and 5 jobs flow shop problem. Apply Johnson's group technology layout.

Jobs	Processing Time		
	Machine	Machine	Machine
	1	2	3
1	8	5	4
2	10	6	9
3	6	2	8
4	7	3	6
5	11	4	5

Sol : **(June-18)**

Johnson's Rule (Extension)

Step-1

Check if either or both the following conditions satisfied.

Condition

Min $M_1 \geq$ Max M_2

Minimum processing time on machine $M_1 = 6$

Maximum processing time on machine $M_2 = 6$

$6 = 6$

$\therefore$ Min M_1 = Max M_2

Condition is satisfied.

Since, condition - 1 has satisfied no need to check condition - 2.

Step - 2

Creating two fictitious machines G and H with processing times are follows,

$G = M_1 + M_2$

$H = M_2 + M_3$

Jobs	Machines	
	G	H
1	8 + 5	5 + 4
2	10 + 6	6 + 9
3	6 + 2	2 + 8
4	7 + 3	3 + 6
5	11 + 4	4 + 5

New processing time table (in minutes).

Machine/Jobs	1	2	3	4	5
G	13	16	8	10	15
H	9	15	10	9	9

Step-3

Applying Johnson's rule of processing 'n' jobs though two machines.

The minimum time is 9 under H, so it has to be sequenced at extreme right.

2	3	5	1	4

Job	Machine M_1				Machine M_2				Machine M_3			
	In Time	Process Time	Out Time	Idle Time	In Time	Process Time	Out Time	Idle Time	In Time	Process Time	Out Time	Idle Time
2	0	10	10	0	10	6	16	10	16	9	25	16
3	10	6	16	0	16	2	18	0	25	8	26	0
5	16	11	27	0	27	4	31	9	31	5	36	5
1	27	8	35	0	35	5	40	4	40	4	44	4
4	35	7	42	0 + 9	42	3	45	2 + 6	45	6	51	1
				9				31				26

Therefore, total elapsed time = 51 minutes

Idle time for M_1 = 9 minutes (51 – 42)

Idle time for M_2 = 31 minutes

Idle time for M_3 = 26 minutes.

8. Consider the following three machines and five jobs flow shop problem. Check if Johnson's rule can be extended to this problem. If so, what is the optimal schedule and the corresponding makes pan ?

Job	Machine 1	Machine 2	Machine 3
1	11	10	12
2	13	8	20
3	15	6	15
4	12	7	19
5	20	9	7

Sol : **(Dec.-18)**

Step 1

Check if either (or) both the following conditions statisfied

Condition

Min $M_1 \geq$ Max M_1

Minimum processing time on machine, M_1 = 11

Maximum processing time on machine, M_2 = 10

11 > 10

$\therefore$ Min M_1 > Max M_2

Condition 1 is satisfied.

Since, condition - 1 has satisfied no need to check condition 2.

Step 2

Creating two fictitious machine G and H with processing times as follows,

$G = M_1 + M_2$

$H = M_2 + M_3$

Jobs	Machines	
	G	H
1	11 + 10	10 + 12
2	13 + 8	8 + 20
3	15 + 6	6 +15
4	12 + 7	7 + 19
5	20 + 9	9 + 7

New processing trime table (in minutes)

Machine / Jobs	1	2	3	4	5
G	21	21	21	19	1929
H	22	28	21	26	16

Step 3

Applying Johnson's rule of processing 'n' Jobs through 2 machines.

The minimum time is 16 under machine H, so, it has to be sequence at extreme right.

				5

By following the above procedure, we get the sequence as,

4	1	2	3	5

Computation of Times

Job	Machine M_1				Machine M_2				Machine M_3			
	In Time	Process Time	Out Time	Idle Time	In Time	Process Time	Out Time	Idle Time	In Time	Process Time	Out Time	Idle Time
4	0	12	12	0	12	7	19	12	19	19	38	19
1	12	11	23	0	23	10	33	4	38	12	50	0
2	23	13	36	0	36	8	44	3	50	20	70	0
3	36	15	51	0	51	6	57	7	70	15	85	0
5	51	20	71	0 + 21	71	9	80	14 + 12	85	7	92	0
Total				21				52				19

Therefore, total elapsed time = 92 hours

Idle time for machine, M_1 = 21 minutes (92 – 71)

Idle time for machine, M_2 = 52 minutes (92 – 80)

Idle time for Machine, M_3 = 19 minutes

9. Consider the following 3 machine and 5 job flow shop problem:

JOB	Processing time in hours at Machine 1	Processing time in hours at Machine 2	Processing time in hours in Machine 3
1	10	10	12
2	12	8	20
3	16	6	14
4	12	4	20
5	20	8	8

(a) Check whether Johnson's algorithm can be extended to this problem.

(b) If yes, find the optimal sequence and the corresponding make-span.

Sol : **(Aug.-21)**

(a) Johnson's Rule (Extension)

Johnson's algorithm can be extended to the given problem.

Step - 1

Check if either or both the following condition satisfied.

Condition

Min $M_1 \geq$ Max M_2

Minimum processing time on machine-1 (M_1) = 10

Maximum processing time on machine-2 (M_2) = 10

10 = 10

$\therefore$ Min M_1 = Max M_2

Condition 1 is satisfied.

Since, condition-1 is satisfied no need to check condition-2.

Step-2

Creating two fictitious machines G and H with processing times as follows,

$G = M_1 + M_2$

$H = M_2 + M_3$

Jobs	Processing Time	
	Machine-G	Machine-H
1	10 + 10	10 + 12
2	12 + 8	8 + 20
3	16 + 6	6 + 14
4	12 + 4	4 + 20
5	20 + 8	8 + 8

New processing time in hours

Jobs	1	2	3	4	5
Machine-G	20	20	22	16	28
Machine-H	22	28	20	24	16

Computation of Times

Job	Machine - 1				Machine - 2				Machine - 3			
	In Time	Process Time	Out Time	Idle Time	In Time	Process Time	Out Time	Idle Time	In Time	Process Time	Out Time	Idle Time
4	0	12	12	0	12	4	16	12	16	20	36	16
1	12	10	22	0	22	10	32	6	36	12	48	0
2	22	12	34	0	34	8	42	2	48	20	68	0
3	34	16	50	0	50	6	56	8	68	14	82	0
5	50	20	70	0+20	70	8	78	14+12	82	8	90	0
				20				**54**				**16**

Therefore, Total elapsed time = 90 hours

Idle time for machine-1 = 20 hours (i.e., 90 – 70 = 20)

Idle time for machine-2 = 54 hours (Total idle time of machine-2 + differences between out times of machine-3 and machine-2).

Idle time for machine-3 = 16 hours.

Q8. What are the set of priority rules for scheduling jobs through single machine? Explain briefly each of them.

Ans : **(Dec.-18)**

Single machine scheduling is a simple and basic scheduling problem which deals with limited number of resources. It is a scheduling technique which involves single processor and n jobs wherein each job is assigned with one particular operation. Single machine scheduling was studied and Nanot's ten priority rules were elaborated by Nair. Ten priority rules of scheduling developed by Mr. Nanot are as follows,

1. FCFS = Based on first come first served rule priority is assigned to jobs.
2. SPT = Based on shortest processing time, priority is assigned to jobs.
3. SS = Jobs with smallest static slack is assigned with first priority.
4. SS/ST = Jobs with lowest SS/ST ratio is assigned with first priority.
5. SS/RO = Jobs with lowest SS/RO ratio comes first in priority.
6. FISFS = Based on first in system first served rule, priority is assigned to jobs.
7. LCFS = Based on last come first served rule, priority is assigned to jobs.

8. DS = Jobs with lowest dynamic slack comes first in priority.

9. DS/PT = Jobs with lowest DS/PT ratio is given first priority.

10. DS/RO = Jobs with lowest DS/RO ratio is given first priority.

The above mentioned acronyms and important terminology used in scheduling stands for:

FCFS wherein first come will be served first. Job which arrives first in waiting line will be processed first. SPT means Shortest Process Time. Here, job with shortest processing time among all jobs in waiting line will be processed first.

Slack time is the time gap between processing time and deliver due date.

Static slack is the time gap between delivery due date and arrival date at work centre.

Dynamic slack is the time gap between static slack and processing time.

RO stands for remaining operations which are expressed in terms of numbers.

Earliest due date implies that job with closest delivery date among all jobs in waiting line is processed first. Weighted Shortest Process Time (WSPT) means job with weighted shortest processing time in waiting line will be processed first.

Longest Processing Time (LPT) means job with longest processing time among all jobs in waiting line will be processed first. Longest Alternate Processing Time (LAPT) means job to be processed on alternative machine which possess longest processing time among all the jobs in waiting line.

4.3 JOB SHOP SCHEDULING

4.3.1 Introduction

Q9. Explain the concept of Job Shop Scheduling.

(OR)

What is meant by Job Shop Scheduling problem.

Ans : **(Dec.-19)**

Meaning

i) In job shop problem, we assume that each job has m different operations. If some of the jobs are having less than m operations, required number of dummy operations with zero process times are assumed.

ii) By this assumption, the condition of equal number of operations for all the jobs is ensured. In job shop scheduling problem, the process sequences of the jobs are not the same. Hence, the flow of each job in job shop scheduling is not unidirectional.

iii) The time complexity function of the job shop problem is combinatorial in nature. Hence, heuristic approaches are popular in this area.

iv) Unlike the flow shop model, there is no initial machine that performs only the first operation of a job, nor is there a terminal machine that performs only the last operation of a job.

v) In the flow shop, an operation number in the operation sequence of a job may be same as the position number of the required machine.

vi) Hence, there is no need to distinguish between them. But, in the job shop case, different jobs will have different operation sequences.

vii) So, we cannot assume a straight flow for the job shop problem. Each operation j in the operation sequence of the job i in the job shop problem will be described with triplet (i, j, k) where k is the required machine for processing the /th operation of the rth job.

4.3.2 Types of Schedules

Q10. What are the different types of schedules available for job shop problem?

(OR)

Discuss different types of schedules in detail.

(OR)

Explain various types of schedules

Ans : **(Dec.-19, June-18)**

1. Local-left Shift

In local-left shift, some operations may be started earlier in time without affecting the sequence of operations.

2. Global-left Shift

In global-left shift, few operations are started earlier in time without causing any delay in any other operation. Global left-shift affects the sequence of operations. Based on the above two concepts, schedules for job shop problem have been classified into three types:

i) Semi-active schedule

ii) Active schedule

iii) Non-delay schedule.

i) Semi-active Schedule: A semi-active schedule does not contain superfluous idle time. It is a schedule where no local left-shift exists.

ii) Active Schedule: An active schedule is a schedule in which no global left-shift exists i.e., no operation can be started earlier without delaying any other operation.

iii) Non-delay Schedule: A non-delay schedule is a schedule in which none of the machines is kept idle at a time, when such machine could start processing certain operations.

4.3.3 Schedule Generation

Q11. Explain briefly about Schedule Generation.

(OR)

Explain various types of Schedule Generation.

Ans : **(Dec.-19)**

The schedule generation process plays a significant role in job shop scheduling. It is an important phase of job shop scheduling. The process of generating schedules are classified into two mechanisms. They are,

1. Single-pass Mechanism

In this mechanism, the start/beginning time of every operation is fixed forever. A complete schedule could be generated via single pass through the list of operations.

2. Adjusting Mechanism

Under adjusting mechanism, the start/beginning time of each operation is not permanently fixed. The start time of each operation is re-assigned as and when the successive operation is added to the schedule.

The scheduling decisions in job shop problem becomes essential when any machine is idle. Such decision will be either to leave the machine idle or assign any operation from the list of operations waiting for processing. This kind of decisions are taken through dispatching procedure. Dispatching procedures are single-pass mechanisms/procedures and are essential for schedule generation. In case of dispatch procedures, an operation is taken into account only if all the predecessors of such operation are scheduled one. The number of stages for a single-pass procedure will be equivalent to the total number of operations or nm.

nm = Number of jobs × Number of operations

4.4 Heuristic Procedures

4.4.1 Priority Dispatching Rules

Q12. Write about heuristic procedures and priority dispatching rules ?

(OR)

"Heuristic procedure is a quantitative technique for getting an optimal solution of a general job shop problem".

Ans : **(Oct.-20)**

Since, the job shop problem comes under combinatorial category, the time taken to obtain optimum solution will be exponential in nature. In this type of problem, the number of feasible schedules will grow

exponentially, even for small increment in problem size. As a result, it will be impossible to solve large size problems optimally. Hence, we should resort to heuristic approach to get near optimal solution.

In complete enumeration procedure or branch and bound procedure, the number of schedules generated before reaching an optimal schedule would be enormous. But, heuristic procedures will generally aim to generate only one full schedule. Whenever there is a tie (conflict) in selecting an operation from among competing operations, we will have to use a priority rule. If there are ties at different levels, then we need more than one priority rule to break deep ties. For a given priority rule R, a heuristic based on the active schedule generation is given below.

Heuristic active schedule generation

Step 1: Let t = 0 and assume $P_t = \{0\}$.

S_t = {All operations with no predecessors}.

Step 2: Determine $q^* = \min [q_j]$ and the corresponding machine m* on which q* could be realized.

Step 3: For each operation which belongs to S_t that requires machine m* and satisfies the condition $p_t < q^*$, identify an operation according to a specific priority and add this operation to P_t as early as possible, thus creating only one partial schedule, P_{t+1} for the next stage.

Step 4: For each new partial schedule P_{t+1} created in Step 3, update the data set as follows:

(a) Remove operation j from S.

(b) Form S_r + i by adding the direct successor of operation j to S.

(c) Increment t by one.

Step 5: Repeat from Step 2 to Step 4 for each P_{t+1} created in Step 3 and continue in this manner until all active schedules are generated.

Similarly, another heuristic can be devised for the non-delay schedule generation algorithm by replacing the condition pj < q* with pj = p* in Step 3. These two heuristic algorithms (one for active dispatching and the other for non-delay dispatching) may construct different schedules. The quality of the solution obtained by these heuristics mainly depends on the effectiveness of priority rules which are used in them.

A sample set of priority rules are presented below.

(a) SPT (shortest processing time). Select the operation with the minimum processing time.

(b) FCFS (first come first served). Select the operation that entered S, earliest.

(c) MWKR (most work remaining). Select the operation associated with the job having the most work remaining to be processed.

(d) MOPNR (most operations remaining). Select the operation that has the largest number of successor operations.

(e) LWKR (least work remaining). Select the operation associated with the job having the least work remaining to be processed.

(f) RANDOM (Random). Select the operation at random.

To illustrate the calculations involved in priority dispatching rules, let us assume that MWKR is applied to the non-delay schedules for the example problem given earlier in this lesson.

The construction of a complete schedule for this problem requires 12 stages because there are 12 operations. At each stage, it is necessary to identify the jobs in S, and to keep track of the times that the machines are available for processing. These times are denoted as f_k.R_j is the work remaining on the job associated with operation j.

4.4.2 Two Jobs and m Machines Scheduling

Q13. Write the algorithm to solve Two Jobs and m Machines Scheduling.

Ans :

This type of sequencing problem deals with two jobs to be processed through 'm' machines with main objective of determining optimum solution or sequence that minimizes total elapsed time. The steps involved in solving two jobs and 'm' machines sequencing problem are as follows.

Step 1

Draw two mutually perpendicular lines (i.e., X and Y axes) with horizontal line representing processing time for job 1, while 2nd job remains idle and vertical line represents processing time for job 2 while job 1 remains idle.

Step 2

Mark the processing time for jobs 1 and 2 on horizontal and vertical lines respectively according to the given problem.

Step 3

Construction of various blocks with respect to each machine considering the time at which it will be used for job 1 and job 2.

PROBLEM

10. Consider a flow shop the has only two processors. A job is completed first on processor 1 and then on processor 2. The data for 10 jobs are as follows,

Job	1	2	3	4	5	6	7	8	9	10
Processor 1	2	7	9	0	3	10	1	5	6	8
Processor 2	6	8	4	10	9	7	5	1	2	3
Due date	25	19	30	25	16	55	60	32	45	39

(a) Determine the schedule that minimizes the maximum flow time.

(b) What is the maximum flow time for your schedule?

(c) How many jobs are tardy in your schedule?

Sol.: **(April-23, May-19, Imp.)**

Johnson's Procedure for Flow Shop Scheduling

Step-1

Ascertain the minimum processing time on both the machines i.e., (Processor 1 and 2).

Step-2:

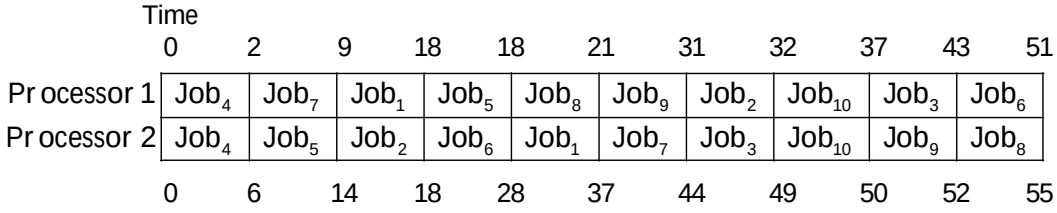
(a) If in case, the machine 1 (processor 1) has the minimum processing time, then place it in the first position.

(b) If in case, the machine 2 (processor 2) has the minimum processing time, then place it in the last position.

Step-3

The job which is sequenced either by step 2(a) or step 2(b) will be removed. The process would be repeated again starting from the step 1, till all the jobs are scheduled. Ties must be broken arbitrarily.

(a) Determination of the Schedule



(b) (i) Determining the Maximum Flow Time of the Schedule for Processor 1

Job	Processor 1 (p_i)	Due date (d_i)	Completion time for SPT schedule (c_i)	Flow time (f_i) $f_i = c_i$
1	2	25	3	3
2	7	19	24	24
3	9	30	41	41
4	0	25	0	0
5	3	16	6	6
6	10	55	51	51
7	1	60	1	1
8	5	32	11	11
9	6	45	17	17
10	8	39	32	32

Maximum flow time for processor 1 is 51 for job 6.

(ii) Determining the Maximum Flow Time of the Schedule for Processor 2

Job	Processor 2 (p_i)	Due date (d_i)	Completion time for SPT schedule (c_i)	Flow time (f_i) $f_i = c_i$
1	6	25	40	40
2	8	19	27	27
3	4	30	49	49
4-	10	25	10	10
5	9	16	19	19
6	7	55	34	34
7	5	60	45	45
8	1	32	55	55
9	2	45	54	54
10	3	39	52	52

Maximum flow time for processor 2 is 55 for job 8.

(c) (i) Determining the Number of Tardy Jobs in Processor 1

Job	Processor 1 (p_i)	Due date (d_i)	Completion time (c_i)	Tardy jobs ($c_i - d_i$)
1	2	25	3	0
2	7	19	24	5
3	9	30	41	11
4	0	25	0	0
5	3	16	6	0
6	10	55	51	0
7	1	60	1	0
8	5	32	11	0
9	6	45	17	0
1 0	8	39	32	0

Conclusion

From the above computation, it is clear that there are two tardy jobs. The first tardy job is 2 and the second tardy job is 3.

(ii) Determining the Number of Tardy Jobs in Processor 2

Job	Processor 2 (p_i)	Due date (d_i)	Completion time (c_i)	Tardy jobs ($c_i - d_i$)
1	6	25	40	15
2	8	19	27	8
3	4	30	49	19
4	10	25	10	0
5	9	16	19	3
6	7	55	34	0
7	5	60	45	0
8	1	32	55	23
9	2	45	54	9
10	3	39	52	13

Conclusion

From the above calculation, it is clear that there are tardy jobs on 7 jobs i.e., 1, 2, 3, 5, 8, 9 and 10.

4.5 Quality Control Concepts

Q14. What is Quality Control? What are its objectives and benefits?

(OR)

Explain about the concept of quality control.

Ans : **(Oct.-20)**

Meaning

i) Quality control refers to all those functions or activities that must be performed to fill the company's quality objectives.

ii) Quality control on the other hand, may also include establishment of criteria for the selection of production equipment, tooling and personnel.

iii) It often involves statistical analysis (referred to as statistical quality control or SQC).

iv) Quality control aims at investigating the root cause for defects identified by inspection and take corrective action to overcome the defects for future production.

v) For instance, a defect observed in a product may be due to defective design, defective machine or defective workmanship of the worker. The exact reason for the defect is identified and appropriate corrective action is taken.

Objectives

i) The ultimate aim of quality control is to provide products which are dependable, satisfactory and economical.

ii) A quality control system is designed to ensure economical production of products of uniform quality which is acceptable to the customer.

Benefits

i) Minimum scrap or rework due to reduced defectives.

ii) Reduced cost of labour and material as a result of reduced defectives.

iii) Uniform quality and reliability of product help in increasing sales turn over.

iv) Reduced variability resulting in-higher quality and reduced production bottle necks.

v) Reduced inspection and reduced inspection costs.

vi) Reduced customer complaints.

vii) Increased quality consciousness among employees.

viii) Higher operating efficiency.

ix) Better utilisation of resources.

x) Better customer satisfaction and employee satisfaction.

Q15. What are the functions of quality control?

Ans :

Following are the functions of quality control:

i) To design the product or service in such a way that it meets customers requirements.

ii) Use of substandard material or components might effect the quality of the produced, products. Hence, the quality control personnel should see that the purchased materials, parts, components, etc. are of standard quality.

iii) To identify and provide information on causes of variations in production process, so that corrective action is taken.

iv) To see that the produced or service meets safety conditions. Especially in case of electrical, electronic and perishable products.

v) To reduce the proportion of scrap, wastage and spoilage during the process.

vi) To provide satisfactory product support services i.e., after sales service.

vii) To make the employees quality conscious by fixing their responsibility at various stages of production.

viii) To prevent rather than detect defective items to be produced.

Q16. Explain the concept of Statistical Quality Control.

(OR)

What is Statistical Quality Control?

Ans : **(Oct.-22)**

Meaning

i) Statistical Quality Control (SQC) is the application of statistical techniques to accept or reject products already produced, or to control

the process and, therefore, product quality while the part is being made. While the latter is called process control, the former is named acceptance sampling.

ii) Mainly, SQC is used for controlling quality during production in mass production industries which produce standard products. SQC for process control is based on probability theory.

iii) It is common knowledge that when several identical parts are manufactured, some are a little large and some a little small, but most will be approximately the same.

iv) The middle or average will be the most frequent, with smaller and larger sizes as extremes from the average.

v) When the frequency or count of the items by size is plotted with size on the horizontal scale and count on the vertical scale, a normal or bell-shaped curve of the type given in Exhibit is obtained.

vi) Variations in size between 0.995 inch and 1.005 inches, with most measuring 1.000 inch are due to chance causes. Chance causes are inherent and cannot be controlled or prevented.

vii) Chance causes are ignored because any effort to eliminate them is uneconomical and may be counter-productive too. However, if the size measures beyond 1.005 inches or below 0.995 inch, it is not due to chance causes but because of assignable causes.

viii) In other words, the part is not normal. Assignable causes include internal temperature and wear am tear of the machine parts, a worn-out tool, improper dimension of raw material, or the setting of the machine being changed unintentionally.

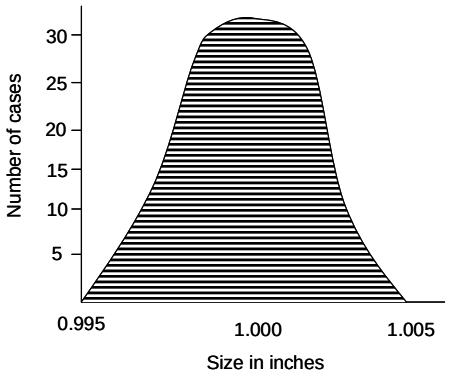


Fig. : Bell Shaped Curve

ix) When it is known that an improper size is made as a result of an assignable cause, it is possible to stop, detect the cause and rectify it.

x) In practice, SQC for process control manifests through control charts. Control charts, first developed by Dr. Walter A. Shewhart of the Bell Telephone Laboratories during the 1920s, are horizontal extensions of the bell-shaped curve.

xi) A typical control chart consists of a central line corresponding to the average quality at which the process is to perform and two other lines corresponding to the upper and lower control limits, also called the tolerance limits. The vertical scale indicates the quality variations and the horizontal scale has time.

xii) Samples of product are taken at specified time intervals, quality checked, measured, averaged and plotted on the chart. If the values plotted are within the control limits, the processing is said to be under control. If the values move away from control limits, the process must be improved.

Q17. What are the advantages of Statistical Quality Control?

Ans :

The following are the advantages of statistical quality control :

1. It helps prevent defects from occurring. Assignable causes signifying deviations in quality are detected and rectified. Costly rework, rejection, and scrap are avoided.
2. It also helps avoidance of the risk of accepting a bad lot.
3. Emphasizing on inspection of only samples, SQC avoids inspection of the entire lot.
4. It ensures the maintenance of high standards of quality and enables the users to build up their goodwill.

Q18. What are the disadvantages of Gantt chart as a scheduling tool?

Ans : **(Dec.-18)**

The following are few disadvantages of Gannt charts.

1. Gantt charts do not show the interrelation-ships among the various activities of the project.
2. Gantt charts have to be updated con-tinuously.

3. Gantt charts increase the complexity of evaluating the alternative schedules, as the processing time of the job changes on the basis of the work centre.
4. Gantt charts immediately become absolete when the changes takes place between the plan and the actual achievement.
5. Gantt charts are suitable only to small projects.
6. Gantt charts doesnot determine the progress of a project.
7. Gantt charts lack preciseness and accuracy at various stages.
8. Gantt charts fail to reschedule and remodel a project, during the times of sudden techno-logical upgradation.
9. Gantt charts fails to reflect project uncer-tainties.

Q19. Explain briefly about Control Charts.

(OR)

Discuss the various types of Control Charts used for variables and attributes.

Ans : **(Imp.)**

Types of Control Charts

Basically, there are two types of control charts:

(a) Control charts for variables,

(b) Control charts for attributes.

(a) Control Charts for Variables

This classification is based on the particular characteristic of interest. If the quality characteristic under consideration is one which can be measured in quantitative terms on a continuous scale of measurement then the control charts in respect of it would be called control charts for variable. The quality dimensions using variable control charts include characteristics like length, width, depth, tensile strength, thickness, elasticity, moisture content etc.

i) Mean Chart - X Bar Chart

The control chart for means, (averages) controls the process average or mean quality level. These charts are also called X bar chart'. The Upper Control Limit (UCL) and Lower Control Limit (LCL) for the X bar charts are calculated with the help of following formulas,

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

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

Value of $\bar{\bar{X}}$ = Center Line (CL).

ii) Range Chart - R Chart

The control chart for range controls the process range. These charts are also called as R charts. The upper control limit (UCL) and lower control limit (LCL) for the R charts are calculated as follows,

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

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

Value of $\bar{R}$ = Center line.

iii) σ Charts for Standard Deviation

The charts for standard deviation are also called 's charts', 'σ' charts are mainly used for controlling the variability of larger sample sizes. The upper control limit (UCL) and lower control limit (LCL) of s charts are calculated with the help of the following formulas,

$$UCLs = B_4\bar{s}$$

$$LCLs = B_3\bar{s}$$

The quality characteristic in question here is capable to direct quantitative measurement. What is done in such a case is that a number of samples 'k' of the product or the component, each of the same size 'w' are selected randomly from the process in a certain period of time. Then the average, in terms of mean, and variability, in terms of range (or standard deviation), of the characteristic in each of the samples taken are measured.

(b) Control Charts for Attributes

On the other hand, if the characteristics cannot be measured, but instead, the items can be classified as being either defective or non-defective (for example the picture tubes used in TV sets can be either working or defective), or if the number of defects in an item may be known (for example, the number of weaving defects in a hundred-meter cloth length, air holes in glass bottles knots and other defects in lumber). We shall have control charts for attributes.

i) Construction of 'np' chart (Number of defective chart) for constant sample size 'n'.

Sample size = n. Number of sub-groups = K

Number of defectives per sub-group = C

Fraction defective $p = \frac{c}{n}$, calculated for each of K sub - groups i.e.,

$$p_1 = \frac{c_1}{n}, p_2 = \frac{c_2}{n} \ldots p_k = \frac{c_k}{n}$$

Average fraction defective,

$$\bar{p} = \frac{\Sigma p}{K} = \frac{p_1 + p_2 + \ldots . p_k}{K}$$

$$\bar{p} = \frac{\frac{c_1}{n} + \frac{c_2}{n} + \ldots . \frac{c_k}{n}}{K} = \frac{c_1 + c_2 + c_3 + \ldots . c_k}{K}$$

$$\bar{p} = \frac{\Sigma c}{nK}$$

Central line, $n\bar{p} = n \times \frac{\Sigma c}{n \times K} = \frac{\Sigma c}{K}$

Upper control limit (UCL) = $n\bar{p} + \sqrt[3]{n\bar{p}(1-\bar{p})}$

Lower control limit (LCL) = $n\bar{p} - \sqrt[3]{n\bar{p}(1-\bar{p})}$ = zero (if negative)

Test for homogeneity should be done by comparing all individual values of np (or c) with the values of UCL and LCL and discarding the sample results for any group for which np (or C) value falls outside the limit values. Again the values of modified CL, UCL and LCL have to be calculated for the homogenised or rational sub-groups.

The 'np' chart is drawn is drawn as shown in exhibit below:

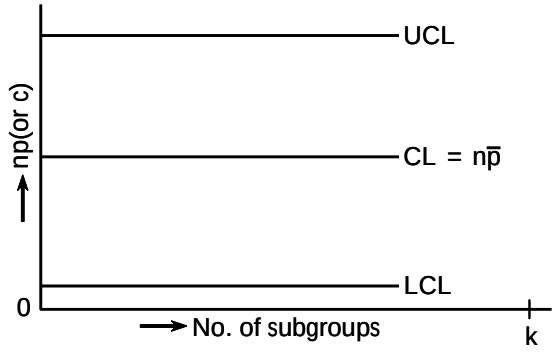


Fig.

ii) Construction of 'p' chart (Fraction defective chart) for varying sample size

The data collected gives the sample size (n_1, n_2 .... n_k) for k sub groups and values of number of defectives (c_1, c_2 ... c_k) for k sub groups. Fraction defective for each sub-group are calculated as $p_1 = \frac{c_1}{n_1}$, $p_2 = \frac{c_2}{n_2}$ .... $p_k = \frac{c_k}{n_k}$.

Central line $\bar{p} = \frac{\Sigma p}{K} = \frac{p_1 + p_2 + p_k}{K}$

Upper control limit (UCL) for each sub-group = $\bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{\text{Sample size}}}$

Lower control limit (LCL) for each sub-group = $\bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{\text{Sample size}}}$

Since sample size varies for each sub-group; there will be as many values of LCL and UCL as the number of values of sample size. (i.e., n_1, n_2, ... n_k). The chart is drawn as shown.

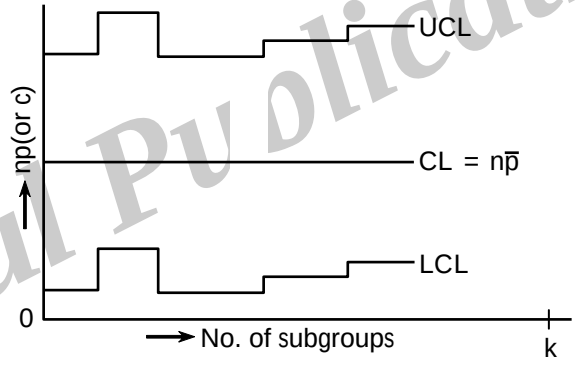


Fig.

iii) Construction of 'C' chart (Number of defect's chart)

The data regarding the number of defects existing in all the samples in each sub-groups ae collected for 'K' sub-groups each of sample size n. The number of defects per sub-groups are say c_1, c_2, ... c_k.

Then central line (CL) $\bar{c} = \frac{\Sigma c}{K} = \frac{c_1 + c_2 \ldots c_k}{K}$

Upper control limit (UCL) for each sub-group = $c - 3\sqrt{c}$

Lower control limit (LCL) for each sub-group = $c - 3\sqrt{c}$

Test for homogeneity is done by comparing the individual values of c_1, c_2, ... c_k with the control limit values and discarding, the sub-groups for which values of 'c' fall beyond the limit values. For the remaining sub-group, modified values of c, UCL and LCL are calculated till homogeneity is obtained. The chart is drawn as below:

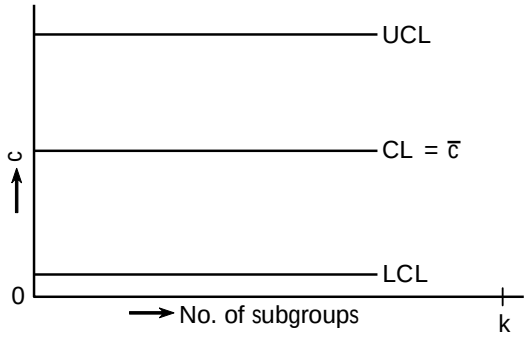


Fig.

iv) Construction of 'u' chart ('No. of defects per unit' chart for varying sample size)

Data regarding the sample size and he number of defects in all the samples in each subgroups are collected of K sub-groups. Let C_1, C_2, ... C_K be the number of defects per sub-group for K sub-groups each having sample size varying from n_1 ; ... to n_k.

Numer of defects per sub-group $u = \frac{c}{n}$ or $\frac{c}{\text{Sample size}}$

i.e., $u_1 = \frac{c_1}{n_1}$; $u_2 = \frac{c_2}{n_2}$; .... $u_k = \frac{c_k}{n_k}$

Central time (CL), $\bar{u} = \frac{\Sigma u}{K} = \frac{u_1 + u_2 .... u_k}{K}$

Upper control limit (UCL) for each sub-group = $\bar{u} + 3\sqrt{\frac{\bar{u}}{\text{Sample size}}}$

Lower control limit (LCL) for each sub-group = $\bar{u} - 3\sqrt{\frac{\bar{u}}{\text{Sample size}}}$

PROBLEMS

11. Construct both $\bar{X}$ and R chart from the following data.

Sub-group number	$\bar{X}$	R	Sub-group number	$\bar{X}$	R
1	6.36	0.10	11	6.32	0.18
2	6.38	0.18	12	6.30	0.10
3	6.35	0.17	13	6.34	0.11
4	6.39	0.20	14	6.39	0.14
5	6.32	0.15	15	6.37	0.17
6	6.34	0.16	16	6.36	0.15
7	6.40	0.13	17	6.35	0.18
8	6.33	0.18	18	6.35	0.13
9	6.37	0.16	19	6.34	0.18
10	6.33	0.13	20	6.34	0.16

Assume constant values $A_2 = 0.73$, $D_3 = 0$, $D_4 = 2.28$.

Sol :

For the construction of $\bar{X}$ – R chart.

The following formulae are used.

(a) For mean chart (X Chart) :

Central line, $\bar{\bar{X}} = \frac{\sum \bar{X}}{K}$

Where K = number of sub-groups = 20

$\bar{\bar{X}} = \frac{127.03}{20} = 6.351$ $\qquad$ $\bar{R} = \frac{\Sigma R}{K} = \frac{3.06}{20} = 0.153$

Upper control limit $UCL_{\bar{X}} = \bar{\bar{X}} + A_2 R$

$= 6.351 + 0.73 \times 0.153$

$= 6.351 + 0.112 = 6.463$

Lower control limit $LCL_{\bar{X}} = \bar{\bar{X}} - A_2 R$

$= 6.351 - 0.112 - 6.239$

(b) For range chart (R chart):

Central line $= R = 0.153$

Upper control limit $(UCL_R) = D_4 R$

$= 2.28 \times 0.153 = 0.349$

Lower control limit $(LCL_R) = D_3 R$ = Nil.

12. For the following data, construct a fraction defective chart.

Group number	Sample Size	No. of defectives
1	32	2
2	32	3
3	50	3
4	50	2
5	32	1
6	80	4
7	50	2
8	50	0
9	32	2
10	32	1

Sol :

Since the sample size is varying, we have to construct p-chart (fraction defective chart) for varying sample size. Since the sample size is varying the control chart has varying control limits.

Control line CL = $\bar{p} = \frac{\Sigma p}{K}$

$$p = \frac{c}{n} = \frac{\text{Number of defectives}}{\text{Sample size}}$$

Group Number	Fraction defective (p)
1	2/32 = 0.0625
2	3/32 = 0.0940
3	3/50 = 0.0600
4	2/50 = 0.0400
5	1/32 = 0.0300
6	4/80 = 0.0500
7	2/50 = 0.0400
8	0/50 = 0.000
9	2/32 = 0.0625
10	1/32 = 0.0300
K = 10	Total (Σp) = 0.469

$$\bar{p} = \frac{\Sigma p}{K} = \frac{0.469}{10} = 0.0649 = 0.047$$

Upper control limit (UCL) = $\bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{\text{Sample size (n)}}}$

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

Since sample size (n) is varying, we have to calculate the UCL and LCL for all sample sizes of n = 32, n = 50, n = 80.

For n = 32, $UCL = 0.047 + 3\sqrt{\frac{0.047(1-0.047)}{32}}$

$$= 0.047 + 3\sqrt{\frac{0.047 \times 0.953}{32}}$$

$$= 0.047 + 3 \times 0.037 = 0.047 + 0.111 = 0.158$$

LCL = 0.047 – 0.111 = 0 (if negative)

For n = 50, $UCL = 0.047 + 3\sqrt{\frac{0.047 \times 0.953}{50}}$

$= 0.047 + 3 \times 0.0299$

$= 0.047 + 0.0897$

$= 0.136$

$LCL = 0.047 - 0.0897$

= NIL (if negative)

For n = 80, $UCL = 0.047 + 3\sqrt{\frac{0.047 \times 0.953}{80}}$

$= 0.047 + 3 \times 0.0236$

$= 0.047 + 0.709$

$= 0.117$

$LCL = 0.047 - 0.0709$ = NIL (if negative)

13. 10 samples (each of size 100) of a component were inspected. The resutls of the inspection are given below:

Sample Number	1	2	3	4	5	6	7	8	9	10
No. of defectives	2	0	4	3	1	2	3	1	1	2

Draw the relevatn control chart taking 3 sigma limits.

Sol :

Since the sample size is constant, we have to draw 'np' chart (fraction defectives chart for constant sample size).

Sample size n = 100

No. of samples (sub-groups) k = 10

No. of defectives per sub-group = c

fraction defective $p = \frac{c}{n}$

Central line = $np = n \times \frac{\Sigma p}{n} = \frac{n \times \Sigma c / n}{k} = \frac{\Sigma c}{k} = \frac{19}{10} = 1.9$

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

$= 1.9 + 3\sqrt{1.9 \times 0.981}$

$= 1.9 + 3\sqrt{1.9 \times 0.981}$

$= 1.9 + 3\sqrt{1.864}$

$= 1.9 + 3 \times 1.365$

$= 1.9 + 4.095 = 6.0$

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

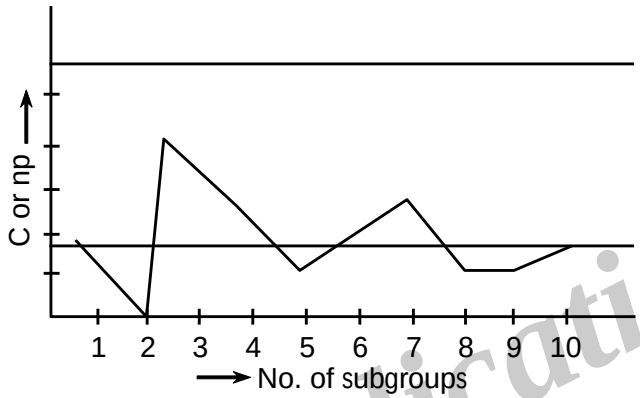
$= 1.9 - 3 \times 1.365$

$= 1.9 - 4.095$

$= -2.2$

$=$ Nill (if negative)

Construction of 'np' chart



14. The following table gives the number of defects in a casting used for making crank cases of a diesel engine,

Casting Number	1	2	3	4	5	6	7	8	9	10
Numberof defects	15	11	25	10	12	20	15	10	17	13

Construct appropriate control chart with the control limits and comment on the process.

Sol :

The number of defects per casting is given. Hence, the suitable chart is 'C chart.

$$\bar{C} = \frac{\text{Total number of defects}}{\text{Total number of samples}} = \frac{148}{10} = 14.8$$

Control Limits for $\bar{C}$ Chart

Upper Control Limit

$$UCL_{\bar{c}} = \bar{C} + 3\sqrt{\bar{C}} = 14.8 + 3\sqrt{14.8}$$

$$= 14.8 + 11.54 = 26.34$$

Lower Control Limit

$$LCL_{\bar{c}} = \bar{C} - 3\sqrt{\bar{C}} = 14.8 + 3\sqrt{14.8}$$

$$= 14.8 - 11.54 = 3.26$$

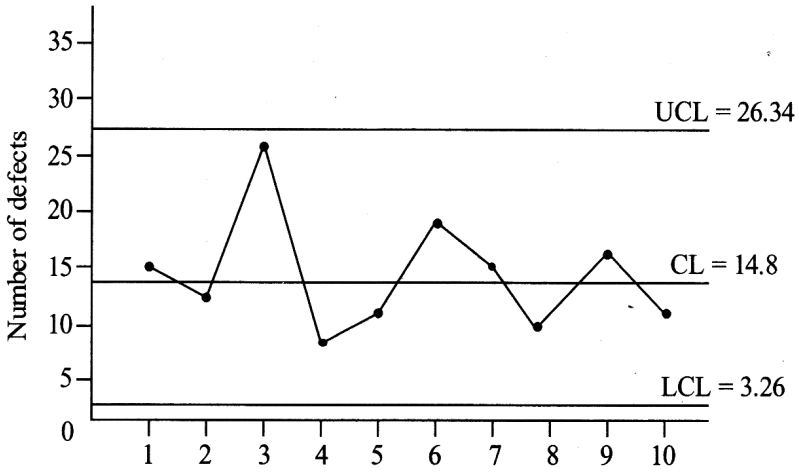


Fig. 'C' Chart

In the above figure, all the points are within control limits. Hence, the quality of casting is considered to be under control.

Short Question and Answers

1. What are the disadvantages of Gantt chart?

Ans :

The following are few disadvantages of Gannt charts.

1. Gantt charts do not show the interrelation-ships among the various activities of the project.
2. Gantt charts have to be updated con-tinuously.
3. Gantt charts increase the complexity of evaluating the alternative schedules, as the processing time of the job changes on the basis of the work centre.

Q2. Explain about Johnson's Algorithm.

Ans :

The task here is to sequence or determine the order of 'n' jobs to be processed on two machines in such a way, that the total elapsed time is kept minimum. The procedure for solving this type of problem was developed by Johnson and Bellman.

This type of problem can be described as,

(i) Only two machines X and F are involved.

(ii) Each job is processed in the order XY.

(iii) Expected processing times $X_1, X_2, \ldots\ldots, X_n$ and $Y_1, Y_2, \ldots\ldots, Y_n$ of jobs 1, 2, ..., n on machines X and Y respectively are known.

3. Define Scheduling.

Ans :

Scheduling pertains to establishing the time of the use of specific resources within an organization. It relates to the use of equipment, machines, facilities and human activities. Scheduling is necessary in every organization regardless of the nature of its activities. For example, in manufacturing organizations, production must be scheduled, which means developing schedules for workers, machines, equipments, maintenance etc. In service organiza-tions such as hospitals, admission, surgery, nursing assignments and support services such as cleaning, maintenance, security, meal preparation etc., must be scheduled. In educational institutions, classrooms, instruction and students must be scheduled.

Scheduling, means organising a production line to produce products in time efficiently with least use of time and maximum utilisation of resources (especially men and machines).

4. Objectives of Scheduling.

Ans :

The following are the objectives of scheduling are:-

(i) To prevent unbalanced use of time among departments and work centres or to evenly load all machines in the production line.

(ii) To utilise machines and labour in such a way that the output is produced within the established lead time so as to,

(a) Deliver the products/services in time and

(b) Complete production in the shortest cycle time possible at minimum total cost of production.

5. Advantages of Scheduling

Ans :

1. It helps in understanding the project.
2. It continuously record the references, deliverables of the project, their time frames and related importance and occurrence.
3. The sequential order and timing of several work packages and activities can be clearly observed.

6. Job Shop Scheduling.

Ans :

In job shop problem, we assume that each job has m different operations. If some of the jobs are having less than m operations, required number of dummy operations with zero process times are assumed. By this assumption, the condition of equal number of operations for all the jobs is ensured. In job shop scheduling problem, the process sequences of the jobs are not the same. Hence, the flow of each job in job shop scheduling is not unidirectional.

The time complexity function of the job shop problem is combinatorial in nature. Hence, heuristic approaches are popular in this area.

Unlike the flow shop model, there is no initial machine that performs only the first operation of a job, nor is there a terminal machine that performs only the last operation of a job.

7. Schedule Generation.

Ans :

The schedule generation process plays a significant role in job shop scheduling. It is an important phase of job shop scheduling. The process of generating schedules are classified into two mechanisms. They are,

1. Single-pass Mechanism

In this mechanism, the start/beginning time of every operation is fixed forever. A complete schedule could be generated via single pass through the list of operations.

2. Adjusting Mechanism

Under adjusting mechanism, the start/beginning time of each operation is not permanently fixed. The start time of each operation is re-assigned as and when the successive operation is added to the schedule.

8. What is Quality Control?

Ans :

Meaning

Quality control refers to all those functions or activities that must be performed to fill the company's quality objectives.

Quality control on the other hand, may also include establishment of criteria for the selection of production equipment, tooling and personnel. It often involves statistical analysis (referred to as statistical quality control or SQC).

9. Functions of quality control?

Ans :

Following are the Functions of quality control.

i) To design the product or service in such a way that it meets customers requirements.

ii) Use of substandard material or components might effect the quality of the produced, products. Hence, the quality control personnel should see that the purchased materials, parts, components, etc. are of standard quality.

iii) To identify and provide information on causes of variations in production process, so that corrective action is taken.

Q10. What is Statistical Quality Control?

Ans :

Statistical Quality Control (SQC) is the application of statistical techniques to accept or reject products already produced, or to control the process and, therefore, product quality while the part is being made. While the latter is called process control, the former is named acceptance sampling.

Mainly, SQC is used for controlling quality during production in mass production industries which produce standard products. SQC for process control is based on probability theory. It is common knowledge that when several identical parts are manufactured, some are a little large and some a little small, but most will be approximately the same.

11. Cause and effect diagram.

Ans :

A cause –and-effect (C&E) diagram is a picture composed of lines and symbols designed to represent a meaningful relationship between an effect and its causes. It was developed by Dr.Kaour Ishikawa in 1943 and is sometimes referred to as an Ishikawa diagram or a fish bone diagram because of its shape.

C & E diagrams are used to investigate either a "bad" effect and to take action to correct the causes or a "good" effect and to learn those causes that are responsible. For every effect, there are likely to be numerous causes. Causes are sometimes broken down into the major causes of work methods, materials, measurement, people, equipment, and the environment. Other major causes could be used for service-type problems, as indicated in the chapter on customer satisfaction.

Exercise Problems

1. There are nine jobs, each of which must go through two machines P and Q in the order PQ, the processing times (in hours) are given below:

	Jobs (s)								
Machine	A	B	C	D	E	F	G	H	I
P	2	5	4	9	6	8	7	5	4
Q	6	8	7	4	3	9	3	8	11

Find the sequence that minimizes the total elapsed time T. Also calculate the total idle time for the machines in this period.

[Ans : A → I → C → B → H → F → D → E → G.]

2. There are five jobs (namely 1,2,3,4 and 5), each of which must go through machines A, B and C in the order ABC. Processing Time (in hours) are given below:

Jobs	**1**	**2**	**3**	**4**	**5**
Machine A	5	7	6	9	5
Machine B	2	1	4	5	3
Machine C	3	7	5	6	7

Find the sequence that minimum the total elapsed time required to complete the jobs.

[Ans : 2 → 5 → 4 → 3 → 1]

3. Find an optimal sequence for the following sequencing problem of four jobs and five machines when passing is not allowed, of which processing time (in hours) is given below:

Job	Machine				
	A	B	C	D	E
1	7	5	2	3	9
2	6	6	4	5	10
3	5	4	5	6	8
4	8	3	3	2	6

Also find the total elapsed time.

[Ans : 1 → 3 → 2 → 4]

Choose the Correct Answers

1. What docs QA and QC stand for? [c]
   (a) Quality Assurance and Queuing Control
   (b) Quality Adjustment and Quality completion
   (c) Quality Assurance and Quality control
   (d) Quality Adjustment and Queuing control
2. Which of the following option is correct regarding QA and QC? [a]
   (a) QC is an integral part of QA (b) QA is an integral pan of QC
   (c) QA and QC arc independent to each other (d) QC may or may not depend on QA
3. Which of the following option involves material and component control? [c]
   (a) Development of standards (b) Development of specification
   (c) Quality control (d) Feedback
4. Which of the following is an example of QA? [a]
   (a) Verification (b) Software testing
   (c) Validation (d) Documentation
5. _____ is regarded as simple thumb rule method which helps in solving difficult problems and providing satisfying solutions to the line balancing. [c]
   (a) Linear programming (b) Dynamic programming
   (c) Heuristic method (d) Computerized line balancing
6. _____ refers to a systematic arrangement of machines in one line on the basis of sequence of operations. [c]
   (a) Fixed position layout (b) Process layout
   (c) Product layout (d) Cellular layout
7. _____ is the process of maintaining the activities which are handled before the machines or equipments fails. [d]
   (a) Breakdown maintenance (b) Routine maintenance
   (c) Predictive maintenance (d) Preventive maintenance
8. _____ is a type of layout in which the similar machines are grouped in one department. [a]
   (a) Process layout (b) Product layout
   (c) Fixed position layout (d) Combined layout
9. _____ mainly deals with the repairs which are made after the equipment or machine is out of order. [b]
   (a) Total productive maintenance (b) Breakdown maintenance
   (c) Preventive Maintenance (d) Planned maintenance
10. _____denotes the processing sequence of jobs for different machines or work centres. [b]
   (a) Tardiness (b) Priority
   (c) Slack time (d) Process time

Fill in the Blanks

1. _____ pertains to establishing the time of the use of specific resources within an organization.
2. _____ can be described as the specifications of the workflow.
3. _____ is the final act of releasing job orders to the workers to go ahead with the production process.
4. _____ machine scheduling is a simple and basic scheduling problem which deals with limited number of resources.
5. In _____ shift, some operations may be started earlier in time without affecting the sequence of operations.
6. In _____ shift, few operations are started earlier in time without causing any delay in any other operation.
7. A _____ does not contain superfluous idle time. It is a schedule where no local left-shift exists.
8. A _____ schedule is a schedule in which none of the machines is kept idle at a time,
9. _____ control refers to all those functions or activities that must be performed to fill the company's quality objectives.
10. SQC stands for _____

ANSWERS

1. Scheduling
2. Routing
3. Dispatching
4. Single
5. Local-left
6. Global-left
7. Semi-active schedule
8. Non-delay
9. Quality
10. Statistical Quality Control

Very Short Questions and Answers

1. Objectives of Scheduling.

Ans :

(i) To prevent unbalanced use of time among departments and work centres or to evenly load all machines in the production line.

(ii) To utilize machines and labour in such a way that the output is produced within the established lead time so as to, deliver the products/services in time and complete production in the shortest cycle time possible at minimum total cost of production.

2. Disadvantages of scheduling,

Ans :

i) Scheduling leads to frequent employee absenteeism and increased inefficiency of labour due to the lack of relevant skills and experience among them.

ii) Resource constraints in scheduling leading to the decline in capacity causing supply delay of materials.

3. Single-pass Mechanism

Ans :

In this mechanism, the start/beginning time of every operation is fixed forever. A complete schedule could be generated via single pass through the list of operations.

4. Statistical Quality Control?

Ans :

Statistical Quality Control (SQC) is the application of statistical techniques to accept or reject products already produced, or to control the process and, therefore, product quality while the part is being made. While the latter is called process control, the former is named acceptance sampling.

5. Advantages of statistical quality control.

Ans :

i) It helps prevent defects from occurring. Assignable causes signifying deviations in quality are detected and rectified. Costly rework, rejection, and scrap are avoided.

ii) It also helps avoidance of the risk of accepting a bad lot.

iii) Emphasizing on inspection of only samples, SQC avoids inspection of the entire lot.

UNIT V

Materials Management: Integrated Materials Management, Components of Integrated Materials Management, Materials Planning, Inventory Control, Purchase Management, e-Procurement, Green Purchasing, Stores Management, EOQ, Models of Inventory, Operation of Inventory Systems, Quantity Discount, Implementation of Purchase Inventory Model, Incoming Materials Control, Obsolete Surplus and Scrap Management, ABC Analysis, XYZ Analysis, VED Analysis, FSN Analysis, SDE Analysis.

5.1 Integrated Materials Management

5.1.1 Components

Q1. Define Integrated Material Manage-ment. What are the components of Integrated Material Management?

Ans : **(April-23, Aug.-17, Imp.)**

Meaning

The term 'integrated material management' refers to the management of resources in an integrative manner to make way for national economic development, through efficient utilization of MIS, advanced technologies and innovative, economic materials for manufacturing.

Definitions

(i) **According to Bailey and Farmer** Materials management is defined as the management of the flow of materials into an organization to the point, where those materials are converted in to the firms end product(s).

(ii) **According to Ammer** Materials manage-ment is defined as, "the process by which an organization is supplied with goods and services that it needs to achieve its objectives.

Components

The scope or components of integrated materials management are as follows,

1. Materials Planning and Control

It is carried out on the basis of sales forecast and production plans. It also includes ascertaining the needs of individuals with respect to the components, preparation of materials budget, determining the levels of inventories, scheduling the orders, inspecting and controlling the performance of production and sales.

2. Purchasing

The purchasing functions consist of selecting the sources of supply with respect to purchase, placing purchase orders, follow-up maintaining a cordial relationship with suppliers, making payments to the suppliers on time, assessing and giving ratings to the suppliers on the basis of their performance.

3. Stores Management

A store plays an important role in the organization as its functions include physical control of materials, store preservation, preventing damages etc.

4. Inventory Control (or) Management

Inventory usually refers to the materials stock either in the raw-form, semi-finished or final product for sale. Effective inventory ;: or: helps in the smooth functioning of the production cycle with less number of interruptions.

5. Standardization

Standardization refers to the process of producing diversified products by using minimum variety of materials, parts, tools and processes. Standardi-zation is a process where standards (or) the units of measures can be compared (or) measured in terms of quantity, quality, value, extent performance etc.

6. Simplification

Simplification is the process which deals with minimizing different types of manufactured products. It helps in minimizing product range, assemblies. parts, materials and design.

7. Specifications

Specification is explained as an accurate in-depth statement which serves the needs of the customers. It can be related to either a product process (or) service

8. Value Analysis

Value Analysis deals with those costs which are being added because of inadequate and unimportant specifications and features. It makes contributions in the maturity stage of product cycle which is the last stage.

Q2. Outline the objectives of Materials Management.

(OR)

What are the objectives of integrated material management ?

Ans : **(Dec.-19)**

There are 2 objectives of material management they are :

(I) Primary Objectives

There are atleast nine primary objectives. These are low prices, high inventory turnover, low cost acquisition and possession, continuity of supply, consistency of quality, low payroll costs, favourable relations with suppliers, development of personnel and good records.

1. Low Prices

Obtaining the least possible price for purchased materials is the most obvious purchasing objective and certainly one of the most important. If the purchasing department reduces the prices of the items it buys, operating costs are reduced and profits are enhanced, 'his objective is important for all purchases of materials and services, including transportation.

2. High Inventory Turnover

When inventories are low in relation to sales, less capital is tied up in inventories. This in turn, increases the efficiency with which, the company's capital is utilized, so that, return on investments is higher. Also, storage and carrying costs of inventories are lower when turnover is high.

3. Low Cost Acquisition and Possession

If materials are handled and stored efficiently, their real cost is lower. Acquisition and possession costs are low when the receiving and stores departments operate efficiently. They are also reduced when shipments are received in relatively large quantities (thereby reducing the unit cost of handling), but they are increased if average inventories are boosted with the large shipments.

4. Continuity of Supply

When there are disruptions in continuity of supply, excess costs are inevitable. Production costs go up, excess expediting and transportation costs are likely and so on. Continuity of supply is particularly important for highly automated processes where, costs are rigid and must be incurred even when production stops because of inavailability of material.

5. Consistency of Quality

As pointed out earlier, quality of end product depends or materials that go into it. When materials purchased are homogeneous and in a primitive stage (e.g., sand and gravel), quality is rarely a problem for purchasing personnel.

6. Low Payroll Costs

The objective of low payroll costs is common to every organization The lower the payroll the higher the profits all other factors being equal.

7. Favourable Supplier Relations

Maintaining cordial relations with suppliers benefits buying company in more than one way. In the first place, a company with good reputation in supplier relations is more likely to attract customers than the one with a bad name. Second the product development and research efforts of suppliers are passed on to the company provided the latter maintains good relations with the former. Thirdly, the materials manage is often faced with the problem of last minute cancellation of existing commitments because of a sudden shift in the demand for materials.

8. Development of Personnel

"If you want to plan for a year, plant corn. If you want to plan for 30 years, plant a tree. But, if you want to plan for 100 years, plant men". So goes Chinese proverb. Every head of every

department should understand this saying and take personal interest in developing the personnel working under him. Each department head should spot the potential leaders among the men and women employed in his department and encourage them to develop into future executives, and the company's future profits will depend on the talents of its managers.

(II) Secondary Objectives

Secondary objectives of materials management are not limited in number or in scope primary objectives. Since they represent the materials management's contribution to achievement of primary objectives of some other departments, they can vary widely from industry to industry.

1. Reciprocal Relations

When a company deliberately buys as much as possible from its own customers, it is said to practise reciprocity, in consumer goods industries, reciprocity is not a problem as the sales are spread among many users. In producer goods industries, however, reciprocity is a fact of business life. A company that is a customer inevitably wants to become a supplier.

2. New Materials and Products

Engineering and manufacturing managers are always interested in new products and materials that will help them more efficiently and thereby achieve one of their primary objectives. The purchasing department can help because it deals regularly with the suppliers responsible for the new developments.

3. Economic Make-or-Buy

Make-or-buy decisions are generally made by committees consisting of departmental heads. The purchasing manager should spot the need for a make- or-buy decision and refer it to the committee for action.

4. Standardization

The fewer the items that need to be controlled, the simpler and more efficient does the materials management process become. Thus, it is to the interest of the materials personnel to promote standardization and simplification of specifications.

Q3. Explain the scope of Materials Management.

Ans :

Materials management has a wider scope. Its scope includes the following:

i) Materials Planning and Control

Materials planning and control is carried out on the basis of sales forecast and production plans. It also includes, ascertaining the needs of individuals with respect to the components, preparation of materials budget, determining the levels of inventories, scheduling the orders and inspecting and controlling the performance with respect to production and sales.

ii) Purchasing

The purchasing function consist of selecting the sources of supply with respect to purchase, placing purchase orders, low-up, maintaining a cordial relationship with suppliers, making payments to the suppliers on time, assessing and giving rating to the suppliers on the basis of their performance.

iii) Stores Management

A store plays an important role in the organization tools as its functions include physical control of materials, store preservation, preventing damages and reducing the obsolescence by efficiently handling the materials etc. A store is also held responsible for maintaining proper stores record, making them available whenever required, verification of records, reconciling the records with the book figures etc.

iv) Inventory Control or Management

Inventory usually refers to the materials stock i.e., which either can be in the raw-form, semi-finished form or final product for sale. Effective inventory control helps in the smooth functioning of the production cycle with less number of interruptions.

v) Standardization

Standardization refers to the process of producing diversified products by using minimum variety of materials, parts, tools and processes. Standardization is a process where, standards or the units of measures can be compared or measured in terms of quantity, quality, value, extent, performance etc.,

Q4. State the importance of Materials Management.

(OR)

Explain the significance of Materials Management in a manufacturing organization.

Ans :

1. Materials Planning and Control

It is carried out on the basis of sales forecast and production plans. It also includes ascertaining the needs of individuals with respect to the components, preparation of materials budget, determining the levels of inventories, scheduling the orders, inspecting and controlling the performance of production and sales.

2. Purchasing

The purchasing functions consist of selecting the sources of supply with respect to purchase, placing purchase orders, follow-up maintaining a cordial relationship with suppliers, making payments to the suppliers on time, assessing and giving ratings to the suppliers on the basis of their performance.

3. Stores Management

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4. Inventory Control or Management

Inventory usually refers to the materials stock either in the raw-form, semi-finished or final product for sale. Effective inventory control helps in the smooth functioning of the production cycle with less number of interruptions.

5. Standardization

Standardization refers to the process of producing diversified products by using minimum variety of materials, parts, tools and processes. Standardization is a process where standards or the units of measures can be compared or measured in terms of quantity, quality, value, extent performance etc.

6. Simplification

Simplification is the process which deals with minimizing different types of manufactured products. It helps in minimizing product range, assemblies, parts, materials and design

5.2 MATERIALS PLANNING

Q5. What is Materials Planning? Explain the significance of Materials Planning.

Ans :

Meaning

Materials planning is the scientific way of determining the requirements of raw materials, components, spares and other items that go into meeting the production needs within economic investment policies. Materials planning is a subset of the overall production planning and control system which has a broad perspective. Materials budgeting is an estimate of expense to be incurred in the procurement of materials and it helps effective execution and control of materials plans.

Significance

(i) Lack of proper materials planning and coordination leads to over-ordering or under-ordering of materials, over-ordering results in over-investment and unproductive use of costly working capital. It creates the need for extra storage facilities to hold unnecessary surplus stocks and may lead to deterioration and obsolescence of materials.

(ii) Poor planning for materials may lead to unwarranted emergency or rush orders, usually processed by costly means of transport.

(iii) Materials planning activity raises the level of the buyer from a mere order placer to a purchase executive (or) manager. Planning enables the purchase people to spend more in an optimum manner.

Q6. What is Material Requirement Planning? Explain its objectives.

(OR)

Explain about Material Requirement Planning .

Ans : **(Dec.-19)**

Meaning

A system of planning and scheduling the time-phased material requirements for production operations. The master production schedule specifies the quantity required for each end item in each planning period, it is set of time phased requirements for end items. But the firm also needs a set of time phased requirements for item parts and raw materials that make up those end items.

Material requirements planning is a production planning and control technique in which the master production schedule is used to create production; and purchase orders for dependent demand items.

Broad Definition

i) It is a simple system of calculating arithmetically the requirement of the input materials at different points of time, based on the plan or schedule of production of the finished good.

ii) MRP is a computer-based information system for scheduling production and purchases of dependent demand items. It uses information about end product demand, product structure and component requirements, production and purchase lead times and current inventory levels to develop cost-effective production and purchasing schedules.

iii) MRP is a system of planning and scheduling the item Phased materials requirement for production operations.

Objectives

1. Inventory Reduction

MRP determines how many units of a component are needed and when they are needed to meet the master schedule. Therefore it enables the mangers to procure that component as it is needed, thereby reducing the costs of excessive inventory.

2. Reduction In Production And Delivery Lead Times

MRP identifies materials and components quantities, timing, availabilities, production & procurement actions required to meet delivery dead-lines.

By coordinating inventories, procure-ment and production decisions, MRP helps in avoiding delays in production. It priorities production activities by putting due dates on customer job orders.

3. Realistic Commitments

By using MRP, production can give marketing timely information about likely delivery times to prospective customers.

Q7. Explain the Components of MRP.

Ans :

Three major sources of information are mandatory in the MRP system

1. A Master Production Schedule
2. A Bill Of Materials
3. An Inventory Status

Using these three information sources, the MRP processing logic (computer program) provides three kinds of information output for each product component.

1. Order Release Requirement
2. Order Rescheduling
3. Planned Orders

1. Master Production Schedule (MPS)

i) The MPS is developed from firm's customer orders or from forecasts of demand before the MPS system begins to operate.

ii) The MPS is designed to meet market demand. So, it identifies the quantity of each end product and when it is to be produced during each future period in the production planning horizon.

iii) Service components for customers are also entered as end items in the MPS.

iv) The MPS provides the focal information for the MRP system.

v) The MPS govern the MRP system's recommended actions on the timing of procuring materials and producing subcomponents.

2. Bill of Materials (BOM)

This is a document describing the details of an item's product building up, including all component items, their build up sequence, the quantity needed for each of the work centers that perform the build up sequence.

The BOM identifies how each end product is manufactured, specifying all subcomponent items, their sequence, their quantity in each finished unit.

This information is obtained from product design documents, work-flow analysis and other standard manufacturing and industrial engineering documentation.

3. An Inventory Status

It consists the complete documentation of the inventory status of each item in the product structure, on-hand quantity, safety stock level, quantity allocated and led-time. The MRP system must retain the up to date file of the inventory status of each item in the product structure.

This file provides accurate information about of every item controlled by the MRP system, which can then maintain an accounting of all inventory transactions, both actual and planned.

Q8. Explain the Benefits and Limitations of MRP.

Ans :

Advantages of MRP

The advantages/merits of MRP are as follows:

1. Requires less inventory levels.
2. Involves low idle time and Needs less setup time.
3. Capable of altering the MPS and Holds the capability to price more competitively.
4. Good customer service and less sales price.
5. Provides good response to market demands.
6. Helps in the capacity planning and in deciding as to when to expedite or deexpedite.

Disadvantages of MRP

The demerits of MRP are as follows:

1. Top management does as not show proper concern for MRP i.e., as they are not committed.
2. MRP constitutes only a part of total system but it is regarded as a complete and stand along system to enable the working of a firm.
3. The functioning of MRP with just-in-time production system has become an issue.
4. MRP requires a greater accuracy to operate/ function.
5. MRP is too rigid in nature as it creates a schedule and in case of emergencies it is difficult to divert from the schedule.

Q9. Discuss Manufacturing Resource Planning (MRP-II) in detail.

Ans :

MRP systems were built depending on a segregated basis instead of a highly integrated information system. Most of the companies have began to logically relate their information subsystems to the MRP systems. Manufacturing Resource Planning (MRP-II or "Closed loop" MRP) is an integrated information system that goes beyond first generation MRP to operate all aspects of the business at the same time. The MRP-II system follows a focal production plan in order to coordinate sales, purchasing, manufacturing, finance and engineering and use a common data base to plan and update activities of the system.

The process of MRP-II includes the development of a production plan from the business plan to determine the levels of production of each month for each product line for next one to five years.

The production plan influence all other functional departments, so it is developed with the agreement of executives which becomes their "game plan" for operations. The production department must produce at the committed levels, the sales department need to sell at these levels and the finance department must provide adequate financial resources for these levels The master production schedule which is supported by production plan determines the weekly quantities of particular products to be developed.

At this situation, it is examined that whether the available capacity is sufficient to sustain the proposed master schedule or not. If so, either the capacity or master schedule need to be changed. Master schedule is used for the purpose of MRP logic to build materials requirements and priority schedules for production. A detailed analysis of capacity requirements identifies the capacity adequate for producing the specified components at each work center during the specified time periods. If capacity is not adequate, the master schedule is changed to indicate the limited available capacity.

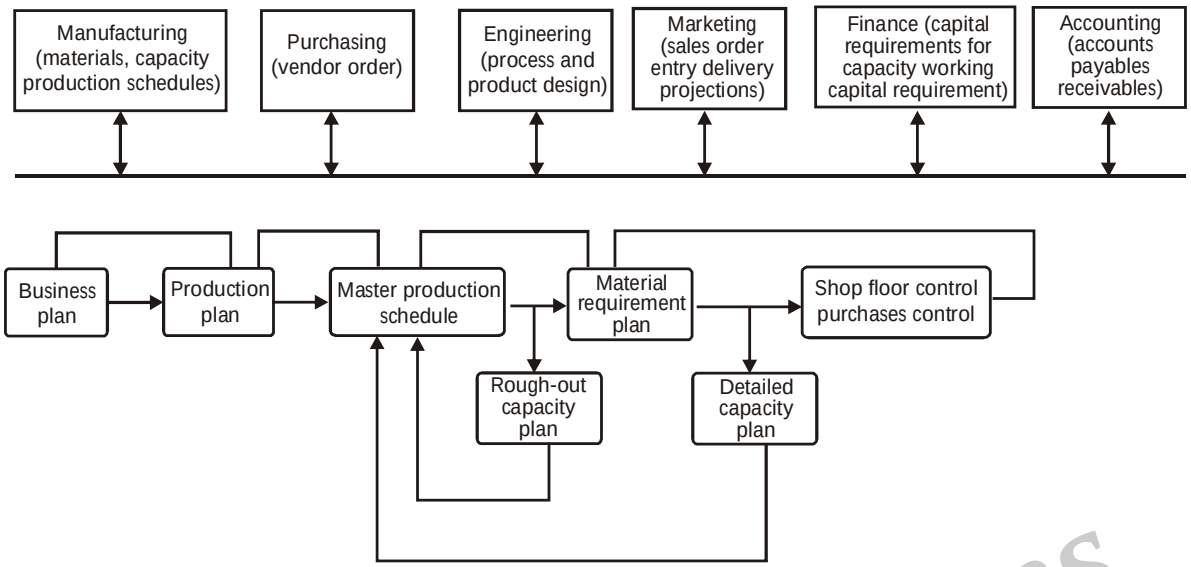


Fig.: MRP-II: An Integrated System for Planning and Control

A capacity-feasible schedule is created which focuses on shifts to implement the plan. Purchase schedules and shop schedules are developed. These schedules are useful to determine work center loading, shop floor control and vendor follow up activities to make sure that the master schedule is met.

Q10. State the differences between MRP I and MRP II.

(OR)

Compare and contrast MRP I and MRP II.

Ans :

S.No.	MRP - I	S.No.	MRP - II
1.	It mainly focuses on raw materials including CRP (Capacity resource Planning) with respect to time.	1.	MRP-II not only takes into consideration the basic MRP-system i.e., production, planning and control activities but also considers the information related to other departments such as, finance, HR, engineering marketing division and accounts.
2.	It was represented and followed as a complete single system to run a concern instead of being a part and parcel of the whole system.	2.	It has been developed, to overcome the problems of MRP-I and its functions as a part and parcel of the total system.
3.	It is implemented by only a few manufacturing organizations.	3.	It is being implemented by many of the manufacturing concerns and it is considered important in providing (or) managing information system at different levels.
4.	MRP-I is the part and parcel of MRP-II.	4.	MRP-II is broader in concept.
5.	It is concerned with production planning only.	5.	It is concerned with both production planning, as well as financial planning in a systematic manner.

5.3 INVENTORY CONTROL

Q11. Define Inventory. Explain the significance of Inventory.

(OR)

What is meant by inventory ?

Ans : **(Dec.-19)**

The term Inventory originates from the French word Inventaire and Latin word Invantariom, which implies a list of things found.

Definitions

The term inventory has been defined by several authors. The more popular of them are :

(i) the term inventory includes materials - raw, in process, finished packaging spares and others stocked in order to meet an unexpected demand (or) distribution in the future.

(ii) Another definition of inventory is that it can be used refer to the stock on hand at a particular time of raw materials goods-in-process of manufacture, finished products, merchandise purchased for resale and the like, tangible assets which can be seen measured and counted. In connection with financial statements and accounting records, the reference may be to the amount assigned to the stock of goods owned by an enterprise at a particular time.

Significance

1. The materials are not immediately available whenever an order is placed for fresh stock. The period between the time of placing the order and time of arrival of stock is subjected to variations. A firm should hence hold some reserve stock in order to allow production operations to continue even if delay occurs in procurement.

2. Due to the variation in the demand, changes may occur in the manufacturing program. In order to meet the increased demand, the company must have enough inventory/stock to allow the production without interference.

3. Stock-out occurs, when a firm has little inventory and runs out of stock. The stock-out of essential materials means interruption in the production. Due to the interruption in the production the cost of production raises.

4. Stock-out means interruption in production, which there by delay the delivery of goods to the customer. After few such delays even a patient customer would start looking out for another supplier who can give him better service.

Q12. Explain the various functions of Inventory.

Ans :

The key function of inventory is to increase profitability with the assistance of manufacturing and marketing support. Inventory includes other key functions such as geographical specialization, decoupling, balancing supply and demand and safety stock.

1. Geographical Specialization

Inventory allows geographical specialization of individual operating units. The economical location for manufacturing is far from areas of demand due to factors of production like power, raw materials, water and labour. The manufactured goods from different locations are gathered at simple marchouse/plant to assemble in final product or to provide customers a single mixed product shipment. This further gives economic specialization among production and distribution units of an enterprise.

2. Decoupling

This inventory function gives maximum efficiency of operations within a single facility. Decoupling is generally carried out by splitting operations in a manner that one operation's supply is independent of another's supply.

Decoupling function aims at the following:

(a) The inventories are generally required to decrease the dependencies between successive stages of operation in a way that break-downs, material shortages or other production changes at one stage may not effect another stages to shut down.

(b) It also helps an organizational unit to schedule its operations independently of another.

3. Balancing Supply and Demand

Balancing function deals with elapsed time between consumption and manufacturing. The balancing function of inventory needs investment in seasonal stocks which are estimated to be fully liquidated within the season.

4. Safety Stock

Safety stock or buffer stock function deals with short range differences in either demand or replacement. An effective inventory planning is required to determine the size of safety stocks. This function of inventory protects against two types of uncertainty. The first is sales in excess of forecast during Replenishment period and the second is delays in replenishment. Furthermore, safety stock helps in improved performance.

Q13. What are the costs associated with inventory?

(OR)

Explain the different types of cost associated with inventory.

Ans : **(Feb.-17, Feb.-15, Aug.-15)**

Inventory management involves different cost concepts that has to be managed with proper care which influences the total production cost of an organization. Depending on their nature, costs have been broadly categorized into two types:

1. Direct cost
2. Indirect cost

1. Direct Cost

Direct cost is again classified into four different cost components as follows,

(a) Capital Costs

Such costs are usually affected by the customer-service policy, tasks and roles of supply chain pipeline, which in turn increases the overall cost of carrying inventory. It can be estimated by determining the rate of interest which reflects role of both inventory as well as the opportunity cost of capital. It can also be obtained by multiplying internal cost of funds with the value of the product. In case of downstream process of supply chain, such costs tend to increase due to the addition of values to the products.

(b) Storage Space Costs

Costs associated with the storage requirements of inventories are usually referred to as "storage space costs". Storage space cost includes handling costs that are found to be associated with movement of products into and out of inventory. Storage cost varies depending on the changes in the levels of inventory.

i) Ordering Costs

Ordering costs are incurred by the firm at the time of placing an order or purchasing the materials. It depends on the number of orders placed. If orders are more, then cost also increases.

ii) Carrying Costs

Carrying costs are incurred by the firm, only when stock is maintained. It involves cost of storage, interest on investment, obsolescence, insurance, etc.

(c) Service Costs

Insurance and taxes comes under the category of service costs of inventory. Such costs are fixed as a penalty on the business depending on the volume of inventory. Suppose if high levels of inventory have to be provided, then more amount of penalty is charged on the business.

(d) Risk Costs

Risk costs are usually dependent on the nature of business. In this context, obsolescence cost is found to be the most important cost as shift in technology or trend makes certain products to be obsolete. Such costs cannot be estimated accurately as they are circumstantial/situational in nature.

2. Indirect Cost

(a) Business Risk

Every firm has to maintain optimal level of inventory for meeting customer demands. In the absence of optional inventory level, firms have to face two issues.

i) If the firm does not maintain sufficient inventory to meet the demand of customers, then it has to face a risk of loosing its existing customers.

ii) Eventhough excessive maintenance of inventory is able to satisfy customer demands, it is also characterized by increasing the direct costs by increasing capital costs, storage costs source and risk costs.

Thus, management needs to take effective decision regarding the level of service, required for the achievement of logistics, marketing and corporate objectives.

(b) Opportunity Costs

Dynamic companies have huge investment opportunities. If such firms invest huge capital on inventories, then they have to incur opportunity costs as they don't left with much capital to invest in other alternatives.

(c) Infrastructure Costs

Such costs have to be increased by the firms if they holds excess inventory within their warehouses as excess inventory associated with over-investment in facilities and transpor-tation.

Q14. Discuss different types of inventories.

Ans :

The various types of inventories are classified as follows,

I) Classification Based on the Stage of the Items in Production

Based on the stage of the items in production, inventories are classified as follows,

(a) Raw Material and Spares Inventory

These items are used directly in the manufacturing or in the process industry.

(b) Work-in-Process Inventory

Normally, at different stages of manufacturing, semi-finished items are accumulated. This is known as Work-in- Process (WIP) inventory. The size of this inventory directly depends on the length of the production cycle.

(c) Finished Goods Inventory

Sometimes, the manufactured items are stocked before they are dispatched or sold. This is known as finished goods inventory.

(II) Classification Based on the Purpose

Based on the purpose, inventories are classified as follows,

(a) Transportation Inventories

Goods have to be transported from various production centers to distribution centers and finally to customers. The inventories which are in transit are called transportation inventories or transit inventories or pipeline inventories.

(b) Buffer Inventories

Buffer inventories have to be carried because sales and production time cannot always be predicted accurately. Since, there are fluctuations in demand and lead times required to manufacture items, quantities in excess of requirement are stocked and are termed as reserve stocks or safety stocks.

(c) Anticipation Inventories

Anticipation inventories are built up fn advance for a great selling season, a special promotion campaign or for plant shut down period. Thus such inventories are created for future requirement.

Example: Crackers, Sweaters etc.

(d) Decoupling Inventories

In continuous production, breakdown of one machine or breakdown at one stage will result in interruption of the production system. To overcome this difficulty to some extent, decoupling inventories are carried.

Decoupling inventories are not only in the form of in-process inventories to 'decouple' successive production stages but also in the form of raw material which are used to decouple the producers from the suppliers and finished goods to decouple the consumers from production.

(e) Lot Size Inventories

Lot size inventories are held for the purchases that are usually made in lots rather than the exact amounts which may be required at any point of time. The other name for lot size inventory is cycle inventory.

(III) Classification Based on Role in Production

Based on role in production, inventories are classified as follows,

(a) Direct inventories

The items which are form an integral part of finished goods come under this classification. Example: Raw materials, WfIP, finished goods and spare parts.

(b) Indirect Inventories

Indirect inventories consist of items which are required in production but do not form an integral part of finished goods.

Example: Consumables like grease, oil, office materials, maintenance items, tools etc.

5.4 Economic Order Quantity (EOQ)

Q15. Define Economic Order Quantity. Derive the formula for determining EOQ?

(OR)

Explain briefly about Economic Order Quantity.

Ans : **(Aug.-16)**

Economic Order Quantity (EOQ) refers to the amount to material to be ordered to make the best use of the firm's resources, taking into consideration factors such as shelf life of the material, space required and space available for warehousing, price breaks for ordering quantity etc.

Formula

$$EOQ = \sqrt{\frac{2AO}{C}}$$

where

A = Annual Consumption

O = Ordering Cost

C = Carrying Cost

Costs

The performance of the inventory system and the process of arriving at economic order quantity involves certain costs which are described as follows.

The various costs involved are,

(a) Purchase cost per unit

(b) Ordering cost per unit

(c) Holding cost per unit of time

(d) Shortage cost.

(a) Purchase Cost

The purchase cost consists of the actual price paid for procurement of items. The unit price is independent of the size of the quantity ordered or purchased.

(b) Ordering Cost

Ordering cost is associated with the cost of placing orders for procurement of items from outside suppliers or it can also be termed as setting cost if the items are produced by setting up of machinery. The cost per ordering generally includes,

i) Requisition cost of handling of invoices, stationary, payments etc.

ii) Cost of service which includes cost of mailing, telephone calls and other follow up actions.

iii) Material handling costs incurred in receiving, inspection and storing of items included in the order.

Ordering cost is independent of the size of the order, rather it varies with the number of orders placed during a period of time. Thus if a large number of orders are placed, more money will be required for purchasing the items.

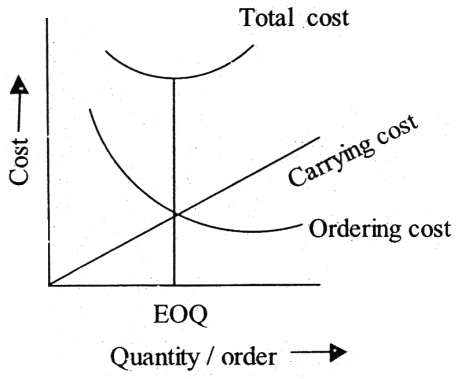


Fig. : Graphical Representation of Economic Order Quantity

(c) Holding Cost

It is also called carrying cost. It is associated with holding inventory carrying cost and is directly proportional to the order size. The factors are :

i) Storage cost incurred for providing warehouse space to store the product.

ii) Insurance charges against possible loss from fire or other forms of damage

iii) Handling cost incurred by payment of salaries to employees for handling inventory.

iv) Interest paid on investment.

v) Obsolescence and deterioration costs incurred When parties of the inventory become obsolete or damaged, detoriated by natural causes.

(d) Shortage Cost

It is also called storage cost. The storage of items is said to happen when actual demand cannot be fulfilled from existing stock of items. We can measure it in the form of goodwill loss and lost profit due to existing demand but non-availability of stock i.e., shortage of stock.

Q16. What are the assumptions and limitations of EOQ?

Ans :

Assumptions

The following are the assumptions of EOQ are :

1. Demand for the product is constant and uniform throughout the period.
2. Lead time (time from ordering to receipt) constant
3. Price per unit of product is constant
4. Inventory holding cost is based on average inventory
5. Ordering costs are constant, and
6. All demands for the product will be satisfied (no back orders are allowed).

Limitations

I. Often inventory holding costs and ordering costs cannot be identified accurately and some items cannot be even identified properly.

2. Economic order quantity applied without due regard to possibility of fall in demand, can lead to high value obsolescent inventory.

3. Economic order quantity may not be applicable when requirements are irregular or when there is a impending proce rise.

5.4.1 Quantity Discount

Q17. Explain EOQ with Quantity Discount.

Ans :

When items are purchased in bulk, buyers are usually given discount in the purchase price of goods. This discount may be a step function of purchase quantity shown as.

Quantity	Purchase Price
$0 \le Q_1 < b_1$	P_1
$b_1 \le Q_2 < b_2$	P_2
$b_2 \le Q_3 < b_3$	P_3
.	.
.	.
.	.
$b_{n-1} \le Q_4$	P_n

The procedure to compute the optimal order size for this situation is given in the following steps.

Step 1 : Find EOQ for the nth (last) price break.

$$Q_n^* = \sqrt{\frac{2C_oD}{iP_n}}$$

If it is greater than or equal to b_{n-1}, then the optimal order size $Q^* = Q_n^*$; otherwise go to Step-2

Step 2 : Find EOQ for the n – 1th price break.

$$Q_{n-1}^* = \sqrt{\frac{2C_oD}{iP_{n-1}}}$$

If it is greater than or equal to b_{n-2}, then compute the following, and select least cost purchase quantity as the optimal order size; otherwise go to Step 3:

(i) Total cost, TC(Q_{n-1}^*)

(ii) Total cost, TC(b_{n-1})

Step 3 : Find EOQ for the n – 2th price break.

$$Q_{n-2}^* = \sqrt{\frac{2C_oD}{iP_{n-2}}}$$

It it is greater than or equal to b_{n-3}, then compute the following and select least cost purchase quantity; otherwise go to Step 4.

(i) Total cost, TC(Q_{n-2}^*)

(ii) Total cost, TC(b_{n-2})

(iii) Total cost, TC(b_{n-1})

Step 4 : Continue in this manner until $Q_{n-i}^* \geq b_{n-i-1}$. Then compare total costs TC(Q_{n-i}^*), TC(b_{n-i}), TC(b_{n-i+1}), ..., TC(b_{n-1}) corresponding to purchase quantities Q_{n-i}^* , b_{n-1}, b_{n-i+1}, ..., b_{n-1}, respectively. Finally, select the purchase quantity w.r.t the minimum total cost.

5.5 MODELS OF INVENTORY

Q18. What are the various models of inventory system?

(OR)

Explain in detail deterministic and probabilistic models of inventory.

Ans : **(Aug.-17, Imp.)**

The inventory models can be classified into

I) Deterministic models

II) Probabilistic models

I) Deterministic Models

The various deterministic models are as given

1. Purchase model with instantaneous replenishment and without shortages.
2. Manufacturing model without shortages.
3. Purchase model with instantaneous replenishment and with shortages.
4. Manufacturing model with shortages.

1. Purchase Model with Instantaneous Replenishment and without Shortages

In this model of inventory, orders of equal size are placed at periodical intervals. The items against an order are replenished instantaneously and the items are consumed at a constant rate. The purchase price per unit is the same irrespective of order size. Let,

D = be the annual demand in units.

C_0 = be the ordering cost/order

C_C = be the carrying cost/unit/year

P = be the purchase price per unit

Q = be the order size.

Then, the corresponding model is shown in Figure.

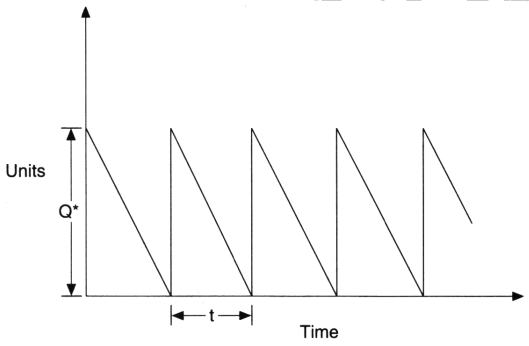


Fig.: Purchase model without stockout

Therefore,

The number of orders/year = $\frac{D}{Q}$

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

Cost of ordering/year = $\frac{D}{Q} \times C_0$

Cost of carrying/year = $\frac{Q}{2} \times C_c$

Purchase cost/year = D × P

The total inventory cost (TC)/year = $\frac{D}{Q} \times C_0 + \frac{Q}{2} \times C_C + D \times P$

Differentiating w.r.t. Q yields

$$\frac{d}{dQ}(TC) = \frac{-D}{Q^2} C_0 + \frac{C_c}{2}$$

The second derivative = $\frac{+2D}{Q^3} C_0$

Since the second derivative is positive, we can equate the first derivative to zero to get the optimal value for Q.

$$\frac{-D}{Q^2} C_0 + \frac{C_c}{2} = 0$$

$$Q^2 = \frac{2C_0 D}{C_c}$$

$$Q^* = \sqrt{\frac{2C_0 D}{C_c}}$$

No. of orders = $\frac{D}{Q^*}$

Time between orders = $\frac{Q^*}{D}$

2. Manufacturing Model without Shortages

If a company manufactures its component which is required for its main product, then the corresponding model of inventory is called "Manufacturing model". This model will be with shortages or without shortages. The rate of consumption of items is uniform throughout the year. The cost of production per unit is same irrespective of production lot size. Let,

r = Annual demand of an item.

k = Production rate of the item (No. of units produced per year).

C_a = Cost per set up.

C_c = Carrying cost per unit per period.

p = Cost of production per unit.

EBQ be Economic Batch Quantity

The operation of the manufacturing model without shortages is shown in Fig. below.

During the period t_h the item is produced at the rate of k units per period and simultaneously it is consumed at the rate of r units per period. So, during this period, the inventory is built at the rate OK - r units per period. During the period t_2, the production of the item is discontinued but the consumption of that item is continued. Hence, the inventory is decreased at the rate of r units per period during this period.

The various formulas for this situation are given below.

$$EBQ = \sqrt{\frac{2C_0 r}{C_c (1 - r/k)}}$$

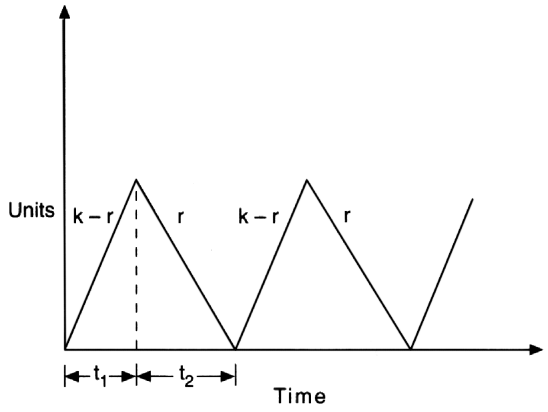


Fig.: Manufacturing model without stockout

$$t_1^* = Q^*/k$$

$$t_2^* = \frac{Q^* [1 - r/k]}{r}$$

$$\text{Cycle time} = t_1^* + t_2^*$$

3. Purchase Model with Shortages (Instantaneous Supply)

In this model, the items on order will be received instantaneously and they are consumed at a constant rate. The purchase price per unit remains same irrespective of order size. If there is no stock at the time of receiving a request for the items, it is assumed that it will be satisfied at a later date with a penalty. This is called back ordering. The operation of this model is shown in Fig. 9.4. The variables which are used in this model are given below.

D = Demand/period.

C_c = Carrying cost/unit/period.

C_0 = Ordering cost/order.

C_s = Shortage cost/unit/period.

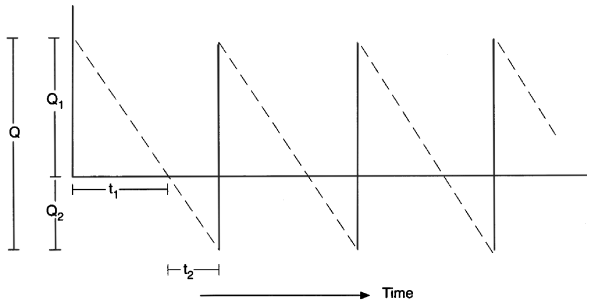


Fig.: Purchase model of inventory with stockout

In the above model,

Q = Economic order quantity,

Q_1 = Maximum inventory, and

Q_2 = Maximum stockout

$$Q^* = EOQ = \sqrt{\frac{2C_0D}{C_c}\frac{(C_s + C_S)}{C_s}}$$

$$Q_1^* = \sqrt{\frac{2C_0D}{C_c}\frac{C}{C_s + C_c}}$$

$$Q_2^* = Q^* - Q_1^*$$

$$t^* = Q^*/D$$

$$t_1^* = Q_1^* / D$$

$$t_2^* = Q_2^* / D$$

4. Manufacturing Model with Shortages

In this model, the items are produced and consumed simultaneously for a portion of the cycle time. The rate of consumption of items is uniform throughout the year. The cost of production per unit is the same irrespective of production lot size. In this model, stockout is permitted. It is assumed that the stockout units will be satisfied from the units which will be produced at a later date with a penalty. This is called back ordering. The operation of this model is shown in Fig. The variables which are used in this model are given below. Let,

r = Annual demand of an item

k = Production rate of the item (No. of units produced/year)

C_a = Cost/set up.

C_c = Carrying cost/unit/period

C_s = Shortage cost/unit/period

p = Cost of production/unit

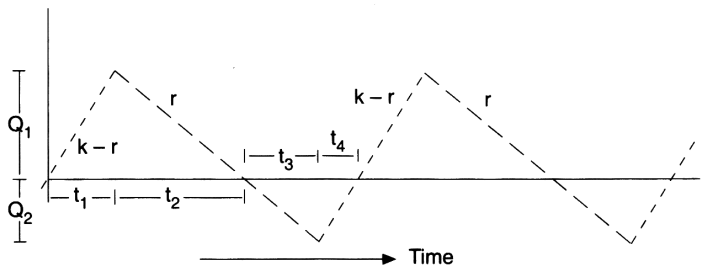


Fig.: Manufacturing model of inventory with stockout.

In the above model,

Q = Economic batch quantity

Q_1 = Maximum inventory

Q_2 = Maximum stockout

$$Q^* = EBQ = \sqrt{\frac{2C_0}{C_c}\frac{kr}{(k-r)}\frac{(C_c+C_s)}{C_s}}$$

$$Q_1^* = \sqrt{\frac{2C_0}{C_c}\frac{r(k-r)}{k}\frac{C_s}{(C_c+C_s)}}$$

$$Q_2^* = \sqrt{\frac{2C_0C_c}{C_s(C_c+C_s)}\frac{r(k-r)}{k}}$$

$$Q_1^* = \left(\frac{k-r}{k}Q^*\right) - Q_2^*$$

$t^* = Q^*/k$

$t_1^* = Q_1^* / (k-r)$

$t_2^* = Q_1^* / r$

$t_3^* = Q_2^* / r$

$t_4^* = Q_2^* / (k-r)$

II) Probabilistic Models

Probabilistic model of inventory is a statistical model that can be applied if product demand (or) any other variable is unknown but the demand can be specified by means of a probability distribution.

The various probabilistic models of inventory are as follows,

1. Instantaneous Demand and No Set-up Cost

This mode, demand is not constant and it will follow probability distribution. Consider the case of a perishable item, say newspaper.

Example, for each unsold newspaper, there will be a penalty which is given by the formula,

Marginal cost of surplus/unit,

S_1 = Purchase price/unit - Salvage value/unit

Similarly, for each shortage unit, there will be a penalty which is given by the formula,

Marginal cost of shortage/unit,

S_2 = Selling price/unit - Purchase price/unit

Let the generalized probability distribution of demand of the item be a discrete distribution as shown below,

Observation, i	1	2	3 ..... n
Demand, D	D_1	D_2	D_3 ..... D_n
Probability, P_i	P_1	P_2	P_3 ..... P_n

Under such situation, the optimal order size D_i is determined by using the following relation,

$$P_{i-1} < \frac{S_2}{S_1 + S_2} < P_i$$

Where, P_i is the cumulative probability of having demand upto D_i .

5.6 Operation of Inventory Systems

Q19. Explain briefly about Operation of Inventory Systems.

Ans :

Consider the purchase of inventory system which is as shown in Figure below.

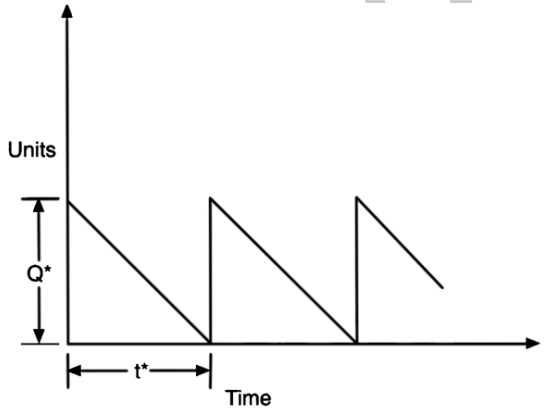


Fig.: Operation of Inventory System

Q^* is the economic order size and t* is the cycle time. If we operate with the system (shown above) as such without any provision to take care of fluctuations in demand and lead time, we will encounter stockout situation very often.

Even if we consider the model with constant demands and constant lead time we will have to place order well before the end of cycle time, so that the items are received exactly at the end of the present cycle or at the beginning of the next cycle.

Let D_{LT} be the demand during lead time.

D_{LT} = demand rate x lead time period

= (d/day) x (LT in days)

If there is no variation in lead time and demand, then it is sufficient to have a stock of D_{LX} at the time of placing order. This is as shown in Fig. below.

Reorder level (ROL) = D_{LT}

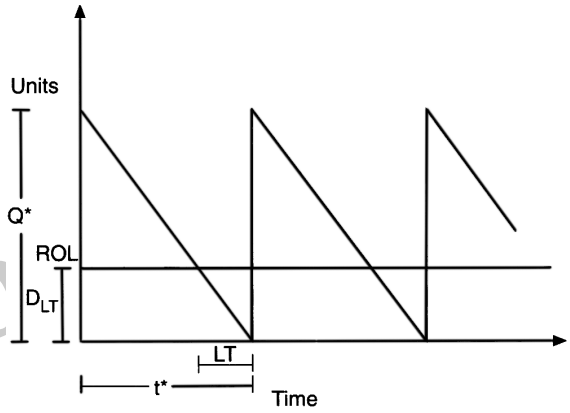


Fig.: Inventory system with constant demand and constant lead time.

Reorder level is the stock level at which an order is placed so that we receive the items against the order at the beginning of the next cycle.

If the demand is varying, then the ROL is as given below.

$$ROL = D_{LT} + SS$$

where SS is the safety stock, which acts as a cushion to absorb the variation in demand.

$$SS = K\sigma$$

Where σ is the standard deviation of demand and K is the standard normal statistic value for a given service level. The corresponding chart is shown in Fig. below.

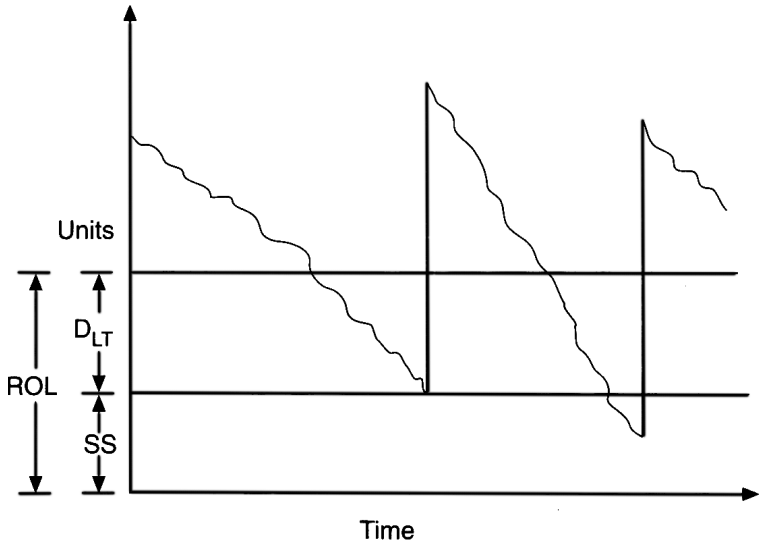


Fig. : Inventory system with safety stock for variation in lead time demand.

PROBLEMS

1. Calculate Economic Order Quantity (EOQ) from the following information:

Annual requirements **1,350 units**

Cost of materials per units **Rs. 32**

Cost of placing and receiving one order: **Rs. 47/-**

Annual carrying cost for inventory value 8%; carrying cost is estimated at cost price of material.

Sol: **(Oct.-20)**

$$EOQ = \sqrt{\frac{2AO}{C}}$$

Where

A = Annual Consumption = 1350 units

O = Ordering cost = 47

$$C = \text{Carrying cost} = 32 \times \frac{8}{100} = 2.56$$

$$\sqrt{\frac{2 \times 1350 \times 47}{2.56}} = \sqrt{\frac{126900}{2.56}}$$

$$= \sqrt{49570.31}$$

= 223 units

2. Calculate Economic Order Quantity (EOQ) from the following :

Annual consumption 6,000 units

Cost of ordering ` 60

Carrying costs ` 2

Sol: **(Dec.-19)**

$$EOQ = \sqrt{\frac{2AO}{C}}$$

where,

A = Annual consumption = 6000 units

O = Ordering cost = 60

C = Carrying cost = 2

$$= \sqrt{\frac{2 \times 6000 \times 60}{2}} = \sqrt{\frac{120000}{2}} = \sqrt{360000}$$

= 600 units

---

3. From the following particulars, calculate the Economic Order Quantity (ECQ)

Annual requirements 1,600 units

Cost of materials per unit ` 40

Cost of placing and receiving one order ` 50

Annual carrying cost for inventory value 10%, carrying cost is estimated at cost price of materials.

Sol: **(Dec.-19)**

$$EOQ = \sqrt{\frac{2AO}{C}}$$

where,

A = Annual consumption = 1600 units

O = Ordering cost = 50

$$C = \text{Carrying} = \frac{40 \times 10}{100} = 4$$

$$= \sqrt{\frac{2 \times 1600 \times 50}{4}}$$

$$= \sqrt{\frac{160000}{4}} = \sqrt{40,000}$$

= 200 units

4. For a given item of constant demand rate, the realy demand is 6025 units. The price of the item per unit is ` 60. The ordering cost is ` 300 per order. What should be the optimum inventory policy ?

Sol: **(Dec.-18)**

In the given problem, carrying cost is missing so we are assuming it as 20% p.a.

Given that,

Annual demand (D) = 6025 units

Units price = ` 60

Ordering cost = ` 300 per order

Carrying cost = 20%

Optimal inventory policy (Economic Order Quantity) EOQ = $\sqrt{\frac{2AO}{C}}$

$C = I \times C$

$= 0.20 \times 60 = 12$

$= \sqrt{\frac{2 \times 6025 \times 300}{12}} = \sqrt{\frac{36,15,000}{12}} = \sqrt{301250} = 548.8 \cong 549$ units.

---

5. A firm has a demand distribution of demand during a constant lead time with a standard deviation of 400 units. The firm wants to provide 95 percent service.

(i) What is the safety stock that needs to be provided ?

(ii) If the dmand during lead time averages 1500 units, what is the appropriate order level ?

Sol: **(Dec.-18)**

Given that,

Standard deviation (σ) = 400 units

Serice percentage = 95%

K value @ 95% service level = 1.65 (From standard normal distribution table)

Demand during lead time (D_{LT}) = 1500 units

(i) Safety Stock = $K_{95\%} \times \sigma$

$= 1.65 \times 400$

$= 660$ units

$\therefore$ A firm should maintain a safety stock of 660 units.

(ii) Re-Order level (ROL) = Demand During lead Time (D_{LT}) + Safety Stock

$= 1500 + 660$

$= 2160$ Units.

6. ABC company manufacturing consumer durables requires 20,000 units of raw material per annum. The ordering cost is Rs.300 per order and inventory carrying cost is 30% per annum on average inventory. The purchase price quoted is Rs.10 per unit.

Sol: **(Oct.-22)**

$$EOQ = \sqrt{\frac{2AO}{C}}$$

A = 20,000 Units

O = 300 Per order

C = 30% per annum

$0.30 \times 10 = 3$

$$= \sqrt{\frac{2 \times 20,000 \times 300}{3}}$$

$$= \sqrt{4000000} = 2000 \text{ units}$$

7. Find the optimal order quantity for the following price break inventory problem,

Annual demand = 3,600 units.

Inventory carrying cost = 20%

Ordering cost = ` 20 per order

Quantity	Price
0 - 499	` 10
500 - 999	` 9
Over 999	` 8

Sol:

Given that,

Annual Demand, D = 3,600 Units

Ordering Cost, C_o = ` 20 per order

Carrying Cost, I = 0.20

Unit Cost: $C_1 = 10$, $C_2 = 9$, $C_3 = 8$

Finding EOQ for the nth (last) price break.

$$(EOQ)\ Q_3^* = \sqrt{\frac{2DC_0}{C_3 \times I}}$$

$$= \sqrt{\frac{2 \times 3,600 \times 20}{8 \times 0.20}}$$

$$= \sqrt{\frac{1,44,000}{1.6}}$$

$$= \sqrt{90,000} = 300 \text{ units.}$$

$\therefore$ Since, $Q_3^* < b_2\,(999)$, Q_3^* is not feasible.

$$Q_2^* = \sqrt{\frac{2DC_0}{C_2 \times I}}$$

$$= \sqrt{\frac{2 \times 3,600 \times 20}{9 \times 0.20}}$$

$$= \sqrt{\frac{1,44,000}{1.8}}$$

$$= 282.84 \text{ Units}$$

$\therefore$ Since, $Q_2^* < b_1(500), Q_2^*$ is not feasible.

$$Q_1^* = \sqrt{\frac{2DC_0}{C_1 \times I}}$$

$$= \sqrt{\frac{2 \times 3,600 \times 20}{10 \times 0.20}}$$

$$= \sqrt{\frac{1,44,000}{2}}$$

$$= 268.33 \text{ Units}$$

$$TC(Q_1^*) = TC\,(268.33)$$

$$= \frac{D}{Q_1^*} \times C_0 + \frac{Q_1^*}{2} \times C_h + DC_1$$

$$\boxed{C_h = I \times C_1}$$

$$= \frac{3,600}{268.33} \times 20 + \frac{268.33}{2} \times (0.20 \times 10) + 3,600 \times 10$$

$$= 268.33 + 268.33 + 36,000$$

$$= ` 36,536.66$$

$$TC(b_1) = TC(500)$$

$$= \frac{D}{b_1} \times C_0 + \frac{b_1}{2} \times C_h + DC_2$$

$$= \frac{3,600}{500} \times 20 + \frac{500}{2} \times (0.20 \times 9) + 3,600 \times 9$$

$$= 144 + 450 + 32,400$$

$$= ` 32,994$$

$$TC(b_2) = TC(999)$$

$$= \frac{D}{b_2} \times C_0 + \frac{b_2}{2} \times C_h + DC_3$$

$$= \frac{3,600}{999} \times 20 + \frac{999}{2} \times (0.20 \times 8) + 3,600 \times 8$$

$$= 72 + 799.2 + 28,800$$

$$= ` 29,671.2$$

Thus, $TC(b_2)$ is the minimum cost, the optimal order quantity is b_2 which is equal to 999.

5.7 Implementation of Purchase Inventory Model

Q20. Describe the approaches to Inventory System.

(OR)

Explain about the implementation of purchase Inventory Model.

Ans :

Purchase inventory model can be categorized into two system namely.

1. Fixed order quantity system (Q system) and
2. Fixed period quantity system (P system).

1. Fixed Order Quantity System (Q-system)

Q-System is also known as 'fixed order quantity system'. In the fixed order quantity system, a fixed quantity of material is ordered whenever the stock in the warehouse attains the reorder level. The fixed order quantity in Q-system is regarded as Economic Order Quantity (EOQ). Eventhough, the order quantity remains constant, the order period changes with the changes in the demand of the consumers.

2. Fixed Period Quantity System (P-system)

P-system is an inventory control method. P-system is known by different names such as, periodic review system, fixed-order period system, periodic system (or) fixed order interval system. In this system, the orders are placed at fixed period, but the order quantity varies from order to order depending upon the demand in the market. In the Q-system, the order quantity remains same but the period of order differs and in P-system, the order quantity differes but period of order remains the same. In the fixed order period system, the stock position of each type of item is checked at regular intervals. The frequency of reviews differs from firm to firm and from one type of material to other types of material of the same firm.

Q21. Explain briefly about fixed order quantity system with its advantages and disadvantages.

(OR)

Describe briefly about Q System.

Ans : **(Imp.)**

Meaning

In this, a fixed quantity of material is ordered whenever the stock on hand reaches the reorder point. The fixed quantity of material ordered each time is nothing but the economic order quantity (EOQ). When the new consignment arrives, the total stock (existing plus new arrival) shall be within the maximum and the minimum limits. A, a supply equal to EOQ is received and the stock reaches point E. Materials are then issued and when the stock reaches F (re-order point) an order-placed and the issues continued. At B, the supplies of order placed at F are received and the stock reaches G. In the further part of the cycle, it should be noted that at C, there is delay the arrival of supplies and the issues cross minimum (safety) level. Similarly at D, safety stock is touched due to heavy consumption of material.

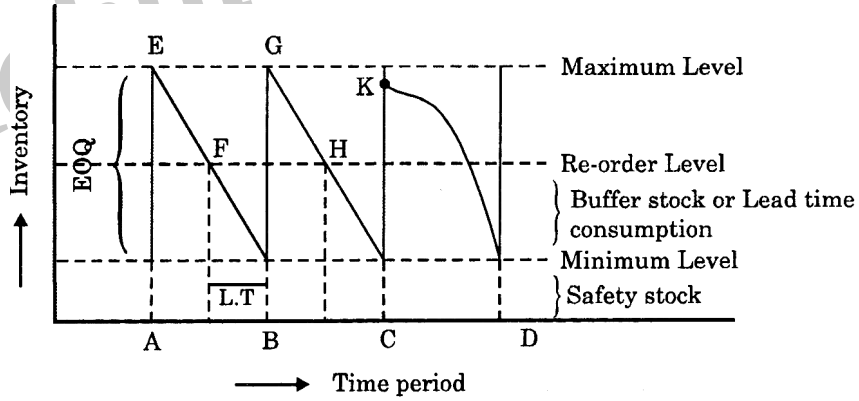


Fig.: Operation of Fixed Order Quantity System

Advantages

1. Each material can be procured in the most economical quantity.
2. Purchasing and inventory control personnel automatically devote attention to the items that are needed only when required.
3. Positive control can easily be exerted to maintain total inventory investment at the desired level simply by manipulating the planned maximum and minimum values.

Disadvantages

1. The orders are raised at irregular intervals which may not be convenient to the suppliers.
2. In case the lead time is very high, say three months, and the ordering quantity happens to be material supplies for one month, there would be two to three pending orders with the supplier each time and there is every likelihood that he may supply all orders at a time.
3. The items cannot be grouped and ordered at a time since the reorder points occur irregularly.
4. EOQ may give you an order quantity which is much below the supplier minimum (for a good discount), and there is always a chance that the ordering level for an item has been reached but not noticed in which case a stock-out may occur.
5. Further, the system assumes stable usage and definite lead time. When these change significantly, a new order quantity and a new order point should be fixed, which is quite cumbersome.

Q22. Explain briefly about fixed order period system with its advantages and disadvantages.

(OR)

Describe briefly about P System.

Ans :

Meaning

In this, the stock position of each item of material is regularly reviewed. When the stock level of a given item is not sufficient to sustain the production operation until the next scheduled review, an order is placed replenishing the supply. The frequency of reviews aries form firm to firm. It also varies among materials within the same firm, depending upon the importance of he material, specific production schedules, market conditions and so forth. Order quantities, likewise, vary for different materials.

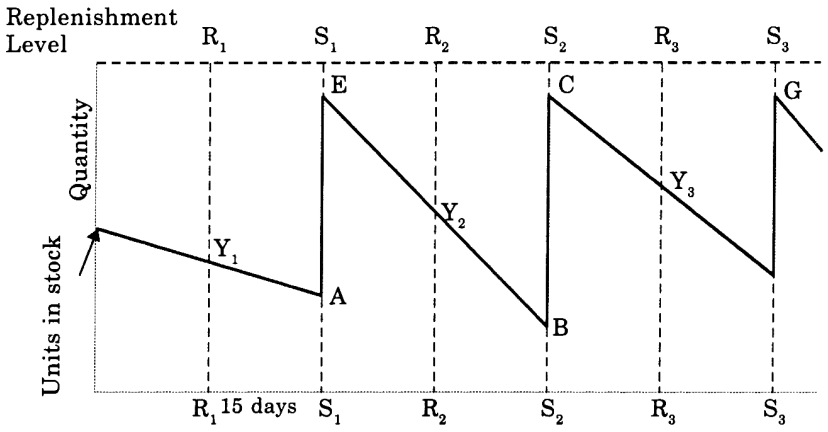


Fig.: Periodic Review System

Suppose we fix review period for an item as two months and the lead time for the item at 15 days. Then the order would be placed every two months, *i.e.,* at ordinate of R_1, R_2, R_3 etc., and the supplies would be received at ordinates S,, S_2, S_3, etc., (15 days after R_r R_2, R_3 etc.).

At R, let us assume that the stock available to be Y,, then this stock together with the quantity ordered at R_1 (supplies received at S,) should be sufficient to last till the next supplies are received at S_1 *i.e.,* to last a total period of 2½ months (review + lead time).

In addition, some buffer stock would also be necessary to take care of any increased consumption or increase in lead time.

Advantages

This system has some distinct advantages.

1. The ordering and inventory costs are low. The ordering cost is considerably reduced though follow-up work for each delivery may be necessary.
2. The suppliers will also offer attractive discounts as sales are guaranteed.
3. The system works well for materials which exhibit an irregular or seasonal usage and whose purchases must be planned in advance on the basis of sales estimates.

Disadvantages

The system has certain limitations also.

1. It compels a periodic review of all items; this in itself makes the system somewhat inefficient. Because of differences in usage rates, supplies may not have to be ordered until the succeeding review. Conversely, the usage of some items during the period may have increased to the point where they should have been ordered before the current review date. Consequently, this system must be augmented with a minimum balance figure which signals the need for an early reorder in the case of a sharp usage increase
2. The periodic review system tends to peak the purchasing work around the review dates.

Q23. What are the differences between Q System and P System.

(OR)

Compare and contrast fixed order quantity inventory system with fixed order period inventory system.

Ans : **(June-18)**

S.No.	Nature	Q System	P System
1.	**Initiation of order**	Stock on hand reaches to reorder point	Based on fixed review period and not stock level
2.	**Period of order**	Any time when stock level reaches reaches to reorder point.	Only after the predetermined period
3.	**Record keeping**	Continuously (perpetual system) each time a withdrawal (or) addition is made.	Only at the review period.
4.	**Order quantity**	Constant the same quantity ordered ordered each time.	Quantity of order varies each time is placed.
5.	**Size of inventory**	Less than the 'P' system.	Larger than the Q system.
6.	**Time to maintain**	Higher due to perpetual record keeping.	Less time due to only at the review period.

5.8 Purchase Management

Q24. What is Purchasing Management? Explain the objectives of Purchasing.

Ans : **(April-23)**

Meaning

i) In the narrow sense, the term 'purchasing' refers merely to the act of buying an item at a price.

ii) A broader meaning of purchasing makes it a managerial activity, which goes beyond the simple act of buying and includes the planning and policy activities covering a wide range of related and complementary activities.

Objectives

1. To pay reasonably low prices for the best values obtainable, negotiating and executing all company commitments.
2. To keep inventories as low as is consistent with maintaining production.
3. To develop satisfactory sources of supply and maintain good relations with them.
4. To secure good vendor performance including prompt deliveries and acceptable quality.
5. To locate new materials or products as required.
6. To develop good procedures, together with adequate controls and purchasing policy.
7. To implement such programmes as value analysis, cost analysis, and make-or-buy to reduce cost of purchases.
8. To secure high calibre personnel and allow each to develop to his/her maximum ability.
9. To maintain as economical a department as is possible, commensurate with good performance.
10. To keep top management informed of material development which could affect company profit or performance.
11. To achieve a high degree of co-operation and co-ordination with other departments in the organization.

Q25. Explain the different types of purchase system.

Ans :

Types

The whole system of purchasing, in terms of phases or grouping of related activities, can be classified as follows :

1. Pre-purchase (Ordering) system;
2. Ordering system;
3. Post-purchase (Ordering) system

1. Pre-purchase system

Activities such as initiating the purchase through raising requisitions, requirement programs, selection of suppliers, obtaining quotations and evaluating them, are broadly the pre-purchase activities.

(A) Requisitions : The department concerned (within the organization), in need of a material, usually presents a completed requisition form.

Different types of requisitions used are:

i) Standard Requisition : Also called as Indent for material (or service), Materials requisition plan etc. a requisition is made by an authorized person in the concerned department. However, it has to be countersigned by a senior officer who checks the entries made in. Normally, a requisition , in a pre printed format, contains particulars such as the detailed description of materials or services to be purchased, desired quantity, schedule for receipt of such material / service , the estimated price, possible sources and the account head, requisitioner's identity.

ii) Travelling Requisition : As the name suggests, this requisition form travels from the requisitioning department to the Purchaser directly who then only authorizes the supplier through a Purchase order to deliver the required material. This document is generally used for requisitioning items that are required frequently in bulk quantities over a long period of time.

iii) **Bills of Materials :** Bill of material is a comprehensive list of materials needed to produce a product or service. It is basically the details of materials needed, their specification, quantity, required delivery schedule etc. It is often used as a sequel to firming of a production plan, a stage where the exact material / service needs are known.

(B) Request for Quotation (RFQ): Also called as Tender Enquiries an organization through its Purchase department, invites suppliers to quote rates for supply of materials / service. This is the step taken after receiving the requisition for an item. For this purpose often a standard format is used (customized also in case of large contracts). Against this document the prospective vendors quote their price and other terms and conditions of sale.

(C) Quotation : It is also called tender. A quotation is a proposal from a prospective vendor who has quoted in response to the RFQ sent to him by the purchaser. It contains price offered by the vendor as also the terms and conditions of sale as per the policy of the vendor.

2. Ordering System

Once the decision on supplier and the rates are r finalized, the order is placed with the selected supplier. The next task is to place order. The details of order form are listed as :

i) Purchase order Reference number

ii) Description of the materials and detailed specifications.

iii) Quantity required and delivery schedule.

iv) Price and discounts

v) Shipping instructions

vi) Location where the materials are to be shipped

vii) Signature of the materials manager

viii) Detailed term of conditions.

3. Post-Purchasing System

The activities which are included under this system are follow-up procedure, receipt and checking invoices. Whenever an order is placed, it should be continuously monitored.

Q26. Discuss briefly the procedure to be followed for purchasing materials.

Ans : **(Dec.-19)**

The purchasing functions listed above will be performed in tandem to complete a transaction from its completion. Certain steps can be noticed in the process of initiating and completing the transaction. The steps are :

1. Recognition of need.
2. Description of need.
3. A suitable source is selected for the purchase. Often a source has to be developed.
4. Price and availability are determined.
5. Purchase order is prepared and sent out to the supplier.
6. Acceptance of the purchase order is obtained from the supplier.
7. Follow up is done by the purchasing department to ensure timely delivery of the material.
8. Checking the invoice and approving it for making payment to the supplier.

Q27. Explain briefly about Special Purchase Systems.

Ans :

The following are some special purchase systems.

1. Forward buying

In Forward buying, the purchasing decision for a period (say 1 year) will be taken in advance and the organization will commit accordingly in terms of order quantity, rate and delivery schedule, by taking into consideration the availability of funds and the requirements. Generally, this is used for public buying to avoid favouritism to a specific vendor.

2. Tender buying

In Tender buying the steps are: preparing bidder's list, advertising tenders, receiving bids, evaluating bids and placing order with the bidder with the lowest cost.

3. Blanket Ordering

In Blanket ordering system, the organization will enter into an agreement with its supplies to receive items for a required quantity at a particular rate over a period of time.

4. Zero Stock

Zero stock purchase system is in-line with using the just-in-time manufacturing system. The main idea of this system is to operate the plant with near zero inventory. If the suppliers are situated nearer to the company, they are more reliable in terms of making supply in time. The company can place orders with such suppliers. The company will generally provide even technical know-how, quality control support, etc. to its suppliers.

5. Rate Contract

Rate contract is very much used in public sectors and government departments. The suppliers are on 'rate contract' with DGS&D for a specific period. The organizations can place orders straightaway with such firms without going through the lengthy procedure of purchasing.

Q28. Discuss the important aspects of Purchase Management.

Ans : **(April-23)**

The different aspects of purchasing management are as follows:

1. Price forecasting
2. Purchasing of capital equipments
3. International purchasing
4. Public buying

1. Price Forecasting

Forecasting is nothing but prediction of a future event. In materials management predicting the prices of materials is of utmost importance. The precise prediction of prices would help us in buying the materials in right time and of right quantity.

Methods of Price Forecasting :

i) Charting Method

ii) Moving Average Method

iii) Regression Method

iv) Exponential Smoothing Method.

2. Purchasing of Capital Equipments

All machineries and equipments which are used in value addition process are termed as capital equipments. The frequency of purchase of these equipment is very less, may be once in five years or ten years. But, these equipments involve huge capital outlay which is treated under fixed overhead. Hence, a careful analysis should be done before buying these items.

While comparing different alternatives, one can use any one of the following approaches to select the best alternative :

i) Payback Period Method

ii) Rate of Return Method

iii) Present Worth Method

iv) Annual Equivalent Method

v) Future Worth Method

The various options to satisfy the demand for capital equipment are listed below:

(a) Purchase of New Equipment : For the purchase of new equipments, any one of the methods which are mentioned above may be used to judge each alternative. Then the best alternative is to be selected.

(b) Purchase of Used Equipment : If we purchase used equipment, the market value of the used equipment should be treated as the price of the equipment while comparing alternatives.

(c) Leasing : If the organization may have limitation on fund or it may have very short lead time to procure the equip-ment (or) it may want the equipment for a short

duration then such equipment will be available only on lease. Under such cases, one has to lease the required capital equipment.

3. International Purchasing

In view of the growing global economy, many countries are importing major raw materials, sub assemblies which are available elsewhere at a cheaper rate at the same time the cost of procurement is cheaper when compared to indigenous production/supply of the same. But in some cases, the raw material should be imported just to have a minimum specified quality standard, or , if the raw materials are produced using hi-tech process which is not available within the country.

4. Public Buying

Many organizations are duplicating the same task of purchasing even though the specifications of the materials are the same. Whenever, an order is to be placed, there is a minimum lead time involved to get the items in addition to the minimum time required to source a supplier. These will certainly introduce delay in the purchase of materials and also adds a significant cost to the total cost of purchasing.

Q29. Define Vendor Rating. Explain the importance of vendor rating.

Ans :

Meaning

Vendor Rating is a continuous management process used for the assessment of vendors. It is engaged in measuring, evaluating and improving the supplied performance, which drives the firms for making future sourcing decisions.

In simple terms a Vendor Rating system, is responsible for analyzing the fact, so as to what extent a supplier does, what he agreed to do with regard to quality, delivery, reliability, flexibility and the price.

Importance

Evaluation of Vendor Rating, reveals valuable and important information, which helps the firms to improve the quality of their sourcing decisions. Some of the significant advantages of vendor rating system are as follows:

1. Through Vendor Rating system, a wide range of vendors can be evaluated periodically, in terms of price, quality and delivery.
2. The process of Vendor Rating provides a formal frame work through which, "vendor quality" can be measured in quantitative terms.
3. These ratings provide the overall ratings of a vendor which can be used further for reviewing, comparing and selecting vendors.
4. It acts as a means for quality assurance and acceptance sampling.
5. It can be used as a significant defect prevention device, it is done by maintaining a cordial relationship between a vendor and a customer.

Q30. Outline the Process of Vendor Evalua-tion Rating.

Ans :

The process of vendor evaluation involves the following steps.

1. Vendor selection
2. Performance evaluation
3. Vendor ranking
4. Periodic review of potentialities evaluation

1. Vendor Selection

The selection of vendor depends on several factors which are as follows:

(a) Production Abilities of Vendor

i) The vendor should be able to manufacture the desired product in desired quantities.

ii) The vendor must have the ability to expand the capacity in future.

iii) The vendor must have the know-ledge about buying company and its requirements.

(b) Financial Soundness of the Company

The financial soundness of the company depends on the following factors:

i) The capital structure of vendor's company.

ii) Is the vendor company belonging to larger group of companies, private limited company or public limited?

iii) The past profitability records of the company.

iv) Future expansion plans of the company.

(c) Technical Capabilities

i) Vendor should have adequate technical capabilities.

ii) Vendor must have consistency in the quantity produced by firm.

iii) Vendor must follow proper quality control method.

Other Considerations

i) Working conditions of vendor company

ii) Industrial relations in the vendor companies

iii) Are there any chances of disrup-tion in supply of materials in qualitative and quantitative terms due to human relations problems in the vendor company?

2. Performance Evaluation

Although the above factors are important while relating the vendors the following characteristics act as the basis for rating or evaluating the vendors:

i) Delivery (of products as per the order).

ii) Quality (delivering the products according to the quality specifications).

iii) Price (Supplying the products at reasonable price). Other factors like:

1. Ability to meet urgent orders.

2. Providing help in different areas such as supplying useful market information, willingness to try new designs, methods, orders, etc.

3. Vendor Ranking

After evaluating all the vendors, the firm compares all the vendors and the vendor who is providing quality products at the least cost must be selected. The qualified vendor, should provide quality products so that, the firm can produce the best quality products. This also helps in building an effective relationship, between the firm and the supplier.

The other vendors who are not selected are provided feedback so that, they can improve in the areas where they are lacking and provides best products in the future.

4. Periodic Review of Potentialities Evaluation

The vendor selected should be periodically reviewed, as this helps in determining whether the materials supplied by the vendor are of the same quality.

If the vendor is not supplying the products of good quality then he must be changed and some other vendor who is providing good quality materials must be selected.

In case the vendor is providing the materials of good quality, then it would be better for the firm to maintain the same relation with the vendor.

Q31. Explain the Role of Vendors in Produc-tions and Operations Management.

Ans :

Vendors play a very important role in the production and operations management. Any delay in delivering the materials or defects in the item supplied, significantly affects the production schedule, increases the inventory costs and results in delays in delivering the end products.

The role of vendors in productions and operations management can be studied as follows:

1. On-time Delivery

The vendors, by providing the materials on-time to the company, contribute towards the smooth flow of production process. Any late deliveries

can disrupt the production process. Hence, vendors, ensure on-time delivery of material to the organization.

2. Quality

By supplying the right quality of material to the organization, vendors, contribute towards the production of high quality products and reduces the wastage.

3. Low Inventory Cost

By making the on-time delivery, the vendors reduce the inventory cost which in turn improves the productivity.

4. Reasonable Price

The reasonable price quoted by the vendors, enables the company to make the bulk purchases from them. Some vendors also offer discounts on bulk purchases, which helps in reducing the purchasing cost.

5. Inventory Policy of Vendor

The vendors, by maintaining an inventory policy for keeping the spare parts in advance helps the firms in times of an emergency equipment break down. In such cases, the companies can take the help from vender.. to avoid the delays in the production process.

6. Improves Customer Satisfaction

The good quality material and on-time delivery provided by the vendors, help in developing quality products for the customers. This in turn improves the customer satisfaction.

Q32. Explain various Methods of Rating the Supplier.

Ans :

The performances of suppliers are evaluated, by using different rating techniques. Some of the important vendor rating techniques are as follows:

1. Categorical plan
2. The weighted point plan
3. Critical incidents method.
4. Checklist system.

1. Categorical Plan

Categorical plan is a technique in which, personnel from different divisions maintains informal evaluation records. These indivi-duals/ personnel, belong to several divisions like, purchasing, engineering, control, inspection quality and receiving. Each person develops a list a performance factors, which are significant to him for each major supplier.

During the monthly meeting, the perfor-mance of each major supplier is evaluated, against each evaluator's list of factors. After the elevation, each supplier is allotted an overall group evaluation, which is expressed in terms like, "preferred", "neutral" (or) "unsatisfactory". Categorical plan is easy to understand and operate and is commonly used in many firms.

2. The Weighted Point Plan

The weighted Point Plan Technique, evaluates the performance factors such as quality, delivery, price and services by giving the "weights".

3. Critical Incidents Method

In this technique, a record of events and occurrences associated with the buyer-vendor relationship, must be maintained in each vendors file, for evaluating the performance of vendors. The information provided in the record, must be relevant and should be used for showing the positive and negative aspects of a performance. This type of documentation, helps in overcoming the difficulties, improving performance, determining the competence of a vendor and if required considering the termination. As this technique is executed easily, it is very helpful for small organizations.

4. Checklist System

In this technique, the performance of vendors are evaluated with the help of a simple check list. This technique is designed to make the vendor

rating easy, from the perspective of financial strength, size, product, service, price and quality. The checklist system is simple and is very helpful in evaluating the performance of suppliers.

Some of the elements which are included in a typical checklist are as follows:

(a) Reliability

i) Whether the supplier company is a financially strong, stable and reputed company.

ii) Whether the ability and integrity of supplier is proved, by its past performance.

iii) Whether the supplier is providing savings, along with product improvement.

(b) Technical Abilities

i) Is the supplier providing enginee-ring assistance.

ii) Whether the suppliers analytical engineering, assist in enhancing the efficiency of firms basic processes.

iii) Is the supplier providing design assistance.

iv) Is the supplier capable of handling special needs and design.

v) Can a supplier contributes towards general advancement, by basic research.

(c) After Sale Service

i) Is a service center provided by a supplier when a firm needs it?

ii) Whether the supplier provides emergency service?

iii) Whether the supplier have renewal parts when the firm requires?

d) Availability

i) Whether the supplier ensures on time delivery

ii) Are the stocks provided to the firm in short span of time?

iii) Is the location of supplier beneficial to the firm

iv) Will the supplier plan shipment for minimising the inventory?

v) Is the supplier depended upon for providing a continuous flow of products or materials?

e) Buying Convenience

i) Is the supplier providing full line of associated products?

ii) Is the supplier packaging his product appropriately as per the firm's use?

iii) Is the supplier having a local sales contact? It the supplier qualified to help the firm? Can a supplier contact specialists for solving the difficult problems of the firm?

iv) Does the supplier assists the firm to reduce acquisitions such as qualifying visits, telephone calls, lab tests, rejects and complaints?

f) Sales Assistance

i) Will the supplier assist the firm to develop mutual markets? Will they suggest products for the firms?

ii) Will the appearance of suppliers product improves appearance of firm's product?

PROBLEMS

8. Calculated the vendor rating for the following. The item under consideration is the same from all suppliers.

Supplier's Data	A	B	C
Quantity supplied	90	80	75
Quantity accepted	78	80	70
Price of each item (Rs.)	4	4.2	3.9
Delivery promised (in weeks)	6	6	6
Actual deliveries made in (weeks)	8	6.2	7

Weightage for quality = 70%, price = 2%, delivery = 10%

Sol.

	Particulars	A	B	C
(a)	Percentage accepted	$\frac{78}{90}\times 100$ = 86.66%	$\frac{80}{80}\times 100$ = 100%	$\frac{70}{75}\times 100$ 93.3%
	Quality rating (weightage of 70%)	86.66×0.7 = 60.66%	100×0.7 = 70%	93.3×0.7 = 65.33%

(b) Price ratio = $\frac{\text{lowest price}}{\text{Net price}}\times 100$ Price rating = Price ratio × Weightage

	Particulars	A	B	C
	Price ratio	$\frac{3.9}{4}\times 100$ = 97.5%	$\frac{3.9}{4.2}\times 100$ = 92.85%	$\frac{3.9}{3.9}\times 100$ = 100%
	Price rating @ 20% weightage	97.5×0.2 = 19.5%	92.85×0.2 = 18.57%	100×0.2 = 20%
(c)	Delivery promise kept	$\frac{6}{8}\times 100$ = 75%	$\frac{6}{6.2}\times 100$ = 96.77%	$\frac{6}{7}\times 100$ = 85.7%
	Delivery rating @ 10% weightage	75×0.10 = 7.5%	96.77×0.1 = 9.68%	85.7×0.1 = 8.57%
	Total vendor rating	87.66%	98.25%	93.87%

9. Calculate the vendor rating for the following weightage.

Quality = 50; Delivery = 25, Price = 15; Response to suggestions = 10.

Supplier's Data	I	II	III
Quantity supplied	108	90	80
Equivalent quantity accepted	102	90	75
Price of item (Rs.)	1	1.2	1.1
Delivery promised (in weeks)	3	4	4
Actual delivery (in weeks)	2.7	5	4.4
Response to suggestion (%)	90	85	100

Sol.

Particulars		A	B	C
(a)	Quality rating			
	Percentage accepted	$\frac{102}{108}\times 100$ = 94.4%(1)	100%	$\frac{75}{80}\times 100$ = 93.75%
	Quality rating	94.4 × 0.5 = 47.2%	100 × 0.5 = 50%	93.75 × 0.5 = 46.875%

(b) Price ratio = $\frac{\text{Lowest price}}{\text{Price of supplier}}\times 100$ Price rating = Price ratio × Weightage

Particulars		I	II	III
	Price ratio	$\frac{1.0}{1.0}\times 100$ = 100%	$\frac{1}{1.2}\times 100$ = 83.33%	$\frac{1}{1.1}\times 100$ = 90.9%
	Price rating	100 × 0.15 = 15%	83.33 × 0.15 = 12.50%	90.9 × 0.15 = 13.63%
(c)	Delivery rating	I	II	III
	Delivery promise lept	$\frac{3}{2.7}\times 100$ = 111.11%	$\frac{4}{5}\times 100$ = 80%	$\frac{4}{4.4}\times 100$ = 90.99%
	Delivery rating	111.11 × 0.25 = 27.77%	80 × 0.25 = 20%	90.99 × 0.25 = 22.72%
		I	II	III
(d)	Response to suggession	90%	85%	100%
	Response rating	90 × 0.10 = 9%	85 × 0.1 = 8.5%	100 × 0.1 = 10%
	Total rating	I	II	III
		98.97%	91.00%	93.23%

Since vendor I has highest rating, he is ranked number one; vendor III is rank number two and vendor II is rank number three.

5.8.1 e-Procurement

Q33. Define e-Procurement. State the commponents of e-Procurement.

Ans :

Meaning

E-procurement is the process of obtaining goods, services, equipment, and supplies through the internet or other information systems like enterprise resource planning or electronic data interchange. Electronic procurement began in the late 20th century, after electronic data interchange. This technology allowed businesses to share files and documents easily, changing the nature of supply chain management. With electronic data interchange, companies can communicate remotely with suppliers and exchange invoices, contract agreements, receipts, and orders using the internet. Electronic procurement, or supplier exchange, is primarily a business-to-business process, as it connects businesses to suppliers.

Components

1. E-informing

This is the first stage of electronic procurement and occurs before purchasing the relevant good or services. E-informing is exchanging purchase data between relevant internal and external parties. It involves determining the needs of a business by assessing its various production units or departments. It also includes determining which information the company can share with suppliers and reviewing information to ensure it's sufficient and credible. E-informing involves ensuring the data reaches the suppliers to facilitate a seamless supply process. It's essential for businesses using enterprise resource planning.

2. E-tendering

E-tendering involves exchanging relevant contract documents through electronic means, like emails or other information management systems. This process also occurs before the purchase of the relevant goods or services. Under this process, the business and suppliers exchange documents containing details, like product specifications, design instructions, and order details. E-tendering helps simplify the tendering process, which can be long and cumbersome when using paper-based methods. In addition to easing communication between suppliers and businesses, e-tendering also ensures greater accuracy of information, as many e-tendering systems use specific sections and questions to obtain information that the buyer requires.

3. E-auctioning

E-auctioning is bidding for various goods through the internet. Under this process, the supplier gathers interested buyers on a predetermined electronic platform to engage in competitive bidding for products of their choice. This process forms a part of procurement where buyers advertise their contracts to potential suppliers. E-auctioning offers many benefits over traditional auctioning, including greater transparency, enabling more parties to participate in the auction, and easier completion of post-auction processes. There are various methods of e-auctioning that businesses can adopt, depending on its needs.

4. Vendor Management

Vendor management is a process through which businesses manage suppliers to improve the quality of products they receive. This process is an essential part of procurement, as it enables businesses to control product quality, cost, risks, and service delivery. Usually, the supply chain unit responsible for managing contracts also caters to vendor management. This process includes conducting research into market prices and available product quality. It also involves maintaining good relationships with vendors by providing frequent feedback and ensuring prompt payment for services. Vendor management is essential to help ensure business processes continue smoothly.

5. Catalogue Management

A catalogue contains details about a supplier's products or services. These documents contain prices, product specifications, warranties, and relevant buyer policies. Catalogue management is the process of ensuring the accessibility, quality, and accuracy of a supplier's catalogue. Effective catalogue management aids electronic procurement, allowing buyers to review products without frequent communication with the supplier. Suppliers can host their catalogues on business websites or third-party applications.

6. E-purchasing

E-purchasing is the process of buying products online. This term usually applies when businesses purchase low-value products in large quantities. Usually, these products don't have complex details or specifications and don't require the tendering of documents. In e-purchasing, buyers can access the supplier's catalogue online and make orders for the type and quantity of products they require for a business. E-purchasing encompasses the process of selecting items, making an order, processing payment, and tracking delivery. E-purchasing systems are usually complex software that can handle these processes.

7. E-ordering

E-ordering is the aspect of electronic procurement involving the approval and management of purchase orders. It includes all processes from making an order to receiving the products. Under electronic procurement, special software handles the process of e-ordering, improving the efficiency of the business' supply chain. Usually, this software is accessible to all relevant employees, allowing various departments access to the resources they require to function.

8. E-invoicing

E-invoicing involves processing and exchanging invoices through electronic means. Usually, the same software that handles catalogue management, e-purchasing, and e-ordering also caters to e-invoicing. After the buyer selects the products they want and orders, the software can automatically generate an invoice and forward it to the buyer for payment. In large companies, the accounts payable department reviews the invoices it receives and ensures proper processing and prompt payment.

9. E-contract Management

This involves managing all relevant contract documents in the procurement process, including creating, editing, and settling contracts. E-contract management allows businesses to process multiple contracts effectively and without spending on paper and employees. E-contract management also enables companies and suppliers to conclude on contracts remotely, improving efficiency and transparency.

Q34. Explain the advantages of e-Procurement .

Ans :

Advantages

Here are some benefits of electronic procurement to businesses and suppliers:

1. Automation

One of the primary benefits of electronic procurement is that it enables the automation of many processes. For example, employees can quickly complete catalogue management, make purchases, and exchange documents. Other processes like making orders, payment processing, and delivery tracking enjoy full automation, reducing the burden on employees.

2. Productivity

Electronic procurement allows businesses to source their products much faster than traditional methods. It also reduces error by improving the accuracy and timeliness with which businesses can share information. These factors enable a more seamless procurement process, allowing business production to function more effectively.

3. Cost-effectiveness

Electronic procurement processes involve automation, reducing the need for paperwork and employee supervision. The automation of electronic procurement helps businesses complete their operations faster, allowing them to derive more value for their

money. Electronic procurement helps businesses have a broader reach to vendors and suppliers, increasing the likelihood of obtaining quality products for more budget-friendly prices.

4. Transparency

With electronic procurement, all processes occur on a centralized system that relevant stakeholders can access. This means that businesses can easily access contracts, purchases, and payments records. This aids transparency, enables easy fraud detection, and simplifies several internal processes like auditing, tax filing, and legal compliance.

5. Inventory Management

Electronic procurement makes it easier for businesses to keep records of all their products. As a result, employees know the number of businesses' products and when they expire. This makes supply chain management easier and reduces the risk of exhausting supplies at the wrong time.

5.8.2 Green Purchasing

Q35. What is Green Purchasing? State the benefits of Green Purchasing.

Ans :

Meaning

Green purchasing means the procurement of products that have a lesser or reduced negative impact or increased positive effect on human health, safety, or the environment when compared to competing products serving the same purpose. Green Purchasing results from a set of policies and procedures and uses tools that allow an organization to make the most efficient use of materials, produce a minimum of waste and pollution, encourage reuse, and stimulate the use of post- consumer material.

Benefits

Green procurement, also known as eco-procurement or sustainable procurement, is the process of selecting goods and services with a reduced environmental impact. businesses that adopt green procurement practices can enjoy a number of benefits, including:

1. Reduced Costs

Green procurement can help businesses reduce their overall costs by reducing waste, improving energy efficiency, and choosing products with a longer lifespan.

2. Improved Brand Image

Consumers are becoming more aware of the environmental impact of the products they purchase. By adopting green procurement practices, businesses can improve their brand image and appeal to environmentally-conscious consumers.

3. Increased Competitiveness

Many businesses are beginning to see the competitive advantage of green procurement. Those who adopt green procurement practices early will have a leg up on their competitors when it comes to attracting eco-conscious consumers and winning government contracts.

4. Enhanced Sustainability

Green procurement helps businesses move towards enhanced sustainability by reducing their reliance on natural resources and ensuring that the products they procure have a minimal environmental impact.

5.9 STORES MANAGEMENT

Q36. Define Stores Management. Explain the objectives of Stores Management.

(OR)

Briefly explain the objectives of Stores Management.

Ans : **(April-23, Aug.-16)**

Introduction

Store is a building where goods are kept, stores is defined as supplies of goods. Storage is defined as the act of storing the goods.

Stores or storage is the function of receiving, storing and issuing materials. It involves the supervision of raw materials, maintaining the goods in good condition, and providing for production whenever required.

Meaning

The purchased materials are to be stored/ warehouses and issued for production as and when they are required. As already stated, stores contains inventory mainly to provide uninterrupted supply of materials to the production divisions.

Objectives

i) To provide services to operating functions by balanced flow of raw materials, components, tools and tackles and other consumable materials.

ii) To provide these services in the most economical manner, keeping the stocks at the optimum level and bringing down inventory holding and ordering costs to the minimum 10.

iii) To account for all the materials received and issued, proper storage to avoid deterioration and loss of materials, economical material handling, stock verification and reconciliation of discrepancies.

iv) To receive scrap and other discarded materials and arrange prompt and most economical disposal.

v) Maintain proper coordination and cordial relationship with departments.

Q37. What are the functions of store keeping?

Ans : **(April-23, Dec.-18)**

The various functions of store department are as follows:

1. Receipt

The stores department receives raw materials, equipments, tools and other needed materials and maintains a record of them.

2. Storage

Stores department is responsible for storing and preserving different items/goods for future use.

3. Issue

Stores department issues the required materials to the production department and fulfills the demands of consuming departments.

4. Scrap and Surplus Stock

Stores department tries to reduce obsolescence, scrap and surplus stock by managing, preserving and codifying the materials effectively.

5. Housekeeping

The store department makes sure that the stores are maintained in a good condition for effective performance of functions like materials handling, receipt of materials, storage of materials and issue of materials.

6. Verification

Stores department checks the stock in storehouse regularly and provide on time information to purchase department with regard to the status of stock for avoiding the stock out situation.

7. Control Measures

Stores department emphasises on stock collection, over consumption and discrepancies (or) inconsistencies and develops effective control measures to overcome them.

Q38. State the importance of stores management.

(OR)

Elucidate the importance of stores management.

Ans : **(Jan.-18)**

Importance

1. It increases the value of stock when compared to all other possessions of an enterprise.
2. If helps in the prevention of typing-up of huge amount of working capital with less valuable items.
3. It enables the enterprise to carry out its operations smoothly by efficiently maintaining the stock of important items.
4. It helps in increasing the profits of an enterprise by keeping the stock of more demandable goods in excess when compared to other items.

Q39. Explain the Responsibilities of Stores Management.

Ans :

i) Identification

Identification is the process of systematically defining and describing all items of materials in stock, it includes the preparation of a Stores Code or Vocabulary, the adoption of materials specifications and the introduction of a degree of standardization. In certain cases, part of this work may be done by the design, planning or standard departments or sometimes the purchase of department.

ii) Receipt

Receipt is the process of checking and accepting from all sources (vendors, production units, repair units etc.), all materials and parts which are used in the organization. These include supplies for manufacturing or operating processes, plant maintenance, offices and capital installations.

iii) Inspection

Inspection involves the examination of incoming consignments for quality. Very often there is a separate quality, control or inspection department which undertakes this work for most materials. Otherwise, goods are inspected by stores personnel. Whatever may be the system of inspection in force, it is the duty of stores to ensure that the inspection procedures laid down are carried out before materials are accepted into stock.

iv) Materials handling

Materials handling involves movement and handling. This can be manual or mechanical (e.g. by use of forklifts). Heavy items, dangerous or inflammable goods and delicate merchandise have all to be handled differently.

v) Packing

Materials dispatched to customers from the finished goods store or from one store to another at different location require to be packed. Materials require packing according to their nature and this may vary from heavy wooden crates to ordinary paper cartons.

vi) Issue and Dispatch

This is the process of receiving demands, selecting the items required and handling them over to users, or dispatching them to customers.

vii) Stock Records

These are the documents which record, from day to day, full particulars of individual receipts, issues and balances of materials in stock.

viii) Stores Accounting

Stores accounting is the process of recording details of stock movements and balances in terms of financial value. It is sometimes undertaken by the accounts department, but there is much to be said for it being handled by stores. In practice, it is often found that such an arrangement saves a good deal of work and duplication. It has the added advantage of making stores personnel responsible for providing their own financial information which they require for the purpose of inventory control.

ix) Inventory Control

Inventory control is the operation of contin-uously arranging receipts and issues in such a way so as to ensure that stock-balances in quantity and/or value are adequate to support the current rate of consumption at all times with due regard to economy.

It involves the related process of provisioning, which is the means whereby instructions are given for the placing orders to correspond with future estimated requirements. In some industrial concerns, the production department may have a large share in provisioning; at least as far as production materials are concerned. Nevertheless, this should always ultimately be the function of Stores.

x) Stock-taking

Stock-taking is the process of physical verification of the quantity and condition of goods in store.

Q40. Explain the Factors that influence the Management of Stores.

Ans :

The following are the factors which influence the management of stores:

1. A Proper Purchasing Practice

This can be achieved through making availa-ble raw materials to meet the operational requirements. A proper purchasing practice of raw materials ensure the time by delivery to customers.

2. An Adequate Procedure of Receipt and Issue of Materials

Receipt is the process of accepting the raw materials which are used in the operational requirement process.

The procedure of receiving the demands of the users, selecting, packing and loading of vehicles with the required items for delivery, comprises of issuance of materials.

3. Proper Method of Storing Materials

One of the most important factors of stores management is to store the materials in a proper manner. This comprises stock yards and store houses and also the storage equipment for better safe guard of the materials.

4. An Effective System of Physical Control of Materials

Physical verification or control of quantities in store house and stockyards are the effective means of stores management. It is done at the end of the fiscal year or at regular intervals of time. There are various kinds of physical control of materials such as continuous physical inventory and the periodical physical inventory.

5. A Proper Method of Keeping the Records

This is the final step in stores management, to record the day to day transactions or filing the records of transactions with receipts, issues, and balance of stock.

Hence, the success of the business, to a large extent, depends on the storage and material control; or in the words efficient functioning of the stores management.

Q41. Explain the Requirements for Efficient Management of Stores

Ans :

Requirements for efficient management of stores:

1. Designation and qualification of store keeper

This reflects the status accorded to the storekeeper. A good and efficient store keeper is a prerequisite for efficient management of stores. His/her responsibilities include planning and organizing material receipts, inspection, material handling, inventory control, and accounting for online stores and complying with statutory and government regulations.

Centralized Vs Decentralized

The efficient management requires to decide whether the stores should be centralized or decentralized.

It is a matter of convenience for each organization. A careful consideration of merits of the systems is useful for planning an appropriate system.

Some of the advantages of centralized stores are: a wider range of goods is provided for all users, inventory can be minimum, better control is possible, economy in storage space is possible etc. A combination of centralization and decentralization operates in many cases.

2. Stores Location

It is a primary and crucial factor mainly concern with the place and point of storeroom. The right place or location of storeroom facilitates production and minimize handling time and cost.

3. Stores Layout

It is a fundamental factor in determining efficient performance of the department. The layout should have provisions for easy receipt, storage and disbursement of materials, nearness to point of use, minimum handling and transportation of materials, goods accessibility, efficient utilization of floor space and height, clear and quick location of items, protection against waste, deterioration, damage etc.

4. Storage System

Choosing the most suitable storage system largely influences the management of stores. A satisfactory storage system is a compromise between the use of space and use of time. The way in which stock is located helps to make the compromise a satisfactory one.

There are three basic ways of locating stock:

(a) Fixed Location : Goods of a particular type have a position in the store assigned to them exclusively.

(b) Random Location : Items can be stored in any storage position which is available.

(c) Zoned Location : Goods of a particular product group are kept in a given area (randomly stored or at fixed locations)

(d) Type of Layout : Comb type layout – stocks on one side of aisle tree type layout-stocks on both side of aisle

5. Stores Manual

Manual is written statement of policies and procedures. A proper manual helps in efficient management of stores. It has several advantages such as spelling out responsibilities and authority of store keeping, standardizing store keeping activities.

6. Proper Classification and codification

Good store keeping requires proper classification and codification of various items stored in stock.

It has advantages such as, it enables reduction in sizes and varieties, it helps in standardization of materials and helps in finding substitutes, it avoids duplicate stocks of same items, it helps to arrange bin cards, it helps in easy identification.

5.9.1 Incoming Material Control

Q42. Explain the concept of Incoming Material Control.

Ans :

The quality of incoming materials need to be checked regularly for ensuring standardized quality. For this purpose acceptance sampling method is used.

Acceptance Sampling

Acceptance sampling is a statistical method wherein a sample is taken from a lot to test the goods produced or received from the supplier for taking a decision whether to accept or reject the lot. A random sample is taken from a lot to test the quality of the sample. The process of choosing a sample from a lot randomly is known as "Lot Acceptance Sampling" or "Acceptance Sampling ". Checking the quality of the lot through acceptance sampling is neither a complete inspection nor it is equal to zero inspection. Acceptance sampling lies between zero inspection and 100% inspection. If the size of the sample selected from the lot is large then the cost involved in quality testing will also be high. The two main key issues involved in the process of acceptance sampling are,

1. Deciding the number of items which has to be checked in each lot for quality testing.
2. Deciding the confidence level at which the decision to accept or reject the lot is taken.

Significance of Acceptance Sampling

The following points help us to know the significance of acceptance sampling,

1. As it is not possible to test the quality of each and every material received from the supplier or products produced by the company, acceptance sampling can be used to test the quality of the big lot by inspecting the random sample selected from the lot.
2. The chances of accepting bad lots and rejecting good lots are very less in acceptance sampling.
3. The acceptance of bad quality materials for production purpose leads to huge rejections from the customer. Which in turn results in the total waste of time, money and efforts spent on producing the products. These rejections can be avoided by conducting inspection of materials through acceptance sampling method.
4. The company's image and reputation adversely get affected if bad quality products are sent for inspection.

5. The decision whether to accept or reject the lot of materials is taken depending upon the information acquired from the quality test conducted on the sample selected from the lot.

Uses of Acceptance Sampling

The main objective behind using acceptance sampling method is to take the decision regarding whether to accept or reject the lot. Some of the situations in which acceptance sampling method is used are as follows,

1. Acceptance sampling is used if it is very expensive to conduct 100% inspection.
2. Acceptance sampling is used if it is not possible to test the material without damaging the material. For instance, testing the breaking strength of bricks.
3. Acceptance sampling is also used if 100%> inspection consumes lot of time.

Q43. Define store accounting. Explain various methods of Store Accounting.

Ans :

Meaning

A stores is a virtual money that can be encashed. However, this money needs to be properly counted or accounted for. Stock accounting is thus a systematic way of assessing the money value of the items lying in stores as also the items under transaction through stores.

Transactions , in terms of receipts and issues are a regular feature in any stores and therefore Stock accounting process , in most of the cases, concentrates only on the stock in hand, lying in Stores.

Stores accounting is very much useful in determining the materials cost of a product. The different elements of cost of the material received are material price, freight charges, insurance and taxes.

Methods

The issues of the stores are accounted using any one of the following methods:

1. First In First Out (FIFO) method
2. Last In First Out (LIFO) method
3. Average Cost method
4. Standard Cost method
5. Market Price method

1. **First In First Out (FIFO) method:** In FIFO method, the assumption is that the old stock is depleted first. This means that the rate pertaining to that will be applied while accounting issues.
2. **Last In First Out (LIFO) method:** In LIFO method, the assumption is that the most recent receipts are issued first.
3. **Average Cost method:** In Average Cost method, the issues to the production department are divided into equal batches from each shipment at stock.
4. **Standard Cost method:** In Standard Cost method, a standard rate for the material is fixed based on the detailed analysis of market prices. This cost would be used for a fixed period, say six months or above.
5. **Market Price method.** In Market Price method, the prevailing market rate of the material is applied for costing the material at the time of issue.

5.9.2 Obsolete Surplus and Scrap Management

Q44. Explain the various reasons for accumulation of Obsolete Surplus and Scrap Management.

Ans :

1. Obsolete Surplus

They are those items which are not damaged and have economic worth but are not suitable for the company's specific operations. For example, the spare parts of machines that have been phased out. Changes in product design, technological advancements, rationalistic, food and drugs whose effectiveness has lapsed over time, wrong codification etc. are some of the reasons why obsolescence occurs. As the name implies, they are non-moving items of the inventory.

2. Surplus Stocks

These are materials which have no immediate use or at least in the foreseeable future. They have accumulated due to faulty planning, forecasting and purchasing. Sometimes, they may have accumulated since they are standard bought in quantities only and not in loose form where they would be more expensive. In short, surplus stocks are the items which are in excess of their requirement.

Reasons for Accumulation of Obsolete, Surplus and Scrap items

The materials and parts which are used in industries for carrying out production activity become obsolete because of so many reasons. This in turn results in surplus and scrap.

The following are the main reasons for accumulation of obsolete, surplus and scrap items:

1. Change in product design.
2. Rationalization of raw materials so as to minimize variety and simplify procurement procedure.
3. Cannibalization; which is due to the usage of components of failed machineries which are not in operation for a long time, in order to rectify some of the similar machineries which are actively used in production process. This will make the old machineries obsolete after some time because of missing components.
4. Faulty planning, over estimation of demand and wrong indenting are some of the main reasons.
5. Faulty purchase procedure. Just to avail quantity discount, seasonal availability, some industry will make bulk purchase. But, this will introduce surplus and scrap.

Q45. Explain the measures of accumulation of obsolete, surplus and scrap items.

Ans :

We can avoid such accumulation of obsolete, surplus and scrap items by using the following measures.

1. Periodically, items can be classified into moving and non-moving items. If some items are not moving for longer duration say, 2 years and above, then action may be initiated to dispose of such items. So periodically the stores items must be combed for such details.
2. If there is any change in the design, then the corresponding details must be circulated among concerned departments, so that they can avoid placing orders on such items which are currently used.
3. Effort should be made to recycle the scrap to the extent possible. For instance, we take a company which manufactures gear blank to rotate kiln in cement factories and sugar factories, and the scrap generated from machine shops is recycled in its foundry. The excess scrap is sold outside.
4. In some cases, if there is a possibility of salvaging the scrap into some useful components/ products, there would be a significant improvement in its materials productivity. For example, the scrap, generated in press workshop while manufacturing large size washers, may be recycled to manufacture small size washers.
5. It is possible to generate substantial amount of money by way of disposing scrap by using optimal methods. Though it is a scrap in the present factory, it may be vital raw material for some other factory. Hence, the responsibility of the store is to identify such potential customers and dispose the scrap at an attractive price. The same may be done by proper advertisement.

5.10 ABC ANALYSIS

Q46. Explain briefly about ABC Analysis.

(OR)

What is ABC Analysis? Explain the procedure of ABC Analysis.

(OR)

Explain ABC Analysis techniques of inventory Management.

(OR)

Discuss ABC analysis in detail.

(OR)

What is ABC analysis explain its proces?

Ans : **(May-19, Dec.-18)**

ABC analysis is a technique which is used to classify the items in store based on the demand of the stock.

There may be variety of items that need to be purchased and stocked in advance for issuing the same to various production departments. One has to continuously monitor the stock according to the demand pattern of each item and issue the replenishment order. If the stock on hand of a particular item becomes less than or equal to its reorder level, immediately an order is to be placed for its economical quantity. It will be very difficult to continuously monitor the stock level of each item and place order on the above mentioned condition. Hence, it is highly essential to classify the items of the stores into different categories. Then it will be easy to apply tight control on selected categories.

ABC analysis is one such technique which classifies the items into A, B and C class items. The concept of this classification is illustrated in Fig.

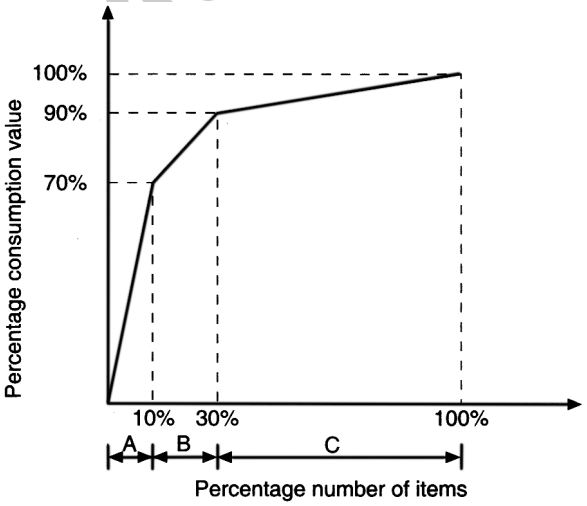


Fig.: Cumulative curve of ABC Analysis

From Fig. above, it is clear that 10 per cent of the items accounts for 70 per cent of the annual consumption value of the items, 20 per cent of the items accounts for 20 per cent of the annual consumption value of the items and 70 per cent of the items accounts for 10 per cent of the annual consumption value of the items. These combinations are only ideal. In reality, it is very difficult to fix percentages simultaneously on number of items and annual consumption of items. Mainly, the percentages on the annual consumption of items will be used as a criterion for classifying the items into A, B and C classes.

Procedure

The steps of ABC analysis are presented below.

Step 1: Input the following.

i) Total number of items.

ii) Item code, annual consumption in terms of units and unit price for each of the items.

Step 2: For each item, compute annual consumption value in terms of rupees by multiplying its annual consumption units with its unit price.

Step 3: Arrange the items and their details in descending order of the annual consumption values computed in Step 2.

Step 4: Compute cumulative values of the annual consumption values.

Step 5: Group the items into A, B and C classes by dividing the items into 70 per cent, 20 per cent and 10 per cent of the annual consumption values, respectively from top to bottom in the sorted list of Step 3.

Q47. State the advantages and disadvantages of ABC Analysis.

Ans :

Advantages

Some of the advantages of ABC analysis are as follows,

1. It facilitates selective control and thereby saves valuable time of executives.
2. It eliminates lot of unnecessary work involved in various control procedures.
3. It results in better and economic control of items in inventory.

4. It facilitates inventory control and control over usage of store materials which finally results in cost control.

5. By classifying inventory into ABC, it is also possible to reduce the investment in inventories.

Disadvantages

ABC analysis is considered as an effective technique for selective control. However it includes few limitations which are as follows,

1. Although ABC analysis is a fundamental tool for exercising selective control over various inventory items, it does not permit precise consideration of all relevant problem of inventory control.

2. If ABC analysis is not reviewed properly and updated periodically, the real purpose of control may not be furnished.

   For example, sea items, diesel, oil in a firm will become most high value items during crisis and hence requires more attention.

3. The periodic consumption value is considered as the basis for ABC classification, because of which ABC classification can disregard the requirements of spare parts the criticality of which is high, but the value of consumption is low.

PROBLEMS

10. From the following data draw an ABC analysis graph after classifying A, B & C class items.

Item	Unit price	Annual Consumption (units)
1	200.0	3,000
2	2.0	60,000
3	5000.0	20
4	12.5	200
5	9.0	350
6	25.0	6,000
7	1000.0	40
8	70.0	300

Sol :

Step No. 1 : Determination of annual consumption value.

Item	(Annual consumption (units) × Unit price (Rs.)]	Annual consumption value (Rs.) (ACV)
1	3000 × 200	6,00,000
2	60,000 × 2	1,20,000
3	20 × 5000	1,00,000
4	12.5 × 200	2,500
5	9 × 350	3,150
6	25 × 6000	1,50,000
7	1000 × 40	40,000
8	70 × 300	21,000

Step No. 2

Re-arrange the item in the descending order of annual consumption value and calculate cumulative ACV.

Item	(Annual consumption (units) × Unit price (Rs.)]	Annual consumption value (Rs.) (ACV)
1	6,00,000	6,00,000
6	1,50,000	7,50,000
2	1,20,000	8,70,000
3	1,00,000	9,70,000
7	40,000	10,10,000
8	21,000	10,31,000
5	3150	10,34,150
4	2500	10,36,650
	10,36,650	

Step No. 3

Since the basis for ABC classification is not given in the problem, assume the following basis.

Category	Percentage of total ACV
A	70
B	20
C	10

70% of total ACV = 0.70 × 10,36,650 = 7,25,655

Since this value is near to cumulative ACV of Rs. 7,50,000, categorize items 1 and 6 under 'A' category.

(A + B) together account for 90% of ACV.

90% ACV = 0.9 × 10,36,650 = Rs. 9,32,985

since this value is nearer to cumulative ACV of Rs. 9,70,000 categorize items 2 and 3 under 'B' category. The remaining items, 7, 8, 5 and 4 are categorized under 'C' category.

Step 4

Construction of ABC analysis graph

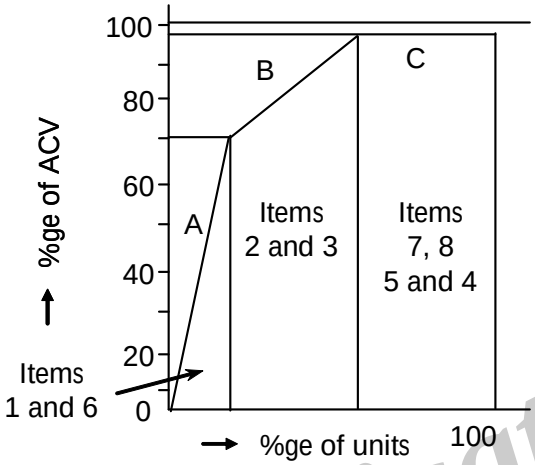
$$\left.\begin{matrix}\text{Exact \% age of ACV of} \\ \text{'A' category items}\end{matrix}\right\} = \frac{7,50,000}{10,36,650} \times 100 = 72.34\%$$

$$\text{Exact \% age of (A + B) items} = \frac{9,70,000}{10,36,650} \times 100 = 93.57\%$$

Exact % age of (A + B) items = $\frac{9,70,000}{10,36,650} \times 100 = 93.57\%$

% age of ACV of 'B' item = 93.57 – 72.34 = 21.23%

% age of ACV of 'C' item = 100 – 93.57 = 6.43%



11. The following data is available on consumption pattern of certain materials in an organization.

Group	No. of Items	Monthly consumption (units)	Price Item (Rs.)
I	40	3000	9
II	20	270	100
III	100	1700	5
IV	200	1500	4
V	60	340	50
VI	300	2500	1
VII	250	2000	2
VIII	30	170	500

Find out A, B, C items when

'A' item account for 85% of consumption value.

'B' item account for 10% of consumption value.

'C' item account for 5% of consumption value.

Sol :

Step No. 1

Calculation of Monthly Consumption Value (MCV)

Group	No. of Items per group	Monthly consumption (units)	Unit price (Rs.)	Monthly consumption value (MCV)
I	40	300	90	10,80,000
II	200	270	100	5,40,000
III	100	1700	5	8,50,000
IV	200	1500	4	12,00,000
V	60	340	50	10,20,000
VI	300	2500	1	7,50,000
VII	250	2000	2	10,00,000
VIII	30	170	500	25,50,000
			Total	89,90,000

Step No. 2

Rearrange the groups in the decreasing order of MCV and calculate cumulative MCV for each group.

Group	MCV in descending order (Rs.)	Cumulative MCV (Rs.)
VIII	25,50,000	25,50,000
IV	12,00,000	37,50,000
I	10,80,000	48,30,000
V	10,20,000	58,50,000
VII	10,00,000	68,50,000
III	8,50,000	77,00,000
VI	7,50,000	84,50,000 B
II	5,40,000	89,90,000 C

Step No. 3

Classifying the group as A, B & C based on MCV

85% of total MCV = 0.85 × 89,90,000 = 76,41,500

Since this value is nearer to cumulative MCV of 77,00,000 the groups VIII, IV, V, VII and III are categorized under group 'A'

(A + B) Comprise 95% of MCV

95% of MCV = 0.95 × 89,90,000 = Rs. 85,40,500

Since this value is nearer to 84,50,000 groups VI is under category 'B' and group II is under category 'C'.

5.11 XYZ ANALYSIS

Q48. Explain briefly about XYZ Analysis. What are the steps involved in XYZ analysis?

Ans : **(Dec.-18)**

This classification is based on the value of inventory of materials actually held in stores at a given time (usually during stock checking annually (or) half-yearly). XYZ analysis helps to control average inventory value by focussing efforts to reduce the inventory of 'X' items which are usually 10% of the number of items stored, but accounting for 70% of the total inventory value. Similarly, 'Y' items are 20% of the number of items stored and account for 20% of the total inventory value. The remaining 70% of the items accounting for 10% of the total inventory value are 'Z' items. The XYZ classification is done in the same way as ABC analysis, the difference being the actual inventory value of items in stores instead of their estimated annual consumption value.

Process

The various steps involved in the process of XYZ analysis are as follows,

Step-1

In the first step, mean demand (p) for each item is calculated. The formula used is,

$$\mu = \frac{D}{n}$$

Where,

D = Demand

n = Number of months.

Step-2

After calculating the mean demand, standard deviation (o) is calculated for each item with the following formula,

$$\sigma = \sqrt{\left(\frac{\Sigma(D-\mu)^2}{n}\right)}$$

Step-3

In the third step, Co-efficient of Variation (C.V) for each item is calculated with percentages. The formula for calculating co-efficient of variation is,

$$C.V = \frac{\sigma}{\mu} \times 100$$

Step-4

After calculating, C.V items are sequenced in an ascending order of the C.V values.

Step-5

Finally, the items are classified into X, Y and Z categories by dividing the total number of items into 20%, 30% and 50%. 20% for category-X, 30% for category-Y and 50% for category-Z.

5.12 VED Analysis

Q49. What is VED Analysis? Explain the process of VED analysis.

(OR)

What is VED Analysis. Explain the three categories of VED Analysis.

(OR)

What is VED analysis ? Explain the importance of VED analysis controlling the inventory.

Ans : **(May-19, Feb.-16)**

VED analysis represents classification of items based on their criticality. The analysis classifies the items into three groups called Vital, Essential and Desirable. "Vital" category encompasses those items for want of which production would come to halt. "Essential" group includes items whose stakeouts cost is very high. And "Desirable" group comprises of items which do not cause any immediate loss of production or their stockout entail nominal expenditure and cause minor disruptions for a short duration.

VED (Vital-Essential 1-Desirable) analysis is carried out to identify critical items. An item which usagewise belongs to C-category may be critical from production point of view if its stockout can cause heavy production loss.

An item may be vital for a number of reasons, namely

i) if the non-availability of the item can cause serious production losses.

ii) lead time for procurement is very large.

iii) it is non-standard item and is procured to buyer's design.

iv) the sources of supply is only one and is located far off from the buyer's plant.

Steps

Steps involved in making VED analysis are as under :

i) Identify the factors to be considered for VED analysis. The commonly considered factors are : effect on production (i.e. stock out cost in the event of its non-availability), lead time, nature of the item and sources of supply.

ii) Assign points/weightages to the factors according to their importance to the company. Typical examples of the weightages to the above four factors may be 30,30,20 and 20 points.

iii) Divide each factor into three degrees and allocate points to each degree. Usually, the first degree is assigned points equal to the weightage of its factor; second degree is allocated points equal to twice the weightage of the factor and third degree is assigned points equal to thrice the weightage of the factor.

iv) Prepare categorisation plan (Table) which provides the basis of classification of items into vital, essential and desirable categories.

v) Evaluate items one by one against each factor and assign points to the item depending upon the extent of presence of the factor in the item.

vi) Place the items into V, E and D categories depending upon the points scored by them (Table 29.3) and basis of classification set under step (iv).

S.No.	Factor	First degree	Second degree	Third degree
1.	Stockout cost in the event of non-availability (30)	Above Rs. x (30)	Between Rs. x to y (60)	Above Rs. y (90)
2.	Lead time for procurement (30)	1 -4 weeks (30)	4-8 weeks (60)	Over 8 weeks (90)
3.	Nature of the item (20)	Produced to commercial standard, or off the shelf availability (20)	Produced to suppliers' design (40)	Produced to buyer's design or proprietory items (60)
4.	Sources of supply (20)	Local (20)	Outstation (40)	Imported, quota items i.e. controlled supply (60)

Table : Typical VED analysis categorisation plan

Points	Classification
100-160	Desirable
161-230	Essential
231-300	Vital

Table : Typical categorisation plan

VED analysis is best suited for spares inventory. In fact, it is advantageous to use more than one method, e.g. ABC and VED analysis together would be helpful for inventory control of spares.

5.13 FSN ANALYSIS

Q50. Explain briefly about FSN Analysis.

Ans :

F-S-N analysis is based on the consumption figures of the items. The items under this analysis are classified into three groups : F (fast moving), S (low moving) and N (non-moving)

To conduct the analysis, the last date of receipt or the last date of issue whichever is later is taken into account and the period, usually in terms of number of months, that has elapsed since the last movement is recorded.

Such an analysis helps to identify :

i) Active items which require to be reviewed regularly.

ii) Surplus items whose stocks are higher than their sale of consumption; and

iii) Non-moving items which arc not being consumed. The last two categories are reviewed further to decide on disposal action to deplete their stocks and thereby release company's productive capital.

Further detailed analysis is made of the third category in regards to their year-wise stocks and items can be sub-classified as non-moving for 2 years, non-moving for 3 years, non-moving for 5 years and so on.

5.14 SDE Analysis

Q51. Explain briefly about SDE Analysis.

Ans : **(Imp.)**

S-D-E analysis is based on the problems of procurement namely :

i) non-availability

ii) scarcity

iii) longer lead time

iv) geographical location of suppliers, and

v) reliability of suppliers, etc.

i) S-D-E analysis classifies the items into three groups called "Scarce", "Difficult" and "Easy". The information so developed is then used to decide purchasing strategies.

ii) "Scare" classification comprises of items which are in short supply, imported or canalised through government agencies. Such items arc best to procure limited number of times a year in lieu of effort and expenditure involved in the procedure for import.

iii) "Difficult" classification includes those items which are available indigeneously but are not easy to procure. Also items which come from long distance and for which reliable sources do not exist fall into this category. Even the items which are difficult to manufacture and only one or two manufacturers are available belong to this group. Suppliers of such items require several weeks of advance notice.

iv) "Easy" classification covers those items which are readily available. Items produced to commercial standards, items where supply exceeds demand and others which are locally available fall into this group.

S-D-E analysis is employed by the purchase department:

i) To decide on the method of buying: e.g. Forward buying method may be followed for some of the items in the "Scarce" group; "scheduled buying" and "contract buying" for "Easy" group.

ii) To fix responsibility of buyers: e.g. Senior buyers may be given the responsibility of "S" and "D" groups while items in "E" group may be handled by junior buyers or even directly by the storekeeper.

Q52. "By combining ABC with XYZ approaches, stock management policies, systems and procedures can be better tailored". Justify.

Ans : **(April-23)**

By combining ABC with XYZ approaches, stock management policies, systems and procedures can be better tailored by taking into account both demand volatility and consumption value.

Accurate forecasts are of great potential benefit to a business. At one extreme, a company could "play it safe" with its forecast demand by maintaining high inventory buffer levels to eliminate stock outs. The costs avoided, or benefits reaped are:

i) Eliminating the need for emergency replenishment. Emergency stock replenishment is usually costly due to, for example, not buying the economic order quantity, off-contract buying, rush penalties and additional transportation costs.

ii) Avoiding production disruption, which leads to lower capacity use, increased standby time and disruption to shifts – driving overtime costs up.

iii) Avoiding loss of customer loyalty due to missed delivery commitments or longer lead times.

iv) Avoiding reputation impairment, leading to erosion of market share. On the other hand, holding costs will go up as:

v) More storage space will be needed to carry the higher buffer levels.

vi) More people will be required to manage the stock.

vii) More equipment will be needed to maintain, move, count and secure the stock.

viii) Insurance costs could be higher as the value at risk of loss is higher.

ix) There is a cost of capital tied up in unproductive working capital.

Short Questions and Answers

1. What do you understand by selective inventory control techniques?

Ans :

Selective inventory control techniques are necessary to have an effective inventory manage-ment through which the nature of inventories can be understood. Inventory analysis and classification techniques is as follows,

1. ABC analysis
2. HML analysis
3. XYZ analysis
4. VED analysis
5. FSN analysis
6. SDE analysis
7. GOLF analysis
8. SOS analysis

2. Categories of Scrap.

Ans :

Scrap is categorized into three types,

1. Administrative Scrap

This scrap is an outcome of administrative decisions taken by the management of the firm. For example, exit from sale, change in design and obsolescence of computed design.

2. Defective Scrap

Defective scrap results from the causes which are avoidable. Generally, this type of scrap is unplanned. For example,

(i) Scrap resulting from the improper handling of machinery and plant.

(ii) Scrap results due to poor quality of raw materials.

(iii) Scrap resulting from improper handling of raw materials.

3. Legitimate Scrap

Legitimate scrap occurs because of the nature of productive process like boring, punching, cutting, sawing. It is not possible to avoid this type of scrap as it is in the nature of the activity. One can predetermine the level of such scrap.

3. Define Integrated Material Manage-ment.

Ans :

Meaning

The term 'integrated material management' refers to the management of resources in an integrative manner to make way for national economic development, through efficient utilization of MIS, advanced technologies and innovative, economic materials for manufacturing.

Definitions

(i) According to Bailey and Farmer Materials management is defined as the management of the flow of materials into an organization to the point, where those materials are converted in to the firms end product(s).

(ii) According to Ammer Materials manage-ment is defined as, "the process by which an organization is supplied with goods and services that it needs to achieve its objectives.

4. What is Material Requirement Planning?

Ans :

A system of planning and scheduling the time-phased material requirements for production operations. The master production schedule specifies the quantity required for each end item in each planning period, it is set of time phased requirements for end items. But the firm also needs a set of time phased requirements for item parts and raw materials that make up those end items.

Material requirements planning is a production planning and control technique in which the master production schedule is used to create production; and purchase orders for dependent demand items.

5. Define Inventory.

Ans :

The term Inventory originates from the French word Inventaire and Latin word Invantariom, which implies a list of things found.

Definitions

The term inventory has been defined by several authors. The more popular of them are :

(i) the term inventory includes materials - raw, in process, finished packaging spares and others stocked in order to meet an unexpected demand (or) distribution in the future.

(ii) Another definition of inventory is that it can be used refer to the stock on hand at a particular time of raw materials goods-in-process of manufacture, finished products, merchandise purchased for resale and the like, tangible assets which can be seen measured and counted. In connection with financial statements and accounting records, the reference may be to the amount assigned to the stock of goods owned by an enterprise at a particular time.

6. Define Economic Order Quantity.

Ans :

Economic Order Quantity (EOQ) refers to the amount to material to be ordered to make the best use of the firm's resources, taking into consideration factors such as shelf life of the material, space required and space available for warehousing, price breaks for ordering quantity etc.

Formula

$$EOQ = \sqrt{\frac{2AO}{C}}$$

where

A = Annual Consumption

O = Ordering Cost

C = Carrying Cost

7. Purchasing Management? Explain the objectives of Purchasing.

Ans :

In the narrow sense, the term 'purchasing' refers merely to the act of buying an item at a price.

A broader meaning of purchasing makes it a managerial activity, which goes beyond the simple act of buying and includes the planning and policy activities covering a wide range of related and complementary activities. Included in such activities are the research and development strategies required for the proper selection of materials and sources from which those materials may be bought, the follow-up to insure proper delivery.

8. Define Vendor Rating.

Ans :

Vendor Rating is a continuous management process used for the assessment of vendors. It is engaged in measuring, evaluating and improving the supplied performance, which drives the firms for making future sourcing decisions.

In simple terms a Vendor Rating system, is responsible for analyzing the fact, so as to what extent a supplier does, what he agreed to do with regard to quality, delivery, reliability, flexibility and the price.

9. Define Stores Management.

Ans :

Introduction

Store is a building where goods are kept, stores is defined as supplies of goods. Storage is defined as the act of storing the goods.

Stores or storage is the function of receiving, storing and issuing materials. It involves the supervision of raw materials, maintaining the goods in good condition, and providing for production whenever required.

Stores Management

The purchased materials are to be stored/warehouses and issued for production as and when they are required. As already stated, stores contains inventory mainly to provide uninterrupted supply of materials to the production divisions.

10. ABC Analysis.

Ans :

ABC analysis is a technique which is used to classify the items in store based on the demand of the stock.

There may be variety of items that need to be purchased and stocked in advance for issuing the same to various production departments. One has to continuously monitor the stock according to the demand pattern of each item and issue the replenishment order. If the stock on hand of a particular item becomes less than or equal to its reorder level, immediately an order is to be placed for its economical quantity. It will be very difficult to continuously monitor the stock level of each item and place order on the above mentioned condition. Hence, it is highly essential to classify the items of the stores into different categories. Then it will be easy to apply tight control on selected categories.

11. Explain briefly about XYZ Analysis.

Ans :

This classification is based on the value of inventory of materials actually held in stores at a given time (usually during stock checking annually (or) half-yearly). XYZ analysis helps to control average inventory value by focussing efforts to reduce the inventory of 'X' items which are usually 10% of the number of items stored, but accounting for 70% of the total inventory value. Similarly, 'Y' items are 20% of the number of items stored and account for 20% of the total inventory value. The remaining 70% of the items accounting for 10% of the total inventory value are 'Z' items. The XYZ classification is done in the same way as ABC analysis, the difference being the actual inventory value of items in stores instead of their estimated annual consumption value.

12. VED Analysis.

Ans :

VED analysis represents classification of items based on their criticality. The analysis classifies the items into three groups called Vital, Essential and Desirable. "Vital" category encompasses those items for want of which production would come to halt. "Essential" group includes items whose stakeouts cost is very high. And "Desirable" group comprises of items which do not cause any immediate loss of production or their stockout entail nominal expenditure and cause minor disruptions for a short duration.

VED (Vital-Essential 1-Desirable) analysis is carried out to identify critical items. An item which usagewise belongs to C-category may be critical from production point of view if its stockout can cause heavy production loss.

13. FSN Analysis.

Ans :

F-S-N analysis is based on the consumption figures of the items. The items under this analysis are classified into three groups : F (fast moving), S (low moving) and N (non-moving)

To conduct the analysis, the last date of receipt or the last date of issue whichever is later is taken into account and the period, usually in terms of number of months, that has elapsed since the last movement is recorded.

14. SDE Analysis.

Ans :

S-D-E analysis classifies the items into three groups called "Scarce", "Difficult" and "Easy". The information so developed is then used to decide purchasing strategies.

"Scare" classification comprises of items which are in short supply, imported or canalised through government agencies. Such items arc best to procure limited number of times a year in lieu of effort and expenditure involved in the procedure for import.

"Difficult" classification includes those items which are available indigeneously but are not easy to procure. Also items which come from long distance and for which reliable sources do not exist fall into this category. Even the items which are difficult to manufacture and only one or two manufacturers are available belong to this group. Suppliers of such items require several weeks of advance notice.

"Easy" classification covers those items which are readily available. Items produced to commercial standards, items where supply exceeds demand and others which are locally available fall into this group.

15. Scrap management

Ans :

Scrap means waste that either has no economic value or only the value of its basic material content recoverable through recycling.

Scrap is generally availed at the end of the manufacture process. Also you can find some products that are damaged or that are unusable due to expiry or for some other reason, which needs to be scraped.

Exercise Problems

1. A factory uses annually 24,000 units of raw-material which costs ` 125 per unit placing each order costs ` 25 and carrying cost is 6% per year of the average inventory.

   (i) Find out the economic order quantity.

   (ii) How many orders are to be placed in a year?

   (iii) What is the total inventory cost for the year including the cost of material.

   [Ans: (i) 400 units, (ii) 60 orders, (iii) 30,03,000].

2. A factory uses annually 24000 units of raw materials which costs ` 1.25 per unit. Placing each order costs ` 25/- and carrying cost is 6% per year of the average inventory.

   (i) Find the EOQ and the total inventory cost including the cost of material.

   (ii) The factory works for 320 days a year. If the procurement time is 10 days and safety stock is 450 units, find the re-order point. The minimum, maximum and average inventories.

   [Ans: (i) 4000 units and 30,300 units, (ii) Re-order point = 1200 units, Max. Inventory = 4,450 units, Min. Inventory = 450 units, Average Inventory = 2,450 units].

3. Classify the following 14 items in ABC categories,

Item no.	Monthly consumption (`)
D-100	451
D-101	1052
D-102	205
D-103	893
D-104	843
D-105	727
D-106	412
D-107	214
D-108	188
D-109	172
D-110	170
D-111	5056
D-112	159
D-113	3424

[Ans: A:70%, B:20% and C:10%].

4. The stores of a repair shop has 10 items whose details are shown in the following table. Apply ABC analysis to the stores and identify A class, B class, C class items.

Details of Store		
Component code	Price/unit (`)	Units/year
C01	110	125
C02	3000	40
C03	225	310
C04	60	720
C05	310	425
C06	700	525
C07	500	900
C08	1000	90
C09	7000	510
C10	800	600

[Ans : A= C06, B= C09, C10, C = C01, C02, C03, C04, C05, C07, C08].

Choose the Correct Answers

1. Raw Materials and WIP can be classified under _____ [b]
   (a) Indirect Material (b) Direct Material
   (c) Finished Material (d) Standard Parts

2. _____ are the basic materials which have not undergone any conversion since their receipt from suppliers. [b]
   (a) WIP (b) Raw Material
   (c) Finished Parts (d) Work Made Parts

3. Buying according to the requirements is called _____ [b]
   (a) Seasonal Buying (b) Hand to mouth buying
   (c) Scheduled Buying (d) Tender Buying

4. Which is not a part of 5R's of buying? [d]
   (a) Right Quality (b) Right Quantity
   (c) Right Source (d) None of the above

5. Storing inventory requires _____ and as inventory increases, so do these costs. [d]
   (a) space and workers (b) workers and equipment
   (c) space and equipment (d) space, workers, and equipment

6. The risks in carrying inventory are: [d]
   (a) Obsolescence and damage
   (b) Damage and pilferage
   (c) Pilferage and deterioration
   (d) Obsolescence, damage, pilferage, and deterioration

7. _____ is the costs incurred in the process of making revenue. [c]
   (a) Income (b) Cost of goods sold
   (c) Expenses (d) Retained earnings

8. _____ are orders placed on manufacturing or on a vendor and represent a commitment to make or buy. [d]
   (a) Planned order releases (b) Releasing orders
   (c) Scheduled receipts (d) Open orders

9. _____ is the number of hours a work center can be used. [c]
   (a) Demonstrated capacity (b) Rated capacity
   (c) Available hours (d) Utilization

10. The term _____ means that the work center is overloaded and the term _____ means the work center is under loaded. [b]
   (a) undercapacity, overcapacity (b) overcapacity, under capacity
   (c) overcapacity, utilization (d) utilization, under capacity

Fill in the Blanks

1. _____ planning is the scientific way of determining the requirements of raw materials, components, spares and other items that go into meeting the production needs within economic investment policies.
2. The _____ is designed to meet market demand. So, it identifies the quantity of each.
3. _____ systems were built depending on a segregated basis instead of a highly integrated information system.
4. The term Inventory originates from the French word Inventaire and Latin word Invantariom, which implies a _____.
5. _____ stock function deals with short range differences in either demand or replacement.
6. _____ It is also called carrying cost.
7. Q-System is also known as _____.
8. RFQ stands for _____.
9. _____ is a continuous management process used for the assessment of vendors.
10. _____ analysis is a technique which is used to classify the items in store based on the demand of the stock.

ANSWERS

1. Materials
2. MPS
3. MRP
4. List of things found.
5. Buffer
6. Holding Cost
7. Fixed order quantity system
8. Request for Quotation
9. Vendor Rating
10. ABC

Very Short Questions and Answers

1. Material Management.

Ans :

Materials manage-ment is defined as, "the process by which an organization is supplied with goods and services that it needs to achieve its objectives.

2. Components of MRP.

Ans :

Three major sources of information are mandatory in the MRP system

1. A Master Production Schedule
2. A Bill Of Materials
3. An Inventory Status

3. Economic Order Quantity.

Ans :

Economic Order Quantity (EOQ) refers to the amount to material to be ordered to make the best use of the firm's resources, taking into consideration factors such as shelf life of the material, space required and space available for warehousing, price breaks for ordering quantity etc.

4. Green Purchasing.

Ans :

Green purchasing means the procurement of products that have a lesser or reduced negative impact or increased positive effect on human health, safety, or the environment when compared to competing products serving the same purpose.

5. VED analysis.

Ans :

VED analysis represents classification of items based on their criticality. The analysis classifies the items into three groups called Vital, Essential and Desirable.

Internal Assessment (Mid Examinations)

In CIE, for theory subjects, during a semester, there shall be two mid-term examinations. Each MidTerm examination consists of two parts i) Part – A for 10 marks, ii) Part – B for 20 marks with a total duration of 2 hours as follows:

1. Mid-Term Examination for 30 marks:

   (a) Part - A: Objective/quiz paper/Short Note questions for 10 marks.

   (b) Part - B: Descriptive paper for 20 marks.

   The objective/quiz paper is set with multiple choice, fill-in the blanks and match the following type of questions for a total of 10 marks. The descriptive paper shall contain 6 full questions out of which, the student has to answer 4 questions, each carrying 5 marks. The average of the two Mid Term Examinations shall be taken as the final marks for Mid Term Examination (for 30 marks). The remaining 10 marks of Continuous Internal Evaluation are distributed as:

2. Assignment for 5 marks. (Average of 2 Assignments each for 5 marks)

3. PPT/Poster Presentation/ Case Study/Video presentation/Survey/Field Study/Group discussion /Role Play on a topic in the concerned subject for 5 marks before II Mid-Term Examination.

   While the first mid-term examination shall be conducted on 50% of the syllabus, the second mid-term examination shall be conducted on the remaining 50% of the syllabus.

   Five (5) marks are allocated for assignments (as specified by the subject teacher concerned). The first assignment should be submitted before the conduct of the first mid-term examination, and the second assignment should be submitted before the conduct of the second mid-term examination. The average of the two assignments shall be taken as the final marks for assignment (for 5 marks).

   PPT/Poster Presentation/ Case Study/Video presentation/Survey/Field Study/Group discussion /Role Play on a topic in the concerned subject for 5 marks before II Mid-Term Examination.

UNIT - I

Part - A

Multiple Choice Questions

1. Which of these would an operations manager not be responsible for? [b]

   (a) Safety and maintenance (b) Sales and marketing

   (c) Selecting suppliers (d) Recruiting employees

2. Which of the following statement correctly explains the role of operations management? [d]

   (a) Sustain the company's operation (b) Protect the company's operation

   (c) Project the company's operation (d) All of the above

3. The role of a _____ manager is to sustain, protect, and project the company's operations side. [b]

(a) Project Manager (b) Operations Manager

(c) Finance Manager (d) Marketing Manager

Fill in the Blanks

4. Intermittent process is classified into two types i.e., _____ and _____ .

(Job Shop Process and Batch Process)

5. _____ involves all those sequential operations which are essential for achieving the product specifications.

(Process Design)

6. _____ are also called as Automatic Screw cutting machines or auto-mats.

(Automatic Machine Tools)

Short Notes

7. Define operations management. **(Unit-I, SQA - 1)**
8. Job Shop Production System. **(Unit-I, SQA - 5)**
9. Flow shop **(Unit-I, SQA - 4)**
10. What is a Corporate Strategy? **(Unit-I, SQA - 7)**

Part - B

1. Explain the Functional Subsystems of Organization. **(Unit-I, Q.No. 9)**
2. Briefly explain the systems perspective of production management. **(Unit-I, Q.No. 10)**
3. What does an operations Manager prefer Job shop production process ? **(Unit-I, Q.No. 16)**
4. Define Batch Manufacturing. What are the advantages and disadvantages of Batch Manufacturing? **(Unit-I, Q.No. 17)**
5. What do you mean by project production? State the characteristics of Project Production. **(Unit-I, Q.No. 19)**
6. What is a Corporate Strategy? State the objectives of Corporate Strategy. **(Unit-I, Q.No. 21)**
7. What do you understand by Functional Strategies? Explain various types of Functional Strategies. **(Unit-I, Q.No. 24)**

UNIT - II

Part - A

Multiple Choice Questions

1. Value analysis examines the [d]

(a) Design of every component

(b) Method of manufacturing

(c) Material used

(d) All of the above

2. Value can be defined as the combination of _____ which ensures the ultimate economy and satisfaction of the customer. [a]

   (a) Efficiency, quality, service and price
   (b) Efficiency, quality, service and size
   (c) Economy, quality, service and price
   (d) Efficiency, material, service and price

3. Value is the cost directly proportionate to [b]

   (a) Price
   (b) Function
   (c) Product Material
   (d) All of the above

Fill in the Blanks

4. _____ deals with the estimation of both the long and short term capacity requirements of a concern.
   (Capacity planning)
5. _____ is a process that follows capacity planning and uses medium range forecast.
   (Aggregate planning)
6. _____ is the process of determining the processing sequence of all the jobs at each work centre or machine.
   (Sequencing)

Short Notes

7. Characteristics of good product Design. **(Unit-II, SQA - 1)**
8. Objectives of product design. **(Unit-II, SQA - 2)**
9. What is process strategy? **(Unit-II, SQA - 4)**
10. What are the Responsibilities of Process Planning Engineer? **(Unit-II, SQA - 9)**

Part - B

1. Describe the Characteristics of good product Design. **(Unit-II, Q.No. 2)**
2. Describe the phases of generic product development process. **(Unit-II, Q.No. 8)**
3. Describe the factors that affect process design. **(Unit-II, Q.No. 12)**
4. Describe the various activities involved in process design. **(Unit-II, Q.No. 17)**
5. Write about process research and capacity planning. **(Unit-II, Q.No. 18)**
6. Describe the various steps involved in value analysis. **(Unit-II, Q.No. 21)**
7. What are the objectives of lean productions system? **(Unit-II, Q.No. 26)**

UNIT - III

Part - A

Multiple Choice Questions

1. Which of the following explain the need for facility location selection? [d]

   (a) When the existing business unit has outgrown its original facilities and expansion is not possible.
   (b) When a business is newly started.
   (c) When the lease expires and the landlord does not renew the lease.
   (d) All of these.

2. Process layout is also known as _____. [d]

(a) Functional layout (b) Batch production layout

(c) Straight line layout (d) Both (a) and (b)

3. Which of the following facility layout is best suited for the intermittent type of production, which is a method of manufacturing several different products using the same production line? [b]

(a) Product layout (b) Process layout

(c) Fixed position layout (d) Cellular manufacturing layout

Fill in the Blanks

4. A _____ refers to the arrangement of machinery, equipment and other industrial facilities **(Plant layout)**

5. Product layout is also called the _____. **(Straight-line layout)**

6. _____ layout helps the workers to associate themselves with the product. **(Fixed position)**

Short Notes

7. What are the factors influencing the plant location? **(Unit-III, SQA - 2)**

8. Define Break-even chart. **(Unit-III, SQA - 3)**

9. What is meant by Plant Location? **(Unit-III, SQA - 4)**

10. Define the term Plant Layout. **(Unit-III, SQA - 6)**

Part - B

1. What are the factors influencing the plant location? **(Unit-III, Q.No. 2)**

2. Explain about Single Facility Location Problem. **(Unit-III, Q.No. 4)**

3. Explain the Model for Multi facility Location Problem. **(Unit-III, Q.No. 6)**

4. What are the principles of plant layout? **(Unit-III, Q.No. 10)**

5. Explain the factors influencing the plant layout. **(Unit-III, Q.No. 11)**

6. Mention different types of layouts. **(Unit-III, Q.No. 12)**

7. Explain about Product layout with its advantages and limitations. **(Unit-III, Q.No. 14)**

UNIT - IV

Part - A

Multiple Choice Questions

1. Which of the following option is correct regarding QA and QC? [a]

(a) QC is an integral part of QA (b) QA is an integral pan of QC

(c) QA and QC arc independent to each other (d) QC may or may not depend on QA

2. Which of the following option involves material and component control? [c]

(a) Development of standards (b) Development of specification

(c) Quality control (d) Feedback

3. _____ refers to a systematic arrangement of machines in one line on the basis of sequence of operations. [c]

(a) Fixed position layout (b) Process layout

(c) Product layout (d) Cellular layout

Fill in the Blanks

4. _____ pertains to establishing the time of the use of specific resources within an organization. **(Scheduling)**

5. _____ is the final act of releasing job orders to the workers to go ahead with the production process. **(Dispatching)**

6. In _____ shift, some operations may be started earlier in time without affecting the sequence of operations. **(Global-left)**

Short Notes

7. What are the disadvantages of Gantt chart? **(Unit-IV, SQA - 1)**

8. Explain about Johnson's Algorithm. **(Unit-IV, SQA - 2)**

9. Define Scheduling. **(Unit-IV, SQA - 3)**

10. Cause and effect diagram. **(Unit-IV, SQA - 11)**

Part - B

1. What are the essential elements of Scheduling? **(Unit-IV, Q.No. 3)**

2. Explain briefly about Johnson's Algorithm. **(Unit-IV, Q.No. 6)**

3. How is sequencing for 'n' Jobs on three Machines. **(Unit-IV, Q.No. 7)**

4. You are given the following data regarding the processing times of some jobs on three machines I, II and III. The order of processing is I-II-III. Determine the sequence that minimizes the total elapsed time (T) required to complete the jobs. Also evaluate T and the idle time of II and III. **(Unit-IV, Prob. 6)**

Jobs	A	B	C	D	E	F	G
Processing Times in House Machine I	3	8	7	4	9	8	7
Machine II	4	3	2	5	1	4	3
Machine III	6	7	5	11	5	6	12

5. Write about heuristic procedures and priority dispatching rules ? **(Unit-IV, Q.No. 12)**

6. Explain briefly about Control Charts. **(Unit-IV, Q.No. 19)**

UNIT - V

Part - A

Multiple Choice Questions

1. Raw Materials and WIP can be classified under _____ [b]

(a) Indirect Material (b) Direct Material

(c) Finished Material (d) Standard Parts

2. Which is not a part of 5R's of buying? [d]
   (a) Right Quality (b) Right Quantity
   (c) Right Source (d) None of the above
3. _____ is the costs incurred in the process of making revenue. [c]
   (a) Income (b) Cost of goods sold
   (c) Expenses (d) Retained earnings

Fill in the Blanks

4. The _____ is designed to meet market demand. So, it identifies the quantity of each. **(MPS)**
5. _____ systems were built depending on a segregated basis instead of a highly integrated information system. **(MRP)**
6. _____ stock function deals with short range differences in either demand or replacement. **(Buffer)**

Short Notes

7. What do you understand by selective inventory control techniques? **(Unit-V, SQA - 1)**
8. What is Material Requirement Planning? **(Unit-V, SQA - 4)**
9. Define Vendor Rating. **(Unit-V, SQA -8)**
10. ABC Analysis. **(Unit-V, SQA - 10)**

Part - B

1. Define Integrated Material Manage-ment. What are the components of Integrated Material Management? **(Unit-V, Q.No. 1)**
2. State the importance of Materials Management. **(Unit-V, Q.No.4)**
3. Explain the various functions of Inventory. **(Unit-V, Q.No.12)**
4. What are the costs associated with inventory? **(Unit-V, Q.No. 13)**
5. Explain briefly about Special Purchase Systems. **(Unit-V, Q.No. 27)**
6. Discuss the important aspects of Purchase Management. **(Unit-V, Q.No. 28)**
7. Explain briefly about XYZ Analysis. What are the steps involved in XYZ analysis? **(Unit-V, Q.No. 48)**

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M.B.A III Semester Examinations **R22**

MODEL PAPER - I

PRODUCTION AND OPERATIONS MANAGEMENT

Time : 3 Hours] **[Max. Marks : 60**

Note : This question paper contains two parts **A** and **B**.

Part A is compulsory which carries 10 marks. Answer all questions in **Part A.**

Part B consists of 5 Units. Answer any **One** full question from each unit.

Each question carries 10 marks and may have a, b, c as sub questions.

PART - A (10 × 1 = 10 Marks)

ANSWERS

1. (a) Define operations management. **(Unit - I, SQA - 1)**

   (b) World Class Manufacturing. **(Unit - I, SQA - 10)**

   (c) What is Value Analysis? **(Unit - II, SQA - 6)**

   (d) What are the attributes of a product design? **(Unit - II, SQA - 10)**

   (e) What are the factors influencing the plant location? **(Unit - III, SQA - 2)**

   (f) Objectives of plant layout **(Unit - III, SQA - 7)**

   (g) What is Statistical Quality Control? **(Unit - IV, SQA - 10)**

   (h) Define Scheduling. **(Unit - IV, SQA - 3)**

   (i) Define Integrated Material Management. **(Unit - V, SQA - 3)**

   (j) Define Vendor Rating. **(Unit - V, SQA - 8)**

PART - B (5 × 10 = 50 Marks)

2. Discuss briefly the various types of corporate level strategies. **(Unit - I, Q.No. 22)**

OR

3. Explain briefly about Sustainable industry 4.0 in production and operations management. **(Unit - I, Q.No. 37)**

4. Describe the factors that affect process design. **(Unit - II, Q.No. 12)**

OR

5. Describe the various activities involved in process design. **(Unit - II, Q.No. 17)**

6. What are the factors influencing the plant location? **(Unit - III, Q.No. 2)**

OR

7. What is Product Layout? Explain the advantages and disadvantages of Product Layout. **(Unit - III, Q.No. 14)**

8. Explain briefly about Johnson's Algorithm. **(Unit - IV, Q.No. 6)**

OR

9. Consider a flow shop the has only two processors. A job is completed first on processor 1 and then on processor 2. The data for 10 jobs are as follows, **(Unit - IV, Prob. 10)**

Job	1	2	3	4	5	6	7	8	9	10
Processor 1	2	7	9	0	3	10	1	5	6	8
Processor 2	6	8	4	10	9	7	5	1	2	3
Due date	25	19	30	25	16	55	60	32	45	39

(a) Determine the schedule that minimizes the maximum flow time.

(b) What is the maximum flow time for your schedule?

(c) How many jobs are tardy in your schedule?

10. Explain in detail deterministic and probabilistic models of inventory. **(Unit - V, Q.No. 18)**

OR

11. What are the objectives of integrated material management ? **(Unit - V, Q.No. 2)**

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M.B.A III Semester Examinations **R22**

MODEL PAPER - II

PRODUCTION AND OPERATIONS MANAGEMENT

Time : 3 Hours] **[Max. Marks : 60**

Note : This question paper contains two parts **A** and **B**.

Part A is compulsory which carries 10 marks. Answer all questions in **Part A.**

Part B consists of 5 Units. Answer any **One** full question from each unit.

Each question carries 10 marks and may have a, b, c as sub questions.

PART - A (10 × 1 = 10 Marks)

ANSWERS

1. (a) Job Shop Production System. **(Unit - I, SQA - 5)**

   (b) What is a Corporate Strategy? **(Unit - I, SQA - 7)**

   (c) Objectives of product design. **(Unit - II, SQA - 2)**

   (d) Explain the benefits of Introducing New Products. **(Unit - II, SQA - 3)**

   (e) Define Break-even chart. **(Unit - III, SQA - 3)**

   (f) What is meant by Plant Location? **(Unit - III, SQA - 4)**

   (g) Cause and effect diagram. **(Unit - IV, SQA - 11)**

   (h) Objectives of Scheduling. **(Unit - IV, SQA - 4)**

   (i) What is Material Requirement Planning? **(Unit - V, SQA - 4)**

   (j) Define Stores Management. **(Unit - V, SQA - 9)**

PART - B (5 × 10 = 50 Marks)

2. Define operations management. Explain the nature of operations management. **(Unit - I, Q.No. 1)**

OR

3. Explain different generic competitive strategies in production with suitable examples. **(Unit - I, Q.No. 23)**

4. Describe the Characteristics of good product Design. **(Unit - II, Q.No. 2)**

OR

5. What is value engineering? What are the important phases of value engineering? Briefly explain each of them. **(Unit - II, Q.No. 21)**

6. What is Multi facility Location Problems? Explain its formulation. **(Unit - III, Q.No. 5)**

OR

7. What are the steps to be followed in designing a layout? **(Unit - III, Q.No. 20)**

8. You are given the following data regarding the processing times of some jobs on three machines I, II and III. The order of processing is I-II-III. Determine the sequence that minimizes the total elapsed time (T) required to complete the jobs. Also evaluate T and the idle time of II and III. **(Unit - IV, Prob. 6)**

Jobs	A	B	C	D	E	F	G
Processing Times in House Machine I	3	8	7	4	9	8	7
Machine II	4	3	2	5	1	4	3
Machine III	6	7	5	11	5	6	12

OR

9. Write about heuristic procedures and priority dispatching rules ? **(Unit - IV, Q.No. 12)**

10. What are the costs associated with inventory? **(Unit - V, Q.No. 13)**

OR

11. From the following particulars, calculate the Economic Order Quantity (ECQ) **(Unit - V, Prob. 3)**

Annual requirements 1,600 units

Cost of materials per unit ` 40

Cost of placing and receiving one order ` 50

Annual carrying cost for inventory value 10%, carrying cost is estimated at cost price of materials.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M.B.A III Semester Examinations **R22**

MODEL PAPER - III

PRODUCTION AND OPERATIONS MANAGEMENT

Time : 3 Hours] **[Max. Marks : 60**

Note : This question paper contains two parts **A** and **B**.

Part A is compulsory which carries 10 marks. Answer all questions in **Part A.**

Part B consists of 5 Units. Answer any **One** full question from each unit.

Each question carries 10 marks and may have a, b, c as sub questions.

PART - A (10 × 1 = 10 Marks)

ANSWERS

1. (a) Flow shop **(Unit - I, SQA - 4)**

   (b) Generic competitive strategies in detail. **(Unit - I, SQA - 8)**

   (c) What are the Responsibilities of Process Planning Engineer? **(Unit - II, SQA - 9)**

   (d) What is process strategy? **(Unit - II, SQA - 4)**

   (e) Define the term Plant Layout. **(Unit - III, SQA - 6)**

   (f) Combine Layout **(Unit - III, SQA - 9)**

   (g) What are the disadvantages of Gantt chart? **(Unit - IV, SQA - 1)**

   (h) Schedule Generation. **(Unit - IV, SQA - 7)**

   (i) Categories of Scrap. **(Unit - V, SQA - 2)**

   (j) FSN Analysis. **(Unit - V, SQA - 13)**

PART - B (5 × 10 = 50 Marks)

2. Briefly explain the systems perspective of production management. **(Unit - I, Q.No. 10)**

OR

3. Explain the role of operations management in strategic management. **(Unit - I, Q.No. 25)**

4. What are the various steps involved in Product Design? **(Unit - II, Q.No. 8)**

OR

5. What are the objectives of lean productions system? **(Unit - II, Q.No. 26)**

6. Explain the factors influencing the plant layout. **(Unit - III, Q.No. 11)**

OR

7. Potential location A, B and C have the cost structures shown for producing a product expected to sell at Rs. 100 per unit. Find the most economical location for an expected volume of 2,000 units/year. Also determine the range of annual volume of production for which each of the locations A, B and C would be most economical. **(Unit - III, Prob. 1)**

Location	Fixed Cost	Variable Cost per Unit (Rs)
A	25,000	50
B	50,000	25
C	80,000	15

8. Write short notes on Scheduling. Explain the scope of scheduling. **(Unit - IV, Q.No. 1)**

OR

9. What are the set of priority rules for scheduling jobs through single machine? Explain briefly each of them. **(Unit - IV, Q.No. 8)**

10. Define MRP. Explain the Components of MRP. **(Unit - V, Q.No. 6, 7)**

OR

11. The following data is available on consumption pattern of certain materials in an organization. **(Unit - V, Prob. 11)**

Group	No. of Items	Monthly consumption (units)	Price Item (Rs.)
I	40	3000	9
II	20	270	100
III	100	1700	5
IV	200	1500	4
V	60	340	50
VI	300	2500	1
VII	250	2000	2
VIII	30	170	500

Find out A, B, C items when

'A' item account for 85% of consumption value.

'B' item account for 10% of consumption value.

'C' item account for 5% of consumption value.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

MBA III-Semester Examinations

R17

December - 2018

PRODUCTION AND OPERATIONS MANAGEMENT

Time : 3 Hours] [Max. Marks : 75

Note: This question paper contains two **Part A** and **B**.

Part A is compulsory which carries 25 marks. Answer all questions in **Part A.**

Part B consists of 5 Units. Answer any **One** full question from each unit.

Each question carries 10 marks and may have a, b, c as sub questions.

PART - A (5 × 5 = 25 Marks)

Answers

1. (a) Conceptualizing production system as a transformation process. Explain atleast two each of manufacturing and services with inputs and outputs. **(Unit-I, SQA-11)**

   (b) What are the attributes of a product ? **(Unit-II, SQA-10)**

   (c) What do you understand by cellular layout? What are its merits ? **(Unit-III, SQA-17)**

   (d) What are the disadvantages of Gantt chart as a scheduling tool ? **(Unit-IV, SQA-1)**

   (e) What do you understand by selective inventory control techniques ? Explain atleast one of them. **(Unit-V, SQA-1)**

PART - B (5 × 10 = 50 Marks)

2. (a) "Production function, though is a vital function in an organization, it remains essentially a behind the scene non glamorous functions". Comment on the statement. **(Unit-I, Q.No. 13)**

   (b) What are generic strategies ? **(Unit-I, Q.No. 23)**

OR

3. (a) What is system concept of production operation ? **(Unit-I, Q.No. 10)**

   (b) What is total productivity ? What is partial productivity ? Explain the difference. **(Unit-I, Q.No. 27, 28)**

4. (a) What is ergonomics ? What is its relevance to production management ? **(Out of Syllabus)**

   (b) What is value engineering ? How does it differ from cost reduction ? **(Unit-II, Q.No. 19, 24)**

OR

5. (a) What is standardization ? What are its advantages in manufacturing ? **(Out of Syllabus)**

   (b) What is process planning design ? **(Unit-II, Q.No. 9)**

6. XYZ company is considering an additional facility. The company is heavily dependent on water transportation. Therefore it has narrowed its choice of location to three port facilities in Mumbai, Karwar and Machilipatnam. On the basis of the following data, which location is preferable ?

Relevant factors	Mumbai	Karwar	Machilipatnam
Variable cost per unit	` 18	` 20	` 19.50
Fixed cost per year	` 15 lakhs	` 30 lakhs	` 40 lakhs
Price per unit	` 300	` 300	` 300
Volume (unit/year)	3 lakhs	2.5 lakhs	3.25 lakhs

(Unit-III, Prob. 3)

OR

7. (a) Bring out the reasons with examples for layout revision. **(Unit-III, Q.No. 19)**

   (b) What are the factors influencing plant layout ? **(Unit-III, Q.No. 2)**

8. Consider the following three machines and five jobs flow shop problem. Check if Johnson's rule can be extended to this problem. If so, what is the optimal schedule and the corresponding makes pan ?

Job	Machine 1	Machine 2	Machine 3
1	11	10	12
2	13	8	20
3	15	6	15
4	12	7	19
5	20	9	7

(Unit-IV, Prob. 8)

OR

9. (a) What are the set of priority rules for scheduling 'm' through single machine ? Explain briefly each of them. **(Unit-IV, Q.No. 8)**

   (b) What is quality control ? What are its objectives are benefits ? **(Unit-IV, Q.No. 14)**

10. (a) For a given item of constant demand rate, the yearly demand is 6025 units. **(Unit-V, Prob. 4)**

    The price of the item per unit is ` 60. The ordering cost is ` 300 per order.

    What should be the optimum inventory policy ?

    (b) Explain ABC analysis technique of inventory management ? **(Unit-V, Q.No. 46)**

OR

11. (a) A firm has a demand distribution of demand during I constant lead time with a standard deviation of 400 units.

    The firm wants to provide 95 percent service.

    (i) What is the safety stock that needs to be provided ?

    (ii) If the demand during lead time averages 1500 units, what is the appropriate order level? **(Unit-V, Prob. 5)**

    (b) What are the functions of storekeeping ? **(Unit-V, Q.No. 37)**

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

MBA III-Semester Examinations

R17

April / May - 2019

PRODUCTION AND OPERATIONS MANAGEMENT

Time : 3 Hours] [Max. Marks : 75

Note: This question paper contains two **Part A** and **B**.
Part A is compulsory which carries 25 marks. Answer all questions in **Part A.**
Part B consists of 5 Units. Answer any **One** full question from each unit.
Each question carries 10 marks and may have a, b, c as sub questions.

PART - A (5 × 5 = 25 Marks)

Answers

1. Answer the following :
   (a) Strategic Role of Operations management. **(Unit-I, SQA-13)**
   (b) Benefits of Standardization to Quality. **(Out of Syllabus)**
   (c) Break-even Chart. **(Unit-III, SQA-3)**
   (d) Cause and Effect Diagram. **(Unit-IV, SQA-11)**
   (e) Categories of Scrap. **(Unit-V, SQA-2)**

PART - B (5 × 10 = 50 Marks)

2. Explain concept of production and discuss five generic competitive strategies in detail. **(Unit-I, Q.No. 10, 23)**

OR

3. Define Job Shop. When does an operations manager prefer job shop production production process ? **(Unit-1, Q.No. 15, 16)**
4. Explain the role of ergonomics product design and steps in process planning. **(Out of Syllabus)**

OR

5. What is Value Analysis ? Explain the objectives and steps in conducting Value Analysis. **(Unit-II, Q.No. 19, 21)**
6. (a) From the following data, you are required to calculate:
   (i) The amount of fixed expenses.
   (ii) The number of units to break-even.
   (iii) The number of units to cam a profit of ` 40,000.

   The selling price per unit can be assumed at ` 100.

   The company sold in two successive periods 7,000 units and 9,000 units uand has incurred a loss of ` 10,000 and earned ` 10,000 as profit respectively. **(Unit-III, Prob. 4)**

(b) A company is making a loss of ` 40,000 and relevant information is as follows :

Sales ` 1,20,000 ; Variable Costs ` 60,000 ; Fixed costs ` 1,00,000. Loss can be made good either by increasing the sales price or by increasing sales volume.

What are Break even sales if,

(i) Present sales level is maintained and the selling price in increased.

(ii) If present selling price is maintained and the sales volume is increased. What would be sales if a profit of ` 1,00,000 is required ? **(Unit-III, Prob. 5)**

OR

7. Discuss the objectives and principles of Plant Layout and brief on design procedure. **(Unit-III, Q.No. 9, 20)**

8. Explain Johnson's algorithm in detail. **(Unit-IV, Q.No. 6)**

OR

9. Consider a flow shop the has only two processors. A job is completed first on processor 1 and then on processor 2.

The data for 10 jobs are as follows,

Job	1	2	3	4	5	6	7	8	9	10
Processor 1	2	7	9	0	3	10	1	5	6	8
Processor 2	6	8	4	10	9	7	5	1	2	3
Due date	25	19	30	25	16	55	60	32	45	39

(a) Determine the schedule that minimized the maximum flow time.

(b) What is the maximum flow time for your schedule ?

(c) How many jobs are tardy in your schedule ? **(Unit-IV, Prob. 10)**

10. What us VED Analysis ? Explain the importance of VED analysis in controlling the inventory. **(Unit-V, Q.No. 49)**

OR

11. Discuss ABC analysis in detail and brief on components of Integrated material management. **(Unit-V, Q.No. 46, 1)**

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

MBA III-Semester Examinations

R17

December - 2019

PRODUCTION AND OPERATIONS MANAGEMENT

Time : 3 Hours] [Max. Marks : 75

Note: This question paper contains two **Part A** and **B**.

Part A is compulsory which carries 25 marks. Answer all questions in **Part A.**

Part B consists of 5 Units. Answer any **One** full question from each unit.

Each question carries 10 marks and may have a, b, c as sub questions.

PART - A (5 × 5 = 25 Marks)

Answers

1. (a) What is meant by production? Explain the systems concept of production. **(Unit-I, SQA-12)**

   (b) What are the responsibilities of process planning engineer ? **(Unit-II, SQA-9)**

   (c) What are the factors influencing plant location ? Explain. **(Unit-III, SQA-2)**

   (d) Explain about Jhonson's algorithm. **(Unit-IV, SQA-2)**

   (e) What is meant by inventory ? Explain about Material Requirement Planning. **(Unit-V, SQA-5, 4)**

PART - B (5 × 10 = 50 Marks)

2. What is a 'strategy'? Explain about various types of strategies. **(Unit-I, Q.No. 20, 22)**

OR

3. Explain about types of production systems. **(Unit-I, Q.No. 14, 15, 17, 19)**

4. Explain about

   (a) Pilot plant development. **(Unit-II, Q.No. 17)**

   (b) Capacity planning. **(Unit-II, Q.No. 18)**

OR

5. Explain

   (a) Steps in process planning. **(Unit-II, Q.No. 15)**

   (b) Steps in product design. **(Unit-II, Q.No. 8)**

6. The following are the potential sites for setting up of ice factory. Using the following details, decide which site be picked up for setting up of ice factory? Annual demand is 3,000 units

Selling price per unit is ` 300/-

Sites	Fixed cost/ year (`)	Variable cost. (`)
Mumbai	50,000	135
Ahemadabad	1,00,000	110
Bangalore	1,20,000	120

(Unit-III, Prob. 6)

7. Write about advantages and disadvantages of group technology. **(Unit-III, Q.No. 17)**

8. What is scheduling? Explain about schedule generation. **(Unit-IV, Q.No. 1, 11)**

OR

9. What is meant by job shop scheduling? Explain various types of schedules. **(Unit-IV, Q.No. 9, 10)**

10. (a) What are the objectives of Integrated Material Management ? **(Unit-V, Q.No. 2)**

(b) Discuss briefly the procedure to be followed for purchasing materials. **(Unit-V, Q.No. 26)**

OR

11. (a) Calculate Economic Order Quantity (EOQ) from the following :

Annual consumption	6,000 units
Cost of ordering	` 60
Carrying costs	` 2

(Unit-V, Prob. 2)

(b) From the following particulars, calculate the Economic Order Quantity (EOQ),

Annual requirements	1,600 units
Cost of materials per unit	` 40
Cost of placing and receiving one order:	` 50

Annual carrying cost for inventory value 10%, carrying cost is estimated at cost price of material.

(Unit-V, Prob. 3)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M.B.A III Semester Examination

R17

October / November - 2020

PRODUCTION AND OPERATIONS MANAGEMENT

Time : 2 Hours] [Max. Marks : 75

Answer any five questions

All questions carry equal marks

Answers

1. Discuss in brief about the different types of production system ? **(Unit-I, Q.No. 14, 15, 17, 19)**
2. Write about process research and capacity planning ? **(Unit-II, Q.No. 18)**
3. Explain about standardization procedure and advantages, application of Standardization ? **(Out of Syllabus)**
4. Explain about Product layout with its advantages and limitations. **(Unit-III, Q.No. 14)**
5. Write about heuristic procedures and priority dispatching rules ? **(Unit-IV, Q.No. 12)**
6. Explain about the concept of quality control. **(Unit-IV, Q.No. 14)**
7. Write about short note on:
   (a) Scrap management **(Unit-V, SQA-15)**
   (b) XYZ and VED analysis **(Unit-V, 48, 49)**
8. Calculate Economic Order Quantity (EOQ) from the following information:

Annual requirements	1,350 units
Cost of materials per units	Rs. 32
Cost of placing and receiving one order:	Rs. 47/-

Annual carrying cost for inventory value 8%; carrying cost is estimated at cost price of material.

(Unit-V, Prob. 1)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M.B.A III Semester Examination

R19

July / August - 2021

PRODUCTION AND OPERATIONS MANAGEMENT

Time : 3 Hours] [Max. Marks : 75

Answer any five questions

All questions carry equal marks

Answers

1. (a) What are the key elements to be considered in product design? **(Unit-II, Q.No. 4)**

   (b) What are the characteristics of flow production? Illustrate your answer with appropriate example. **(Unit-I, Q.No. 14)**

2. What are generic strategies? What is their impact on production management function? **(Unit-I, Q.No. 23)**

3. "While standardization of input components can minimize production problems, ironically, complete standardization of finished products may have serious repercussions to marketing". Comment on the statement. **(Out of Syllabus)**

4. What is value engineering? What are the important phases of value engineering? Briefly explain each of them. **(Unit-II, Q.No. 19, 21)**

5. (a) What is fixed job layout? Where do you come across it? **(Unit-III, Q.No. 16)**

   (b) What are the objectives of plant layout? **(Unit-III, Q.No. 9)**

6. A particular utility provider is trying to find the best location for a solid waste disposal station. At present four locations / are located at the following coordinate locations: Station I (4,12), Station II (6, 5), Station III (11, 8) and Station IV (1, 13).

   The number of loads hauled monthly from these four stations to the master stations will be 400, 250, 300 and 450 units, respectively. Find out the best location for the master station and give its coordinates. **(Unit-III, Prob. 12)**

7. Consider the following 3 machine and 5 job flow shop problem:

Job	Processing time in hours at Machine 1	Processing time in hours at Machine 2	Processing time in hours in Machine 3
1	10	10	12
2	12	8	20
3	16	6	14
4	12	4	20
5	20	8	8

   (a) Check whether Johnson's algorithm can be extended to this problem.

   (b) If yes, find the optimal sequence and the corresponding make-span. **(Unit-V, Prob. 9)**

8. (a) For a given item of constant demand rate, the realy demand is 6025 units. The price of the item per unit is ` 60. The ordering cost is ` 300 per order. What should be the optimum inventory policy ? **(Unit-V, Prob. 4)**

   (b) What is VED analysis? Where is it most useful? **(Unit-V, Q.No. 49)**

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

MBA III - Semester Examinations

September / October - 2022

R19

PRODUCTION AND OPERATIONS MANAGEMENT

Time : 3 Hours] **[Max. Marks : 75**

Answer any Five questions

All questions carry equal marks

Answers

1. (a) What is the nature of production and operations function? **(Unit-I, Q.No. 1)**

   (b) Briefly explain how production function is related to other areas of functional management of the organization. **(Unit-I, Q.No. 26)**

2. (a) Define productivity. What is factor productivity? What is total productivity? **(Unit-I, Q.No. 27)**

   (b) With appropriate examples, explain flow and job shop production systems. **(Unit-I, Q.No. 14, 15)**

3. (a) Explain why process design lags behind product design. **(Unit-II, Q.No. 27)**

   (b) What is the basis, for deciding on the best candidate for value engineering in a manufacturing concern? **(Unit-II, Q.No. 21)**

   (c) What is the need for standardization? **(Out of Syllabus)**

4. For the location of an engineering plant three sites A, B and C are under consideration. The costs of various factors and other relevant aspects in respect of each site are listed below. It is required to make the final selection of the site.

Factors	Site A	Site B	Site C
Cost of land including development of land in Rs.000	50,000	49,000	45,000
Buildings in Rs.000	45,000	42,000	48,000
Labour charges Rs.	4,00,000	2,50,000	3,20,000
Power in Rs.	1,00,000	90,000	1,00,000
Water in Rs.	50,000	10,000	30,000
Cost of raw materials and other supplies in Rs.000	10,000	8,000	8,500
Freight incoming in Rs.	3,00,000	5,00,000	5,20,000
Freight outgoing in Rs.	2,00,000	3,50,000	4,00,000
Local taxes in Rs.	50,000	Nil	30,000
Other factors			
Cost of living	Very high	Low	Moderate
Housing facilities	Excellent	Poor	Good
Community' facilities	Excellent	Poor	Good
Community attitude	Good	Encouraging	Indifferent

Use composite measure method approach in evaluating the site and justify your choice the site. **(Unit-III, Prob. 13)**

5. (a) What is group technology layout? **(Unit-III, Q.No. 17)**

   (b) What is REL chart? Illustrate its application with example. **(Unit-III, Q.No. 22)**

6. There are seven jobs that must be processed in two operations A and B All seven jobs must go through A and B in that sequence A first, then B. The time Required for processing the job in each of the process A and B is indicated below:

Job	Time for process A (hours)	Time for process B(hours)
1	9	6
2	8	5
3	7	7
4	6	3
5	1	2
6	2	6
7	4	7

   (a) Determine the optimal order in which the jobs should be sequenced through the process.

   (b) Draw a bar chart showing the sequence of jobs.

   (c) What is the total time for all seven jobs? **(Unit-IV, Prob. 4)**

7. (a) What is Statistical Quality control? **(Unit-IV, Q.No. 16)**

   (b) Briefly explain the objectives of Stores Management. **(Unit-V, Q.No. 36)**

8. ABC company manufacturing consumer durables requires 20,000 units of raw material per annum. The ordering cost is Rs.300 per order and inventory carrying cost is 30% per annum on average inventory. The purchase price quoted is Rs.10 per unit. **(Unit-V, Prob. 6)**

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

MBA III - Semester Examinations

R19

March / April - 2023

PRODUCTION AND OPERATIONS MANAGEMENT

Time : 3 Hours] **[Max. Marks : 75**

Note : (i) Question paper consists of Part A, Part B.
(ii) Part A is compulsory, which carries 25 marks. In Part A, Answer all questions.
(iii) In Part B, Answer any one question from

PART - A (5 × 5 = 25)

Answers

1. (a) Write Strategic role of Operations Management. **(Unit-I, SQA-13)**
   (b) What are the factors influencing the plant location? **(Unit-III, SQA-2)**
   (c) Write break -even analysis role in POM. **(Unit-III, SQA-3)**
   (d) Define scheduling. Point out the objectives of scheduling. **(Unit-IV, SQA-3, 4)**
   (e) Illustrate the categories of scrap. **(Unit-V, SQA-2)**

PART - B (10 × 5 = 50)

2. (a) Explain concept of production and discuss five generic competitive strategies in detail. **(Unit-I, Q.No. 10, 23)**
   (b) Discuss the Role and Responsibilities of Production Managers in an Automobile Manufacturing Organization. **(Unit-I, Q.No. 32)**

(OR)

3. What do you understand by manufacturing process technology? Explain the role of CAD in manufacturing. **(Unit-I, Q.No. 33)**
4. (a) Explain the role of ergonomics product design and steps in process planning. **(Out of Syllabus)**
   (b) Explain the need of plant location. **(Unit-III, Q.No. 2)**

(OR)

5. (a) Explain the concept of new product development. **(Unit-II, Q.No. 5)**
   (b) Discuss the probable errors in plant selection decision. **(Unit-III, Q.No. 21)**
6. (a) From the following data, you are required to calculate:
      (i) The amount of fixed expenses.
      (ii) The number of units to break even.
      (iii) The number of units to earn a profit of Rs. 40,000. The selling price per unit can be assumed at Rs. 100. The company sold in two successive periods 7,000 units and 9,000 units and has incurred a loss of Rs. 10,000 and earned Rs. 10,000 as profit respectively. **(Unit-III, Prob. 7)**

(b) A company is making a loss of Rs. 40,000 and relevant information is as follows:

Sales Rs. 1,20,000; Variable Costs Rs. 60,000; Fixed costs Rs. 1,00,000.

Loss can be made good either by increasing the sales price or by increasing sales volume. What are Break even sales if

(i) Present sales level is maintained and the selling price is increased.

(ii) If present selling price is maintained and the sales volume is increased.

What would be sales if a profit of Rs. 1,00,000 is required? **(Unit-III, Prob. 8)**

(OR)

7. (a) Explain the classifications of layout. **(Unit-III, Q.No. 12)**

(b) Explain the model for multi facility location problem. **(Unit-III, Q.No. 5)**

8. Explain Johnson's algorithm in detail. **(Unit-IV, Q.No. 6)**

(OR)

9. Consider a flow shop that has only two processors. A job is completed first on processor 1 and then on processor 2. The data for 10 jobs are as follows.

Job	1	2	3	4	5	6	7	8	9	10
Processor 1 2	7	9	0	3	10	1	5	6	8	
Processor 2 6	8	4	10	9	7	5	1	2	3	
Due date	25	19	30	25	16	55	60	32	45	39

(a) Determine the schedule that minimizes the maximum flow time.

(b) What is the maximum flow time for your schedule?

(c) How many jobs are tardy in your schedule? **(Unit-IV, Prob. 10)**

10. (a) "By combining ABC with XYZ approaches, stock management policies, systems and procedures can be better tailored". Justify. **(Unit-V, Q.No. 52)**

(b) Discuss the functions of stores. Point out the parameters of purchasing. **(Unit-V, Q.No. 37, 28)**

(OR)

11. (a) Discuss ABC analysis in detail and brief on components of integrated material management. **(Unit-V, Q.No. 1, 46)**

(b) Write a note on purchase management and stores management. **(Unit-V, Q.No. 24, 36)**