POLITEKNIK MALAYSIA

KEMENTERIAN PENGAJIAN TINGGI

KOLEJ KOMUNITI MALAYSIA

# INDUSTRIAL MANAGEMENT

**Penulis:**

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# INDUSTRIAL MANAGEMENT

# DJJ42022

## ACKNOWLEDGEMENT

## PREFACE

○ This ebook note is for students who are taking DJJ42022-Industrial Management course in the Mechanical Engineering Program, Polytechnic Malaysia, Ministry of Higher Education. The ebook note is published based on the curriculum for Course of Industrial Management issued by the Curriculum Division, Department of Polytechnic Education (DPE), Ministry of Higher Education of Malaysia.

○ Each chapter consists of simple and concise explanation, more easier for beginner engineering students to understand and get some information. Hopefully, students can get some benefits from the theory of Industrial Management and they can use it as basic knowledge when they involve in mechanical industries. The information in this book is suitable for real situations in the mechanical engineering field.

○ In the study of mechanical engineering, Students should learn how to construct and solve the problem by using fundamental theory and mathematical method. The content of this ebook note covers a whole range of topics learned by the students. With the completion of the accompanying examples and exercises that include the answers. The examples contain from simple and introductory to intermediates problems to help the students gain the confidence and understanding for each chapter. Last semester examinations questions also included in this ebook note. Hopefully, students get the picture to solve the problem during final examination at the end of the semester.

○ With the publication of this ebook note, students will be able to use it as one of their alternatives references. Furthermore, this ebook note is written based on the courses taken by the students. Therefore easier for students to adapt the information contained in this ebook note based on the teaching and learning process in the classroom.

## SYNOPSIS

- INDUSTRIAL MANAGEMENT provides students with a strong fundamental understanding of industrial management prospects and production system planning such as inventory, scheduling, production system operation, facilities, plan location, layout and line balancing, work system design . This course also provides knowledge in quality control, and human resource management.

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# REFERENCES

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# Industrial Management
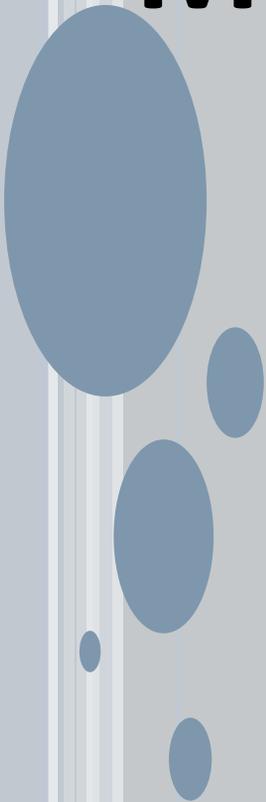
**INTRODUCTION**

- **What is Industrial Management?**

  Mechanical administration maybe
  a department of designing which encourages creation
  of administration framework and coordinating individuals.

  Industrial administration could be a organized approach to manage the
  operational exercises of the organization.

  However, our basic working definition is "Management could be
  a handle utilized to achieve organizational goals".

  **Concept Of Industrial Management**

- Mechanical designing and administration may be
  a profoundly organized present day strategies carrying in industry.

- It includes a handle in arranging, organizing, coordinating,
  controlling, alteration, and overseeing the exercises of any industry.

- It draws upon specialized information and skill in scientific, physical and
  social sciences along
  side the standards and strategies of building examination and design,

- In this way, it indicates, predicts and assesses the result gotten from such
  system.

**HISTORY AND DEVELOPMENT OF INDUSTRIAL MANAGEMENT**

○ Over the last 250 years, industrial engineering has progressed.
  - Revolutionary period before the industrial revolution (up to 1800)
  - The Industrial Revolution is a period of time in which (1800-1890)
  - Management that is scientific (1890-1940)
  - Quantitative phase and operation research (1940-1980)
  - Phase of automation and computer-assisted manufacturing (1980-present)

○ Industrial revolution
  - Start within the mid-eighteen century when production lines were to begin with built and workers were utilized to work with them.
  - Machine control started to substitute for human power.
  - Lead to mass generation of conservative goods.
  - Improved and less exorbitant transportation frameworks got to be available.
  - Created bigger showcase and bigger organization development.
  - Created formalized administration practices.

    What is the definition of management science??
  - Management Science (MS), is a multidisciplinary discipline of applied mathematics focused to optimal decision making, having strong connections to economics, business, engineering, and other sciences.

**CHARACTERISTIC AND TOOLS OF MANAGEMENT SCIENCE**

- Characteristics and tools of scientific management:
  - Separation between planning and implementation
  - Foremanship with a purpose
  - Analyze the job
  - Standardization
  - Worker selection and training based on scientific principles
  - monetary incentives
  - Economy
  - Mental upheaval

- Objective Of Industrial Management

- The prime objective of industrial management:
- The main goal of industrial management is to boost productivity.
- To eliminate non-value-added activity and waste.
- To increase the efficiency with which resources are used.
- Reduction in the manufacturing costs:-
  - Materials
  - Machinery and Equipment
  - Man Power
  - Manufacturing Sevices
  - Product Quality
  - Manufacturing Schedelu

**DIFFERENT SCHOOLS OF THOUGHT OR VARIOUS APPROACH TO STUDY OF MANAGEMENT**

*NEO-CLASSICAL APPROACH*
-Human Relations Approach
-Social System Approach
-Decision Theory Approach

*CLASSICAL APPROACH*
-Scientific Management
-Administrative Management

*MODERN APPROACH*
-System Approach
-Contingency Approach

**MANAGEMENT THOUGHTS**
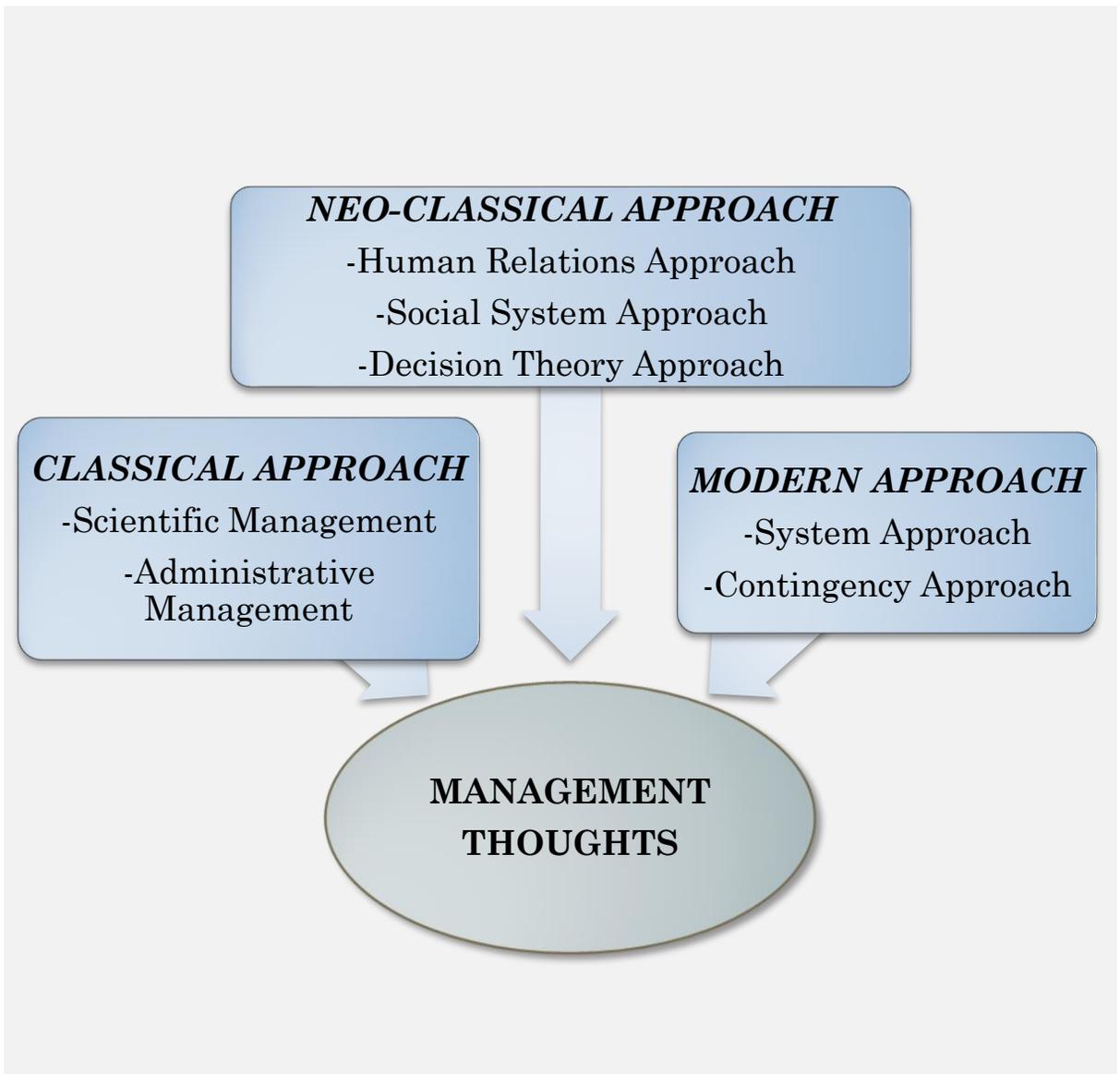
**DIFFERENT SCHOOLS OF THOUGHT OR VARIOUS APPROACH TO STUDY OF MANAGEMENT**

| DATE | CONTRIBUTION | CONTRIBUTOR |
|------|--------------|-------------|
| 1776 | In the manufacturing industry, labour specialisation is common. | Adam Smith |
| 1790 | Cost accounting, interchangeable parts | Eli Whitney et al. |
| 1832 | Basics of time study; division of labour by talent; job assignment by skill | Charles Babbage |
| 1981 | Scientific management time studies and work studies were developed; work planning and execution were divided. | Frederick W. Taylor |
| 1922 | The motion of job research | Frank B. Gilbreth |
| 1916 | In the manufacturing industry, scheduling procedures for personnel and machine jobs are used. | Henry L. Gantt |
| 1924 | Statistical inference applied to a product quality: quality control charts | W.A. Shewart |
| 1947 | Programming in linear form | G.B. Dantzig, William et al. |
| 1950 | On linear and stochastic processes, mathematical programming is used. | A. Charnes, w.w. Cooper |
| 1960 | Organizational behaviour: ongoing research into how people behave at work | L. Cummings, L. Porter |
| 1970 | Computer applications in manufacturing, scheduling and control, and Material Requirement Planning are all examples of how operations can be integrated into overall strategy and policy (MRP) | W. Skinner J. Orlicky and G. Wright |
| 1980 | Japanese applications for quality and productivity, as well as CAD-CAM | W.E. Deming and J. Juran |

**Frederick Wilson Taylor**
Known as the "Father of Scientific Management," he was a pioneer in the field of scientific management (1878)
There are two major management practises:
- Incentive system based on piece rate
- Study of time and motion

**FRANK and LILIAN GILBERT**
- Engineers who are husband and wife
- Finding the best sequence and smallest amount of motions required to execute a task is what motion studies is all about.
- Look at different options for eliminating unnecessary motions and reducing work fatigue.

○   **Henry Fayol (1841-1925)**

- Industrialist and theoretician from France
- At the age of nineteen, he began his working life as a young miner.
- At the age of 47, he rose to the position of supervising the industry and was about to leave after his 77th birthday.
- His business successes brought him widespread acclaim and admiration.
- He published "Administration Industrielle Et Generale" in 1916, which brought to light the refinement of a lifetime of administrative effort.

# 14 Principles of Management by Henri Fayol

| | | |
|---|---|---|
| 1 | | Division of work |
| 2 | | Authority and Responsibility |
| 3 | | Discipline |
| 4 | | Unity of Command |
| 5 | | Unity of Direction |
| 6 | | Subordination of Individual Interest |
| 7 | | Remuneration |

| | | |
|---|---|---|
| 8 | | The Degree of Centralization |
| 9 | | Scalar Chain |
| 10 | | Order |
| 11 | | Equity |
| 12 | | Stability of Tenure of Personnel |
| 13 | | Initiative |
| 14 | | Esprit de Corps |

| 1 | **Workforce division** | To ensure that effort and consideration are focused on different parts of the task, work should be separated among persons and groups. Work specialisation, according to Fayol, is the best approach to make the most of an organization's people resources. |
|---|---|---|
| 2 | **Responsibilities and Authority** | The terms "expert" and "obligation" are intertwined. Fayol defined specialist as the ability to offer orders and the control to ensure proper submission. Being responsible is a part of duty, and it is linked to specialist in this way.<br>Whoever accept specialist moreover expect \srespon sibility. |
| 3 | **Discipline** | A successful corporation necessitates the participation of all employees. To encourage this collaborative effort, penalties should be used sparingly. |
| 4 | **Command Cohesion** | Specialists should be given directions from a single manager. |
| 5 | **Directional Consistency** | The entire organisation should be working toward a shared goal in the same direction. |
| 6 | **Individual interests are subordinated to the common good.** | That one person's interest should not take precedence over the organization's overall interface. |
| 7 | **Remuneration** | Numerous variables, such as the cost of living, have taken their toll. In determining a worker's rate of compensation, factors such as the availability of competent labour, common trade circumstances, and the success of the trade should be addressed. |

| 8 | Centralization | Centralization, according to Fayol, reduces the importance of the subordinate element. The importance of decentralisation is growing. The degree to which a supervisor should accept centralization or decentralisation is determined by the organisation in which he or she works. |
|---|---|---|
| 9 | Chain of Scalars | Directors, like the authority scale, are a part of the chain of command. From the primary line supervisor to the president, each supervisor has a set number of specialists; the primary line boss has the least. Lower-level supervisors should keep upper-level directors informed about their work activities on a regular basis. The presence of a scalar chain, as well as adherence to it, is critical for the organization's performance. |
| 10 | Order | All items and people associated with a specific type of job should be treated as identically as feasible for the sake of efficiency and coordination. |
| 11 | Equity | All employees should be handled in the same manner. |
| 12 | Tenure or Personnel Stability | Keeping profitable representatives should always be a top priority for management. Contracting underused personnel is frequently associated with increased enrollment and determination costs, as well as increased product-reject rates. |
| 13 | Initiative | Professional activity is defined as modern or extra work action embraced through self-direction, and management should take initiatives to stimulate it. |
| 14 | Espirit De Corps | Employees should be encouraged to work together and share positive feelings. |

**ORGANIZATION STRUCTURES**

- What is organization?
  - Organization is the individuals who work together and coordinate their activities to realize particular goals.

- What is organizational structure?
  - The somewhat persistent allocation of work parts and authoritative components that produces a design of interrelated work exercises and allows the organisation to conduct, coordinate, and manage its work activities is referred to as organisational structure.

- **Principles Of Organization**

- An organisation is founded on ten principles, according to Urwick (Notes on the Theory of Organization, 1952).:

- 1. The objective principle states that any organisation must be a representation of its mission.

- 2. The idea of correspondence states that the responsibilities and authority in each position should be equal (equal).

- 3. The The responsibility principle states that the superior bears all responsibility for the actions of the subordinate.

- 4. The The span control principle is as follows: (refers to how many subordinates can work under one head). No one should be in charge of more than five or six direct subordinates whose job is intertwined.

**PRINCIPLES OF ORGANIZATION**

5. The principle of specialisation: Every member of an organised organisation should limit their actions to performing a particular role as much as feasible.

6. The principle of coordination: As part of the organization's unification effort, all employees work together to achieve the organization's goals.

7. The concept of definition: Each position's substance, including both the duties required and the power and responsibility envisioned, as well as the link with other roles, should be explicitly stated in writing and made available to all parties involved.

8. The principle of authority: The supreme power in any organised group must reside someplace. Every member of the group should have a clear line of authority.

9. The principle of balance: It is critical to maintain the equilibrium of an organization's various parts.

10 The continuity principle is as follows: Reorganization is a continual process for which special provisions should be made in every enterprise.

# TYPES OF AN ORGANIZATION AND ITS FUNCTIONAL

**Line, military or scalar organization**
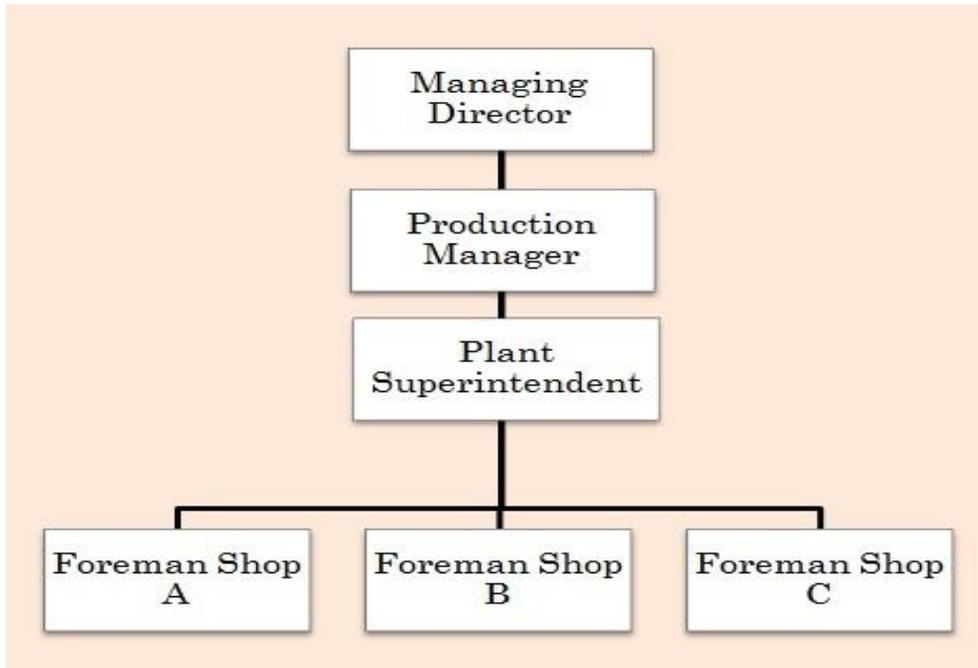


Figure 1.1 : Line ,military or scalar organization

○ It is the most well-established and simple organisational form.

○ Over his subordinate, the chief works out coordinate specialist.

○ Each division is self-contained and operates independently of the other divisions.

○ Specialist lines run vertically (from top to bottom).

# TYPES OF AN ORGANIZATION AND ITS FUNCTIONAL

○ **Line, military or scalar organization**

○ Advantages

- Straightforward to set up and work
- Promotes provoke choice making
- Easy to control as the chief have coordinate control over their subordinates
- Communication is quick and simple as there's as it were a vertical stream of communication

○ Disadvantages

- Specialization is required.
- With so many things to do, the director may become overburdened.
- A single manager's failure to make sound decisions could have ramifications throughout the organisation.
- A single chief's failure to demand right judgments could have an impact on the entire business.Suitable for:
- Small enterprises with a small number of subordinates

## TYPES OF AN ORGANIZATION AND ITS FUNCTIONAL

**Functional organization**
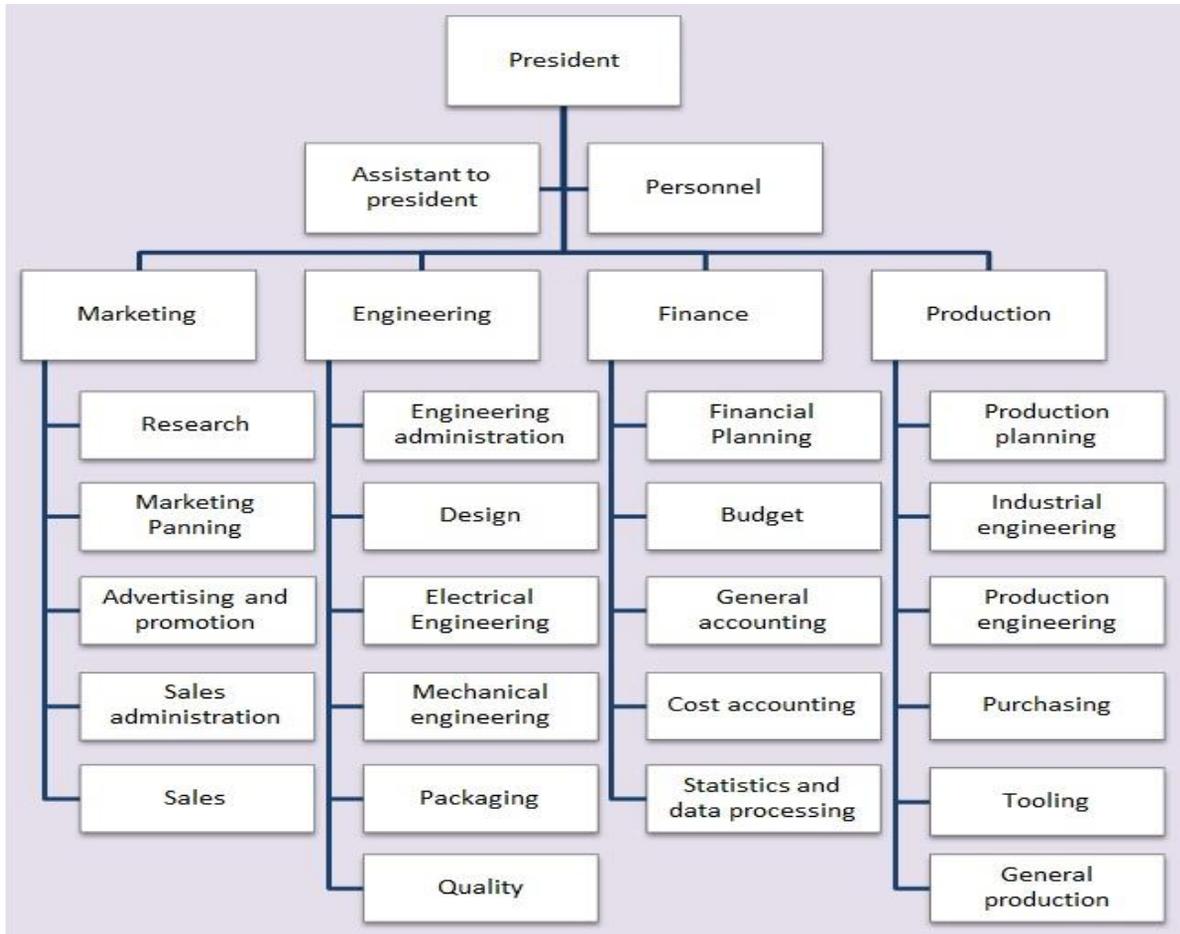


Figure 1.2 : Functional organization

- It is divided into several functional areas. This organisation divides its activities into categories according on the organization's function, such as production, marketing, finance, human resources, and so on.
- For his function, the specialist in charge of a functional department has authority over all other personnel.

# TYPES OF AN ORGANIZATION AND ITS FUNCTIONAL

- **Functional organization**

- Advantages
  - Functions that are logical and reflective
  - Follows the occupation specialisation idea.
  - Because the manager in charge of each functional department is usually a specialist, it simplifies training and allows for better control.
- Disadvantages
  - Overspecialization and narrow perspectives of important employees can stifle an organization's ability to thrive.
  - Reduced inter-functional coordination.
  - Conflicts between distinct functions could be harmful to the company's overall performance.
  - General managers have a difficult time coordinating different departments.
- Suitable for:
  - Larger companies with more opportunities for specialisation. Once adequate coordination among several roles is achieved, an organization's chances of success are assured.

# TYPES OF AN ORGANIZATION AND ITS FUNCTIONAL

## Line and staff organization
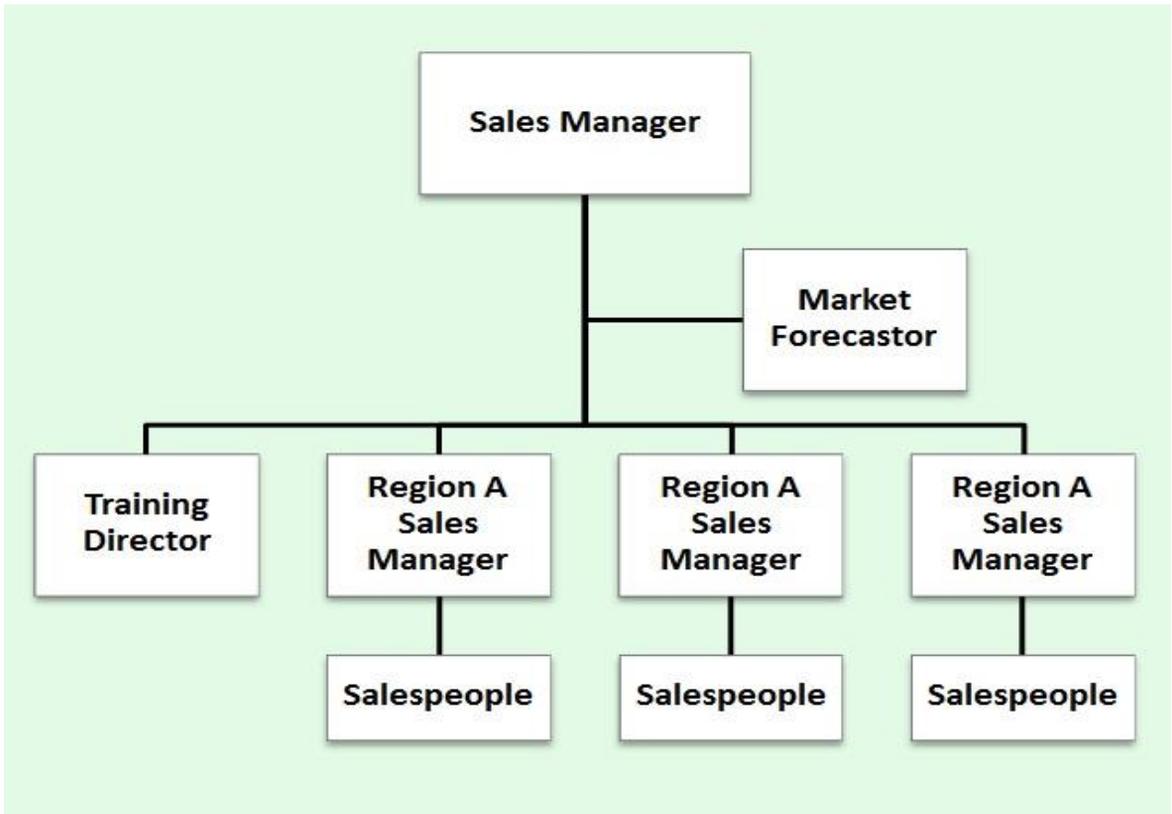


Figure 1.3 : Line and staff organization

A blend of functional and line structures. The authority is organised in a vertical line, with the assistance of staff professionals who serve as advisors. These staff specialists are consulted by the line executive when they require assistance.

**TYPES OF AN ORGANIZATION AND ITS FUNCTIONAL**

- **Line and staff organization**

- Advantages
  - These specialists provide expert assistance to line managers. Staff managers offer specialised guidance that can help departments improve the quality of their judgments.

- Disadvantages
  - On some matters, line managers and staff managers may have disagreements. Coordination could be an issue.

- Suitable for:
  - Large organisations benefit much from line and staff organisation.

**T**YPES OF AN ORGANIZATION AND ITS FUNCTIONAL

○ **Matrix organization**
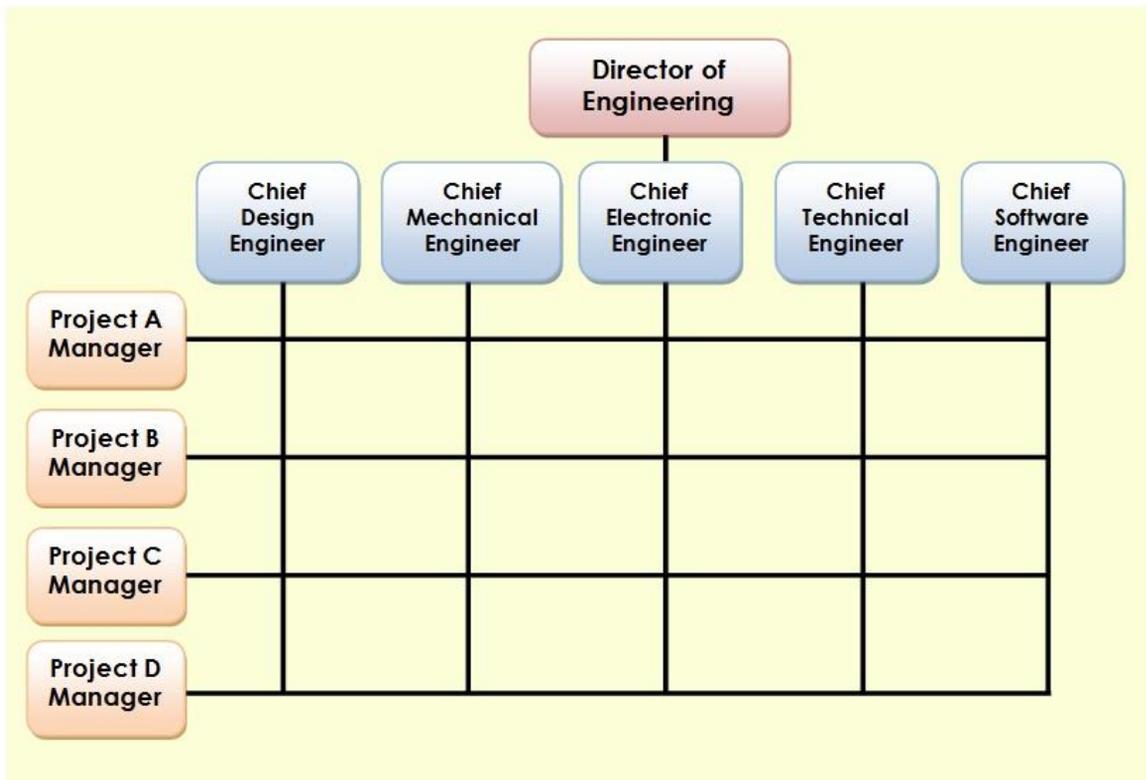


Figure 1.4 : Matrix organization

○ Functional and project structures are combined in this structure.

○ The functional department is a permanent part of the matrix organisation, and it has overall control over the functional units' operations.

○ When specific initiatives necessitate a high level of technical skill and other resources for a limited time, project teams are formed.

○ The horizontal chain of command is formed by the project team, while the vertical chain of command is formed by the functional departments.

# TYPES OF AN ORGANIZATION AND ITS FUNCTIONAL

- **Matrix organization**

- Advantages
  - The professional identification is kept up to date.
  - Determines who is responsible for product profit.
- Disadvantages
  - Conflict in organization authority exists
  - Requires manager effective in human relations

- Suitable for:
  - Industries with highly complex product systems such as weapons

**TYPES OF AN ORGANIZATION AND ITS FUNCTIONAL**

- Reality is………………
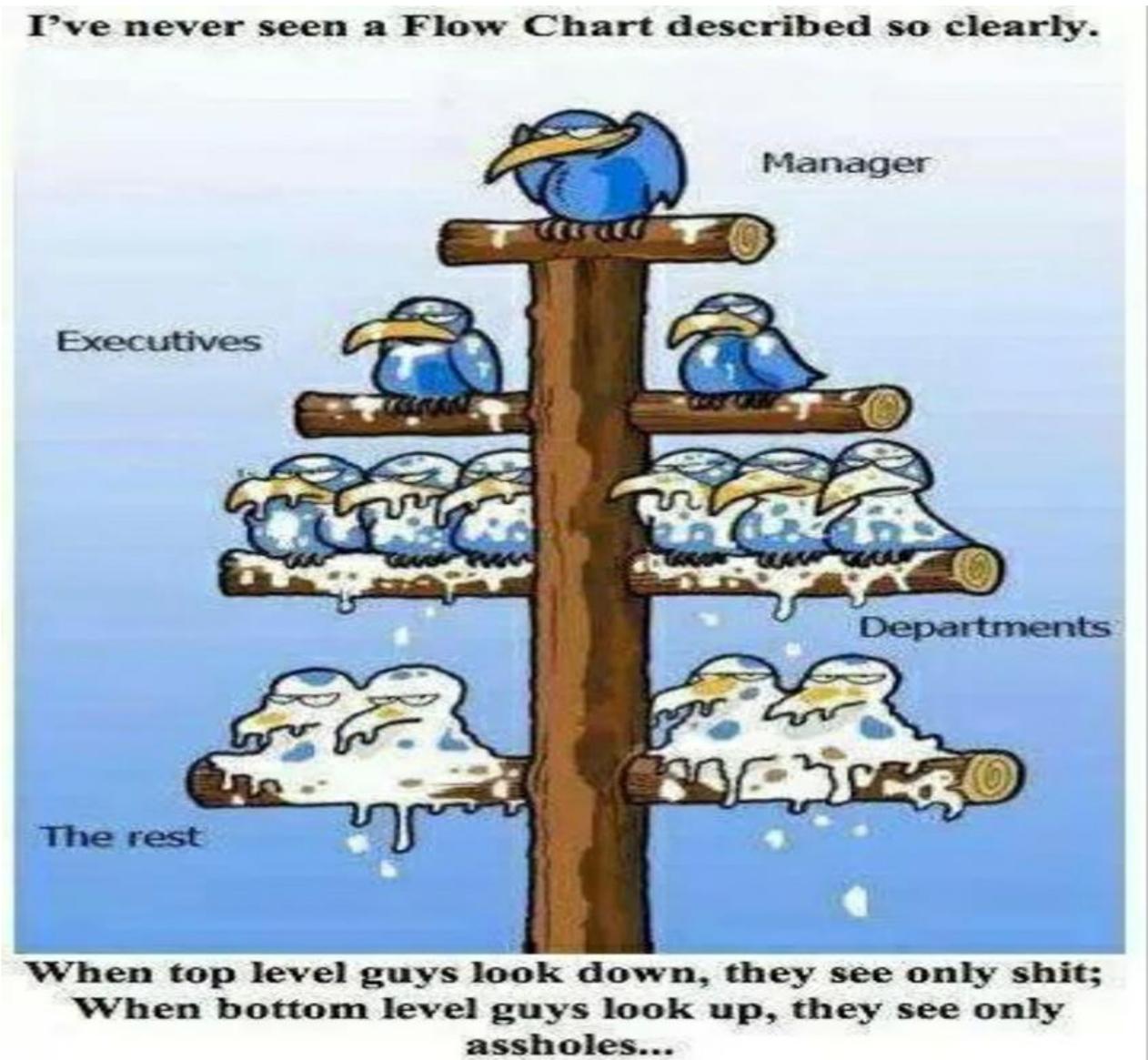


Figure 1.5 :Types of an organization and it functional

**MANAGEMENT PROCESS**
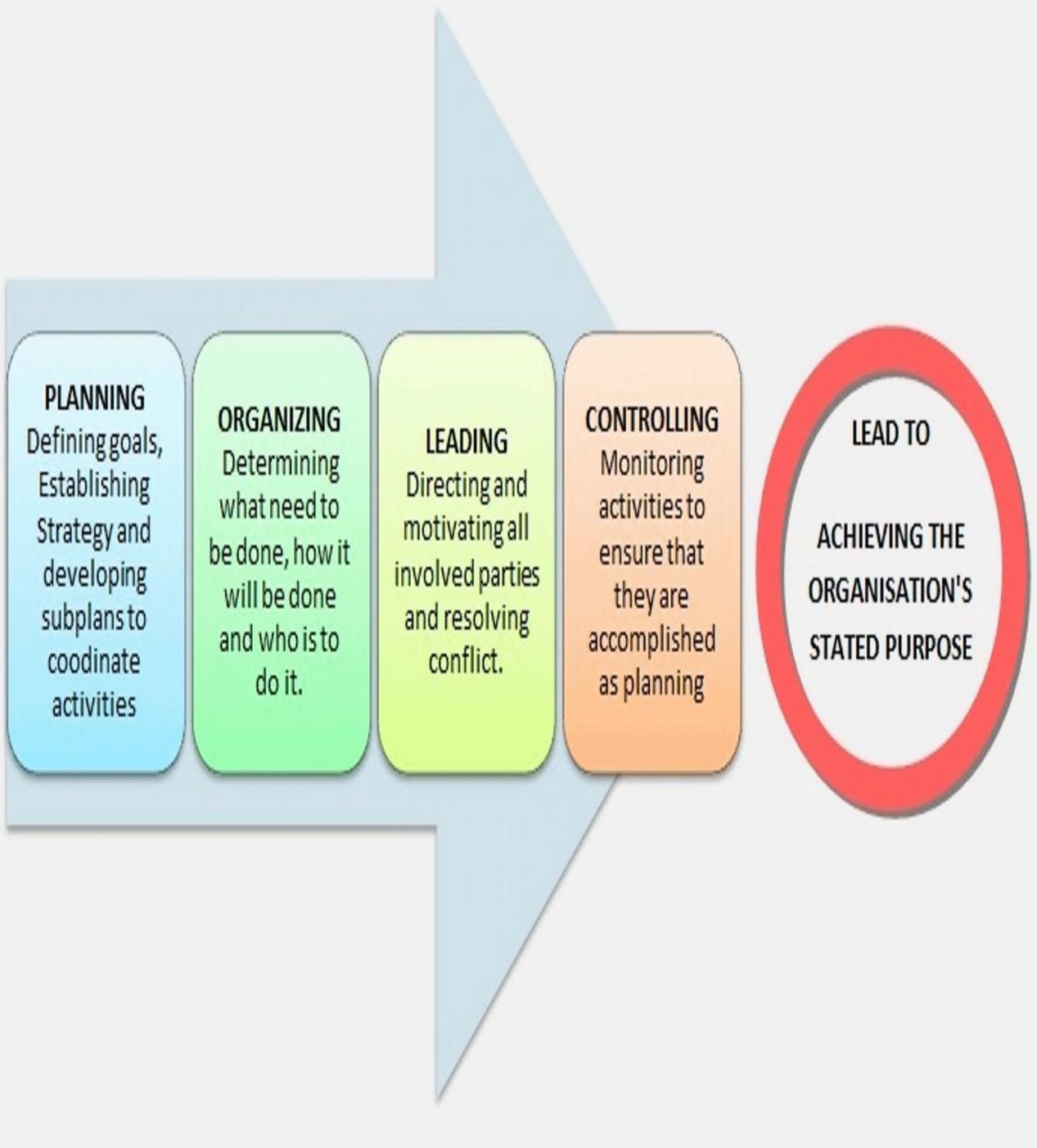
## APPLY OF INDUSTRIAL MANAGEMENT

○ Application areas of industrial management
- Design and Development
- Plant Layout and Material Handling
- Method Study and Work Measurement
- Production Forecasting
- Production Planning and Scheduling
- Proper Inventory Control
- Quality Control
- Production Control
- Method Analysis
- Motivates Workers
- Other Functions

○ **Importance Of Industrial Management**

○ The outcomes of industrial management are reflected in the organization's service to a variety of stakeholders, including:

· The Consumers

· The Investors

· The Community

· The Suppliers

· The Employees

· The Nation

## PROBLEM OF INDUSTRIAL MANAGEMENT

○ Because of changes in the market, technology, people's attitudes, the government, and so on, the job of industrial management is challenging. The following are some of the most common issues in industrial management:

- Problem of Location

- Problem of Selection of Production Methods

- Problem of Plant Layout

- Problem of Designing Product

- Problem of Production and Inventory Control

- Problem of Quality Control

- Problem of labour/workers

- Problem of Cost Control

○ **Scope Of Industrial Management**

○ The scope of industrial management is divided into two categories:

1. System and product design for the manufacturing industry

2. Controlling and analysing the industrial systemIndustrial System-Related Activities DesigningActivities Relating to Industrial System Designing

Two more key issues that the system designer should consider are:

(i) Human considerations, such as the impact of the production system on the workers who operate it.

(ii) Activities in research and development.These two issues have a significant impact on the design of industrial systems.

## EXERCISES

1. Define and describe the notion of industrial management.

2. Trace the evolution and historical progression of the Industrial Revolution.Management.

3. What is the difference between Industrial and Production Management?

4. What is the structure of an industry? What makes this set-up unique in terms of service?organisation?

5. What are the fundamentals of industrial management in a company?

6. What are the various industrial management objectives?

7. What is the purpose of industrial management?

8. What is the human-management relationship in industrial management?

9. What are some examples of industrial management applications?

10. Clearly describe the numerous industrial management functions in a modern organisation.

11. What are the responsibilities of a person in charge of manufacturing?

12. Why is industrial management so important?

13. What are some of the issues that come with industrial management?

14. What does industrial management entail?

Answer

1. Industrial management is defined as "the discipline of engineering concerned with the design and management of systems that combine people, materials, and energy in productive ways," and management planning entails direction, planning, adjustment, control, and cooperation.

2. People made things with hand tools before the Industrial Revolution, in their own homes or in tiny shops. Steam power was first used in machinery in the third quarter of the 18th century. People and machinery were brought together in factories under one roof so that the manufacturing and process could be monitored. This was the start of my career as a shop manager. The scale, degree of mechanisation, and complexity of operation of industries rose quickly over the next hundred years. The expansion, however, was accompanied by a lot of waste and inefficiency.

3. The analysis, design, and control of productive systems are all part of industrial management. Any system that generates a product or a service is referred to as a productive system. Production management, on the other hand, aims to familiarise a person with concepts and procedures related to the study and management of a manufacturing process. The term "production management" is usually linked with the management of a manufacturing setting. It is not responsible for the design or analysis of productive systems. Industrial management, on the other hand, is concerned with the design of systems and the provision of expert knowledge without actually managing the systems.

4. In a large corporation, many departments are involved in diverse activities that assist the production department in meeting its goals. Industrial management is used to manage numerous departments in service organisations such as banks, software businesses, hospitals, and so on.

5. Refer Principles Of Organization page 20 and 21

o    Answer

6. Industrial management's many objectives

   I. Variable costs are being reduced.

   II. Fixed costs are being reduced.

   III. Increase in production volume, allowing fixed costs to be spread out over a larger volume of output, lowering per-unit absorption.

7. Strategic planning, creating targets, managing resources, deploying the people and financial assets needed to achieve objectives, and measuring results are all part of the industrial management process. It also comprises documenting and preserving facts and information for later use or for other purposes within the business, as it is a managerial role.

8. Workers' productivity was determined by a variety of intergroup relationships as well as remuneration. This discovery led to a divide in the field of industrial management, with one branch focusing organisational theory and behaviour and the other on production mechanics, generally known as operations.

9.    Application areas of industrial management
   - Design and Development
   - Plant Layout and Material Handling
   - Method Study and Work Measurement
   - Production Forecasting
   - Production Planning and Scheduling, etc.

10. The methodical control of all areas of the industry is referred to as industrial management (or factory). Beyond enhancing production and managing the mechanical cost component, the approaches used go a step further. They also involve issues with the organization's structure, management, and human resources.

Answer

11. A person in charge of industrial management has a variety of responsibilities.

o  Inventory control strategies are used to keep track of static inventory such as raw materials, purchased parts, finished goods, and supplies.

o  Controlling the flow of materials into the plants using the prudent purchasing strategy.

o  Production control is used to keep track of work in progress.

12. The outcomes of industrial management are mirrored in the organization's service to a variety of stakeholders, including consumers, investors, the community, suppliers, employees, and the nation.

13.  The regular problems faced in industrial management are:

   Problem of Location

   Problem of Selection of Production Methods

   Problem of Plant Layout

   Problem of Designing Product

   Problem of Production and Inventory Control, etc.

14. The scope of industrial management is divided into two categories:

1.  System and product design for the manufacturing industry

2.  Controlling and analysing the industrial system

CHAPTER 2

# Work System Design
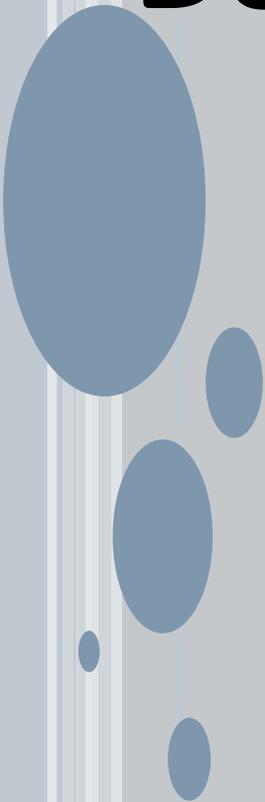
**WORK DESIGN**

- **Definition**

- Work Design is the process or activity of defining the contents, techniques, and relationships of work in order to meet the job holder's technological and organisational needs, as well as his or her social and personal needs (the employee).

- The "content and arrangement of one's job tasks, activities, relationships, and obligations" is what work design is all about (Parker, 2014).

- Work is organised in a way that promotes employee satisfaction and productivity.

- With a formal framework

- Supporting goal-setting shifts

- Reward schemes, as well as the work environment, are important considerations.

- With the most effective performance management techniques

## THE IMPORTANT OF WORK DESIGN

1. Provides comments on the job.

2. Adjustment is possible.

3. Motivated people do better.

4. Employee Training is a focal point.

5. Work and rest schedules are available.

- **Basic Approach To Job Design**

- Engineering : Typical Work & Groups
- High attention to detail and repurposing
- Limited diversity and autonomy in assignmentsMotivational: Improved Occupations
- A wide range of assignments and independence
- Input of information Sociotechnical: Self-Managing Groups
- Assignment add-up control
- Multi-skilled, flexible, and self-regulating

- **Job Design**
  - The determination of an individual's work-related responsibilities.

- **Job Specialization (Division of Labour)**
  - The degree to which the overall task of the organization is broken down and divided into smaller component parts.



- **Design Of Job Systems**
- Specialization
- Behavioural Approaches to Job Design
- Teams
- Methods Analysis
- Motions Study
- Working conditions

## JOB DESIGN SUCCESS

*Successful Job Design must be:*

○ Carried out by experienced personnel with the necessary training and background

○ Consistent with the goals of the organization

○ In written form

○ Understood and agreed to by both management and employees

○ **Work Specialization**

Dividing work activities into separate job tasks (Division of Labor). Individual employees specialize in doing part of an activity rather than the entire activity in order to increase output



Work specialization makes efficient use of the diversity of skills that workers have

**WORK SPECIALIZATION**



each employee can be an expert

higher levels of productivity

work completed faster and more efficiently

quality control costs are lowered

sense of pride and job security

higher profit potential

**The Advantages Of Specialization**

- Practice makes idealize: specialist specializes in a specific errand and gives within the best, in this way creating merchandise speedier and less wastage of fabric. (FASTER)
- Use of apparatus: Specialized apparatus can be utilized which in turn increments productivity.
- Increased output: with advancement in productivity and utilize of apparatus yield is increased.
- Saves time: there's no time squandered in exchanging of employments and in this way the energy of generation can be kept up which leads to less wastage of time.

## THE DISADVANTAGES OF SPECIALIZATION

○ Boredom: performing the same errand over and over once more may lead to boredom for the workers.

○ Lack of assortment: in spite of the fact that the number of merchandise delivered increments but they are indistinguishable or standardized.

○ Low inspiration for the specialist: more than once performing the same assignment may lead to a moo inspiration level for the laborer. The laborer might not have the sense of satisfying a total errand as he is performing as it were a portion of the work.

○ Lack of portability: due to specialization laborers might discover it troublesome to switch between occupations.

○ **Specialization in Business: Advantages**

For Management:

1. Simplifies training

2. High productivity

3. Low wage costs


For Labour:

1. Low education and skill requirements

2. Minimum responsibilities

3. Little mental effort needed

## SPECIALIZATION IN BUSINESS:DISADVANTAGES

For Management:

1. Difficult to motivate quality

2. Worker dissatisfaction possibly resulting in absenteeism, high turnover, disruptive tactics, poor attention to quality

For Labour :

1. Monotonous work

2. Limited opportunities for advancement

3 Little control overwork

4. Little opportunity for self-fulfilment

**Motion Study**

○ Process Chart

· Graphical representation of the arrangement of steps or errands (workflow) constituting a handle, from crude materials through to the wrapped up product

· It serves as a instrument for looking at the method in detail to recognize zones of conceivable improvements

· Also known as a process map

# Process Chart Symbols

| Symbols | Name | Action | Examples |
|---|---|---|---|
| (green ellipse) | Operation | Add Value | Saw, Cut, Paint, Packaging |
| (orange arrow) | Transport | Moves Some Distance | Convey, Truck |
| (blue rectangle) | Inspect | Checks For Defects | Visual Inspect, Dimension Inspect |
| (red D-shape) | Delay | Temporary Delay/Hold | WIP Hold, Queue |
| (yellow triangle) | Storage | Warehouse | Warehouse or Tracked Storage Location |
| (orange hexagon) | Handle | Transfer Or Sort | Re-Package, Transfer To Conveyor |
| (red diamond) | Decide | Make A Decision | Approve/Deny Purchase |

Clip slide

Figure 2.1 : Process chart symbols

## DESCRIPTION OF SYMBOLS

### Operation

- A large circle indicates operation
- An operation takes place when there is a change in physical or chemical characteristics of an object.
- An assembly or disassembly is also an operation
- A main step, where the part, material or product is usually modified or changed

### Transportation

- An arrow indicates transport.
- It refers to the movement of an object or equipment from one place to another.
- E.G. Moving the material by a trolley operator going to the stores to get some tool

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## Inspection

- A square indicates inspection.
- This is the time spent inspecting raw materials, work-in-process, and finished goods, possibly at multiple stages of the production process.
- E.G. Checking the diameter of a rod.

## Delay

Move time:- This is the time required to move items into and out of the manufacturing area, as well as between workstations within the production area

Queue time:- This is the time spent waiting prior to the processing, inspection, and move activities

Example:-

- An operator waiting to get a tool in the stores
- Worked pieces stocked near the machine before the next operation

## Storage

- An equilateral triangle standing on its vertex represents storage

- Storage takes place when an object is stored and protected against unauthorized removal

- Example:- Raw material in the store room
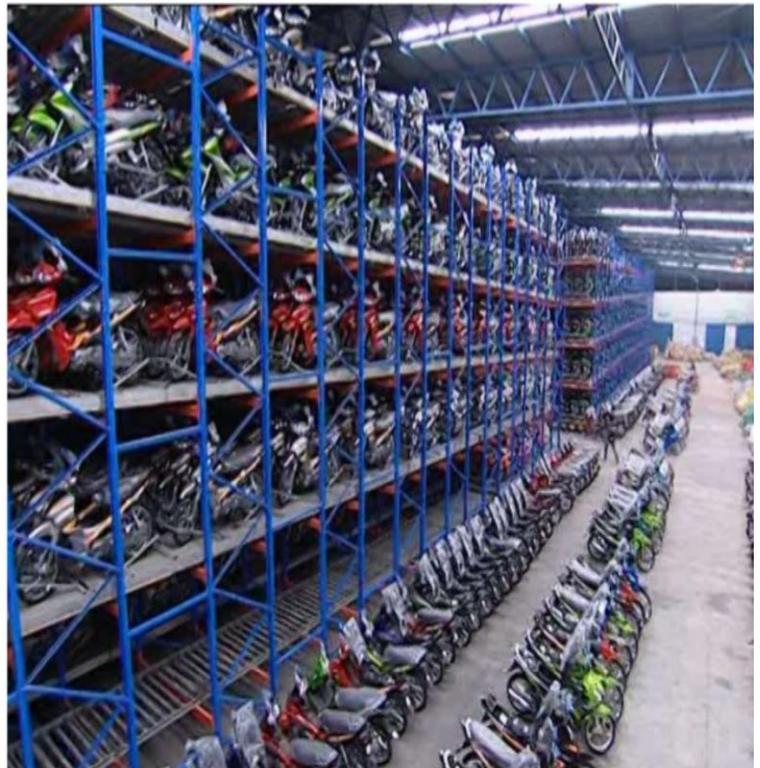
# FLOW PROCESS CHART

## FLOW PROCESS CHART
### Job Requisition of petty cash

**Details of Method**

| Details of Method | Operation | Movement | Inspection | Delay | Storage |
|---|---|---|---|---|---|
| Order made by the office head | | | | | |
| Put in "pick-up" basket | | | | | |
| To accounting department | | | | | |
| Account and signature verified | | | | | |
| Amount endorsed by the treasurer | | | | | |
| Amount numbered by the cashier | | | | | |
| Amount recorded by the bookkeeper | | | | | |
| Petty cash fixed in an envelope | | | | | |
| Petty cash carried to department | | | | | |
| Petty cash checked against requisition | | | | | |
| Receipt signed | | | | | |
| Petty cash put away within the security box | | | | | |

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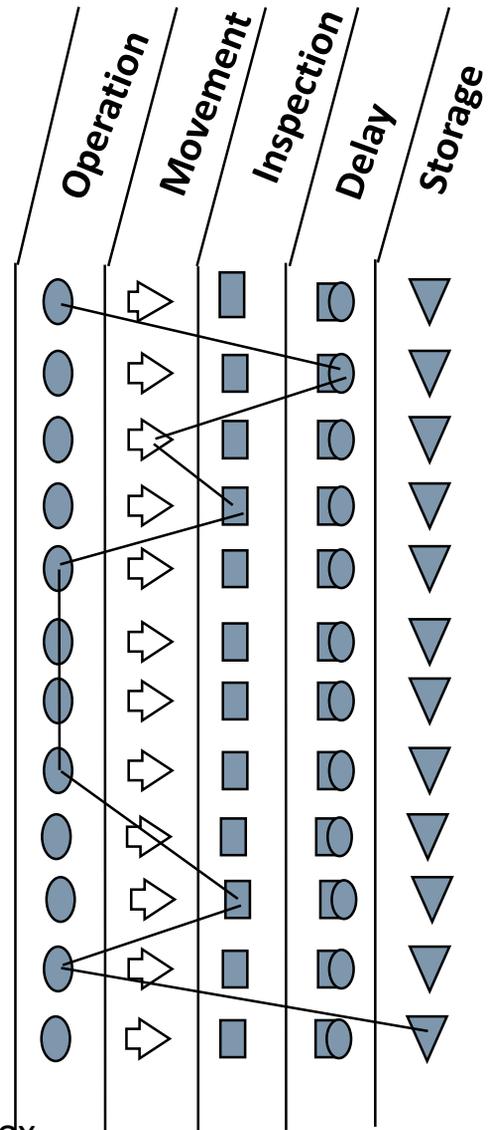
## MOTION STUDY

*Motion study* is the systematic study of the human motions used to perform an operation.
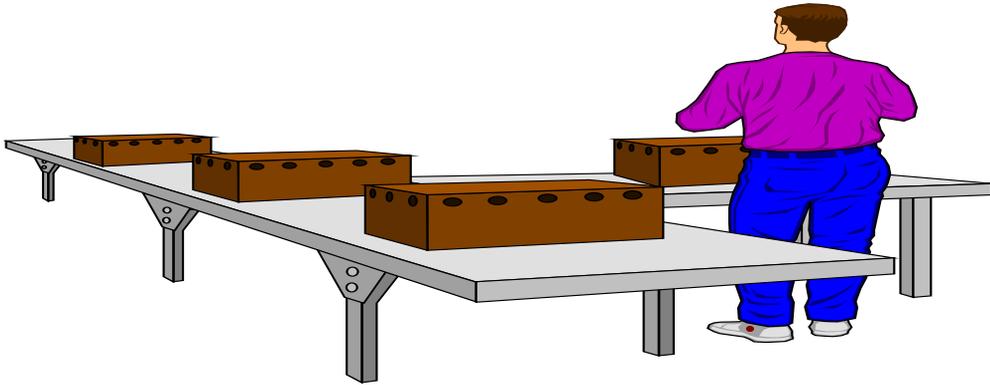


- **Motion Study Techniques**

- *Motion consider standards - rules for planning motion-efficient work procedures*

- *Analysis of therbligs - fundamental basic movements into which a work can be broken down*

- *Micromotion think about – the utilize of movement pictures and moderate movement to ponder movements that something else would be as well fast to analyze*

- *Charts*

- *Therbligs*

- Basic elemental motions that make up a job.
  - Search
  - Select
  - Grasp
  - Hold
  - Transport load
  - Release load

## DEVELOPING WORK METHODS

1. Dispose of pointless motions

2. Combine activities

3. Reduce fatigue

4. Improve the course of action of the workplace

5. Improve the plan of apparatuses and equipment

### Work measurement

#### Definition Work Measurement

o Determination of the sum of time required to perform a unit of work. Work measurement is very important for advancing the efficiency of an organization.

o It empowers administration to compare interchange strategies additionally to do introductory staffing.

o Work estimation gives the premise for appropriate planning.

o The measurement of time is additionally called 'Time Study'.

## WORK MEASUREMENT

- **Work measurement**: Determining how long it should take to do a job.

  - Standard time

  - Stopwatch time study

  - Historical times

  - Predetermined data

  - Work Sampling

### Application of Work Measurement

- 1. Wok measurement is utilized in arranging work and in drawing out schedules.

- 2. Wok estimation is utilized to decide standard costs.

- 3. Wok estimation is utilized as an help in planning budgets.

- 4. It is utilized in adjusting generation lines for modern products.

- 5. Wok estimation is utilized in deciding machine effectiveness.

- 6. To decide time measures to be utilized as a premise for work taken a toll control.

- 7. To set up supervisory goals and to supply a premise for measuring supervisory efficiency.

- 8. To decide time measures to be utilized for giving a premise for wage motivating force plans.

## NORMAL TIME(NT) & STANDARD TIME(ST)

○ **Normal time** is the **time** when work should be done without any delays.

○ **Standard time** is the **time** taken by the worker to complete the work with some unavoidable delays. Every industry carries out the process of Work measurement.

  or

○ The amount of time it should take a qualified worker to complete a specific task, working at a sustainable rate, using given methods, tools and equipment, raw materials, and workplace arrangement.

○ **How do I calculate?: Normal Time(NT) & Standard Time(ST)**

○ Some allowances such as personal allowance (20%), fatigue allowance (5%), preparation allowance (5%) are added in normal **time** to obtain the standard **time**.

$$Normal\ time = Observed\ time\ x\ rating\ factor$$

$$Standard\ time =$$

$$Normal\ time\ x\ \frac{100}{(100 - total\ allowance\ in\ precentage)}$$

## NORMAL TIME(NT) & STANDARD TIME(ST)

Example:

If in a time study, the observed time is 0.75 min, rating factor = 110% and allowances are 20% of normal time, then what is the standard time?

Answer:

$Normal\ time = Observed\ time\ x\ rating\ factor$

$Standard\ time = Normal\ time\ x\ \dfrac{100}{(100 - total\ allowance\ in\ precentage)}$

$Normal\ time = 0.75x\ \left(\dfrac{110}{100}\right) = 0.82\ minute$

$Standard\ time = 0.82\ x\ \dfrac{100}{(100 - 20)}$ =1.025 minute

## EXERCISES

1. Give the meaning and definition of motion study. What are the objectives of motion study?

2. Explain the basic procedure of motion study.

3. What do you mean by a process chart? Explain the symbols used in a process chart.

4. Give the classification of the process chart.

5. Explain the following charts :

   (i) Flow process chart

   (ii) Outline process chart

   (iii) Two-handed process chart.

6. Draw and explain a material type flow process chart.

7. Draw and explain an outline process chart of changing refill of a ballpoint pen.

8. Explain the procedure for preparing two-handed process chart. Draw two-handed process chart for assembling nut and bolt.

9. What is a flow diagram? Discuss with examples, the different steps used in drawing a flow diagram.

Answer

1. A motion study, also known as a movement study, is a formal engineering investigation of work-related motions. In the fabrication or manufacture of things, a worker's motions or movements play a vital role. Study of Motion's Goals 1. Getting rid of unwelcome motions. 2. Making complex motions easier to understand. 3. Improve the efficiency of operations. 4. Improving the sequence of required actions. 5. Alter the order of the activities. 6. Make the materials handling procedure more efficient. 7. Make the activity as risk-free as possible. 8. Standardize the best methods and working circumstances so that all employees accomplish their tasks in the most efficient manner feasible.

2. The fundamental motion study procedure consists of the following steps:

1. Choose a job or process to research, taking into account human, technical, and other considerations.

2. Using proper recording procedures, collect all relevant details about current and proposed work processes.

3. Carefully evaluate the facts that have been documented. Then it's decided if any aspects can be eliminated, combined, or simplified. This stage guarantees that existing procedures are free of flaws.

4. Create a new and improved approach.

5. Decide on the new approach and its specifications.

6. With the help of the supervisor and operator, implement the new procedure.

3. A process chart depicts the operations involved in the process graphically or diagrammatically in order. As a result, a process chart is a visual depiction of events and information that occur during a sequence of procedures. Symbols are commonly used to depict charts.

4. There are three different types of process charts:

1. Process flow diagram

2. Process flow diagram

3. Diagram of a two-handed process.


5. I A flow process chart is a graphical representation of all activities, transportations, inspections, delays, and storage that occur during the course of a process. This comprises data such as the amount of time required, the distance travelled, the quantity, and so on.

(ii) The outline process chart depicts the procedure in its entirety. It only takes into account (primary) operations and inspections. It's a graphical representation of the places where materials are brought into the process, as well as the order of all activities and inspections.

(iii) The two-hand process chart records the activities of the worker's hands (left and right) in relation to one another. This type of chart is typically utilised for short-term repetitive tasks. The same symbols are used as in previous charts, but the meanings of the symbols are different.

Answer

6.                    Material/product type flow process chart

| Activity | Operations<br>○ □ ▽ D ⇨ | Distance Moved (m) | Time (minutes) |
|---|---|---|---|
| Castings lying in foundary store | | — | — |
| Moved to gas cutting machine | | 10 | 3 |
| Wait, cutting machine being set | | — | 5 |
| Rises cut | | — | 20 |
| Wait for trolly | | — | 10 |
| Moved to machine shop | | 20 | 6 |
| Inspected before machining | | — | 15 |
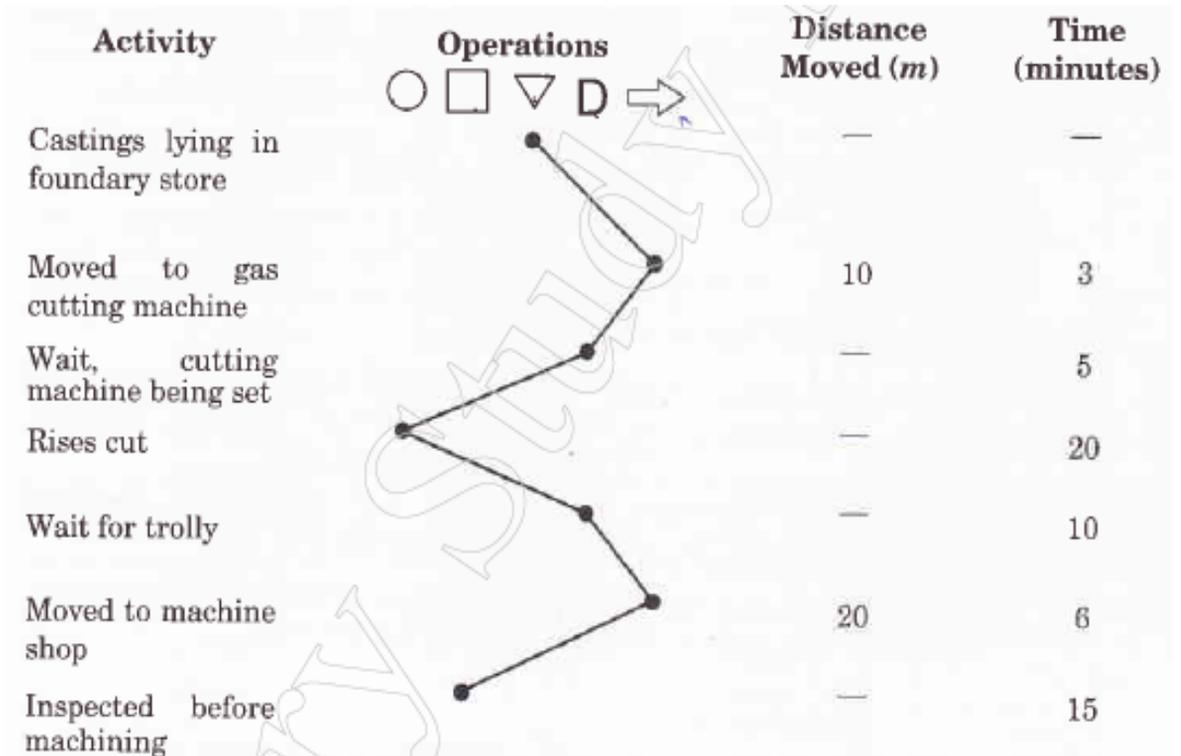
7.        Outline (operation) process chart of changing of ball point pens

1. Unscrew cap
2. Unscrew neck
3. Remove the odd refill
4. Assemble the spring on new refill
5. Place the refill in the barrel
6. Screw the neck
I. Check if ball pen writes
7. Screw the cap
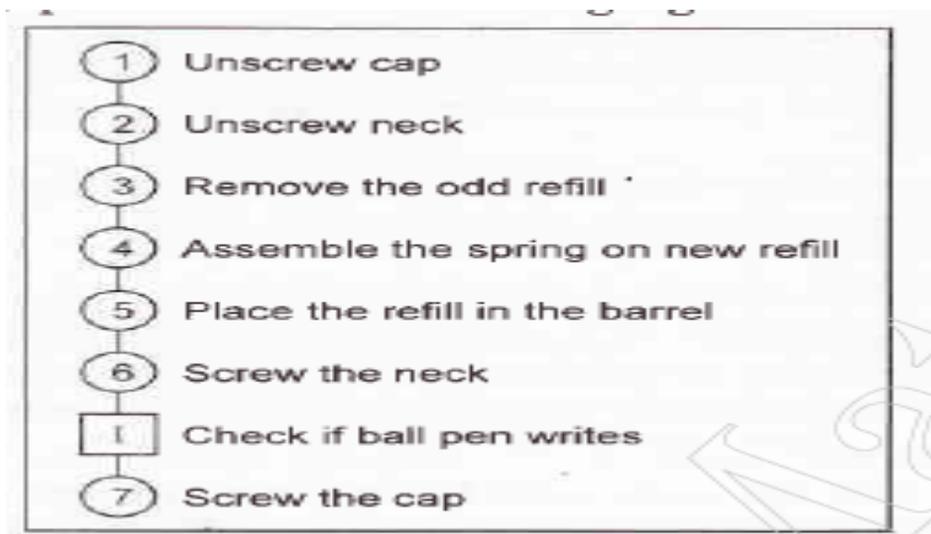
Answer

8. Two handed process chart for assembling nut and bolt.

| Left hand | Symbol | | Right hand |
|---|---|---|---|
| | L.H. | R.H. | |
| Pick up bolt | ① | ① | Idle |
| Hold | ▽1 | ◯1 | Pick up nut |
| Hold | ▽2 | ⇨1 | To left hand |
| Hold | ▽3 | ② | Assemble (screw up) |
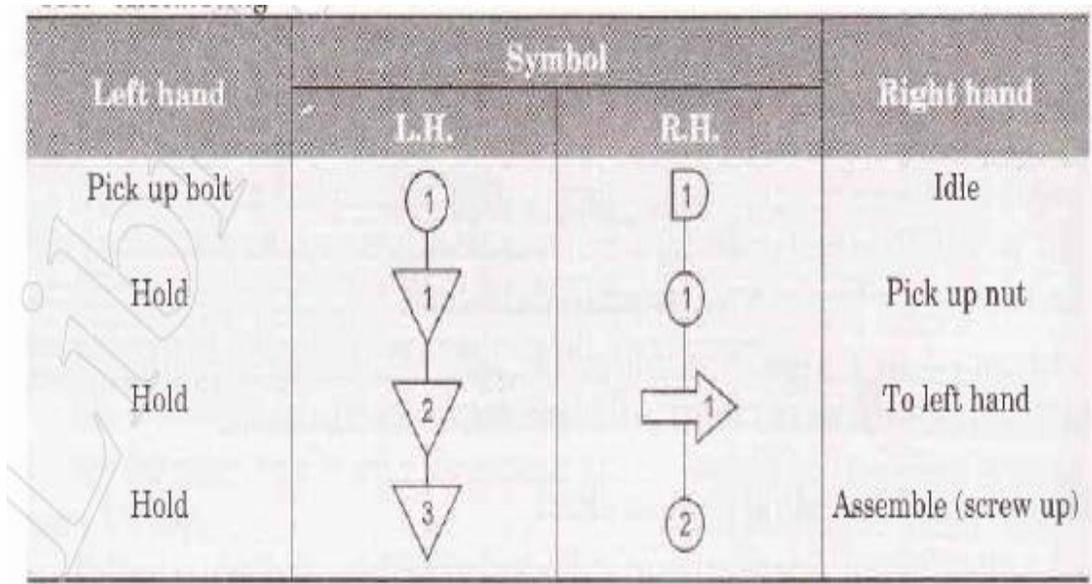
On a scale plan of work, area, department, or factory, a flow diagram is a drawing depicting the pathways of men, material, or components. Drawing a flow diagram can help visualise the path of movement (i.e., movement between two sites and the number of times movement is repeated).

The steps are as follows: I Make a scale drawing of the work area. (ii) Label the locations of machine tools, benches, storage, racks, inspection booths, and other items. iii) On the diagram, draw the real path movements of the material or the worker and indicate the direction of travel based on various observations.

# Plant Location, Plant Layout and Line Balancing

## Introduction
## Plan location and layout

- What is plant location?
  - The establishment of an industry at a particular place

- What is plant layout?
  - Plant layout is described as the most efficient physical organisation of machines, processing equipment, and service departments in order to maximise man, machine, and material coordination and efficiency in a plant.

## Concept and objective of governing plant location

- Concept governing plant location
  - Because a significant investment is made in plant machinery, location selection is critical.
  - Before deciding on a location, a long-term estimate of the company's future needs should be made.

- Objective of selecting the location
  - Saving the cost of production and maximize revenue

## FACTORS GOVERNING PLANT LOCATION

○    Factors governing plant location

1.    Country decision

- Political risk, government regulation, views, and incentives are all factors to consider.
- Intersections of culture and economics
- The market's locationTalent, attitudes, productivity, and cost are all factors to consider.
- Availability of supply, communication, and energy
- Exchange rates and currency risk

2.    Region/community decision

- The desire of the corporation
- The region's attractiveness
- Cost and availability of labour
- Costs and availability of utilities
- Regulation by state and municipal governments
- Fiscal and incentive policies of the government
- Cost of land and construction
- Customer

**FACTORS GOVERNING PLANT LOCATION**

3. Site decision

- The location, the size, and the price
- System of air, rail, highways, and waterways
- Restrictions on zoning
- Needed services/supplies are close by.
- The impact of environmental issues

**OBJECTIVE OF PLANT LAYOUT**

o The layout is one of the most critical factors that impacts an operation's long-term efficiency.

o The layout's goal is to create an effective and efficient layout that meets the company's competitive needs.

## TYPES OF LAYOUT

o    The layouts differ based on the sorts of workflow they require, and the workflow is defined by the product's nature.

o    Basic types of layouts:

- Process layout

  o    The process layout is especially useful when only a little amount of product is required. Because it provides more creator process freedom than others, the process structure is less suitable if the products are not standardised. The machines are grouped according to the nature or kind of the operations rather than the sequence of activities in this type of arrangement. This design is frequently used for non-repetitive tasks.

- Product layout

  o    The layout is called product type of layout when all of the processing equipment and machinery are positioned according to the product's sequence of activities. In this type of structure, each operational region produces only one product type. To justify the product layout, it must be standardised and mass-produced in huge quantities.

- Fixed position layout

  o    For today's manufacturing industry, this form of layout is the least important. The major component remains in a permanent location in this sort of layout, while other materials, parts, tools, machines, labour, and other supporting equipment are brought to this site.

## Process Layout



o   A process layout (also known as a functional layout) is a sort of facility layout in which related processes or machines are clustered together on the floor plan.

o   When numerous variations of a same product are created, this is referred to as a variable workflow.

o   Similar equipment is collected and placed in one location in this layout.

## TYPES OF LAYOUT

○ Process layout

○ Advantages
- Increased adaptability
- Specialization allows for better and more efficient oversight.
- In the event of a breakdown, the job can be transferred to another machine.
- Different product lines' capabilities can readily be enhanced.

○ Disadvantages
- More work is being done.
- More space on the floor.
- The goods has travelled longer distances.

## TYPES OF LAYOUT

## Product Layout



L : : Lathe     D : Drilling
M : Milling     G : Grinding
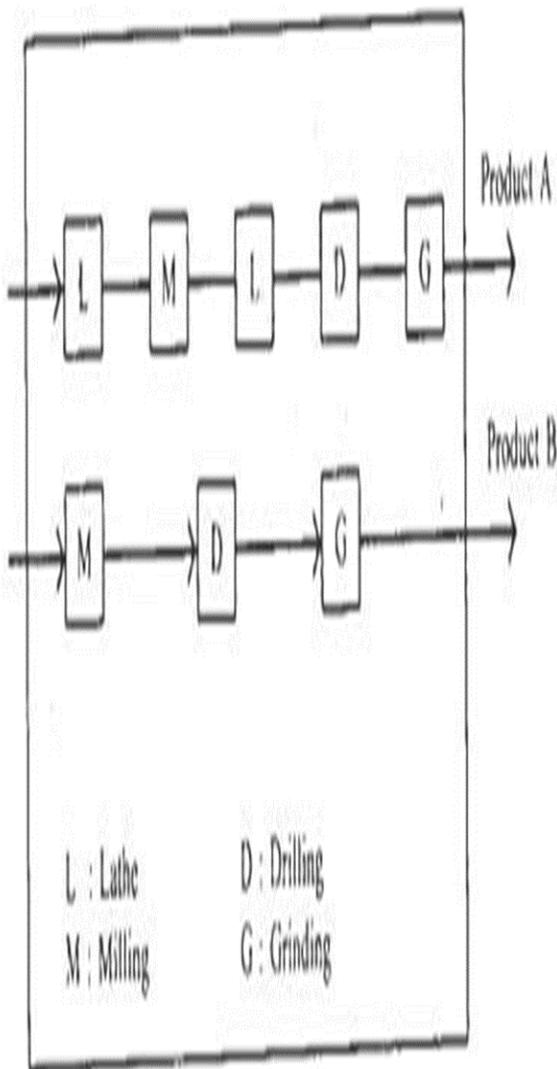
- A product layout is a manufacturing system in which the workstations and equipment are arranged along the production line.

- It's best for mass-producing a single standardised product in big quantities.

- The machine is set up in the order in which the product is created in a series of phases.

**T**YPES OF LAYOUT

o      Product Layout

o      Advantages
   - Costs of material handling can be decreased.
   - It takes up less space on the floor.
   - Better manufacturing control is made possible.
   - Bottlenecks in the production process are avoided.

o      Disadvantages
   - It is tough to expand the production line.
   - It's difficult to keep track of everything.
   - Equipment failure causes output to be disrupted.

## TYPES OF LAYOUT

○    *Process vs. Product Layouts*

| Process Layouts | Product Layout |
|---|---|
| Capable of producing a wide range of items. | Capable of efficiently producing a small number of items. |
| The resources used are all-purpose. | Specialized resources are used. |
| Facilities require extra manpower. | The cost of facilities is higher. |
| In comparison to the market, there is more flexibility. | In comparison to the market, there is a lack of flexibility. |
| Processing times are slower. | The rate of processing has increased. |
| Costs of material handling are high. | Material handling costs are reduced. |
| More space is required. | Space requirements are reduced. |

## Fixed position layout

Fixed-position layout



- A manufacturing technique for assembling items that are too huge, unwieldy, or fragile to transport safely or successfully to a completion location.

- When the product is large, this method is used.

- It is difficult or impossible to move the product.

- All materials must be carried to the location.

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**PLANT LAYOUT PROCESSES SELECTION**

○ Three Major Issues to Consider When Choosing a Plant Layout Process

- How many different items or services will the system have to deal with?
- How much equipment flexibility will be required?
- What is the expected output volume?

○ The answers to those anticipated questions will serve as a guide in determining the best process to use.

**PLANT LAYOUT PROCESSES SELECTION**

○ Basic Plant Layout Process Types:

- There are five basic process types
  - ○ Job shop
  - ○ Batch
  - ○ Repetitive
  - ○ Continuous
  - ○ Project

|  | Job Shop | Batch | Repetitive | Continuous |
|---|---|---|---|---|
| Description | Customized goods or services. | Semi-standardized goods or services. | Standardized goods or services. | Highly standardized goods or services. |
| Advantages | Able to handle a wide variety of work. | Flexibility. | Low unit cost, high volume, efficient. | Very efficient, very high volume. |
| Disadvantages | Slow, high cost per unit, complex planning and scheduling. | Moderate cost per unit, moderate scheduling and planning. | Low flexibility, high cost of downtime. | Very rigid, lack of variety, costly to change, very high cost of downtime. |

| Activity/ function | Job shop | Batch | Repetitive/ assembly | Continu ous | Project |
|---|---|---|---|---|---|
| Cost estimation | Difficult | Somewhat routine | Routine | Routine | Simple to complex |
| Cost per unit | High | Moderate | Low | Low | Very high |
| Equipment used | General purpose | General purpose | Special purpose | Special purpose | Varied |
| Fixed cost | Low | Moderate | High | Very high | Varied |
| Variable cost | High | Moderate | Low | Very low | High |
| Labor skills | High | Moderate | Low | Low to high | Low to high |

## FIVE BASIC PROCESS TYPES (CONT.)

| Activity/ function | Job shop | Batch | Repetitive/ assembly | Continuous | Project |
|---|---|---|---|---|---|
| Marketing | Promote capabilities | Promote capabilities, semi-standardized goods and services | Promote standardized goods and services | Promote standardized goods and services | Promote capabilities |
| Scheduling | Complex | Moderate complex | Routine | Routine | Complex subject to change |
| Work in process inventory | High | High | Low | Low | Varied |

**LINE BALANCING AND NETWORK ANALYSIS**

o   Line balancing is the process of assigning tasks to workstations in such a way that their time requirements are roughly equal.

o   Line balancing is frequently done to reduce machine or personnel imbalance while still satisfying a line's output requirement.

o   The maximum time permitted at each workstation to accomplish its set of tasks on a unit is called cycle time.

o   A precedence diagram is a graphic that depicts basic tasks and the order in which they must be completed.

## Line Balancing Relationships

$$\text{Output capacity} = \frac{\text{operating time per day}}{\text{cycle time}} = \frac{OT}{CT}$$

$$\text{Cycle time} = \frac{\text{operating time per day}}{\text{desired demand rate (units per day)}}; CT = \frac{OT}{D}$$

$$\text{Minimum number of workstations} = \frac{\sum_{i=1}^{m} \text{time for task i}}{\text{cycle time}}; N_{min} = \frac{\Sigma t}{CT}$$

$$\text{Percentage of idle time} = \frac{\text{Sum of idle times}}{\text{(actual number of stations)} \times \text{(cycle time)}} \times 100$$

o   $$\text{Efficiency} = \frac{\Sigma \, task \, time}{(number \, of \, work \, station) \, x \, (assigned \, cycle \, times)}$$

Figure 3.1: Line Balancing Relationship

**LINE BALANCING AND NETWORK ANALYSIS**

○ The table below depicts a work line and the time required to create product R. There are 480 productive minutes of labour available every day at the given daily productivity rate. Furthermore, the assembly line's output must be 40 units each day, according to the production plan. Look for:

| TASK | PERFORMANCE TIME (MINUTES) | TASK MUST FOLLOW THIS TASK |
|---|---|---|
| A | 10 | |
| B | 11 | A |
| C | 5 | B |
| D | 4 | B |
| E | 12 | A |
| F | 3 | C,D |
| G | 7 | F |
| H | 11 | E |
| I | 3 | G,H |
| TOTAL | 66 | |

1. Draw the precedence chart

2. Calculate cycle time

3. Calculate minimum number of work station

4. Calculate the efficiency

o       Assembly Line Balancing

Line-balancing tasks are normally carried out in order to meet a certain line output need. Management must understand the tools, equipment, and working practises employed in order to produce at a set rate. Then, for each assembly task (such as drilling a hole, tightening a nut, or spray-painting a part), the time needs must be determined. Management must also understand the precedence relationship among activities, or the order in which distinct tasks must be completed. Let's make a precedence chart for the data in Example 1's jobs.

o       Example 1

We need to create a precedence diagram for an electrostatic copier that will take 66 minutes to assemble. The duties, assembly periods, and sequence requirements for the copier are listed in the table and figure.

# EXAMPLE 1

| TASK | PERFORMANCE TIME (MINUTES) | TASK MUST FOLLOW THIS TASK |
|---|---|---|
| A | 10 | _ |
| B | 11 | A |
| C | 5 | B |
| D | 4 | B |
| E | 12 | A |
| F | 3 | C,D |
| G | 7 | F |
| H | 11 | E |
| I | 3 | G,H |
| TOTAL TIME | 66 | |

This means that tasks B and E cannot be done until task A has been completed



Precedence Diagram

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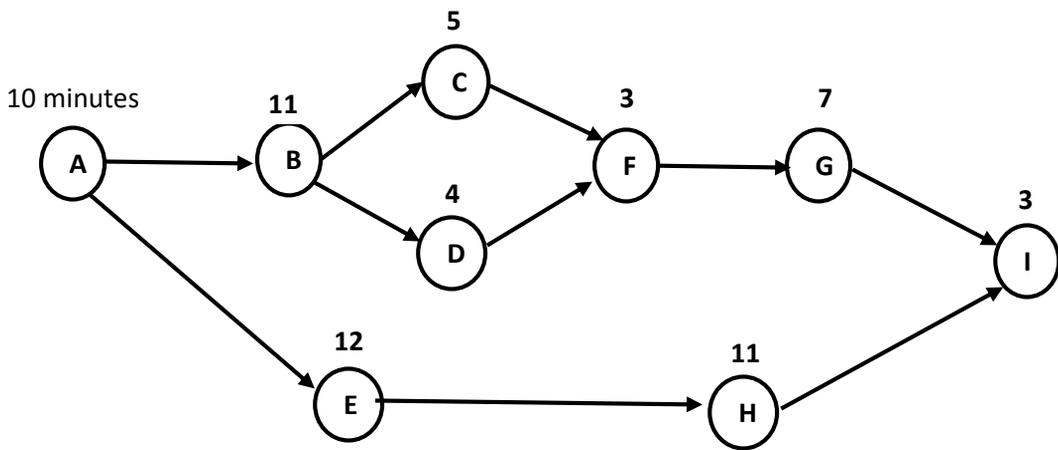
After creating a precedence chart summarising the sequences and performance timeframes, we move on to the task of organising tasks into job stations in order to meet the desired production rate. This technique is broken down into three steps:

1. Subtract the daily demand (or output rate) from the daily productive time (in minutes or seconds). The following is the result of this procedure:
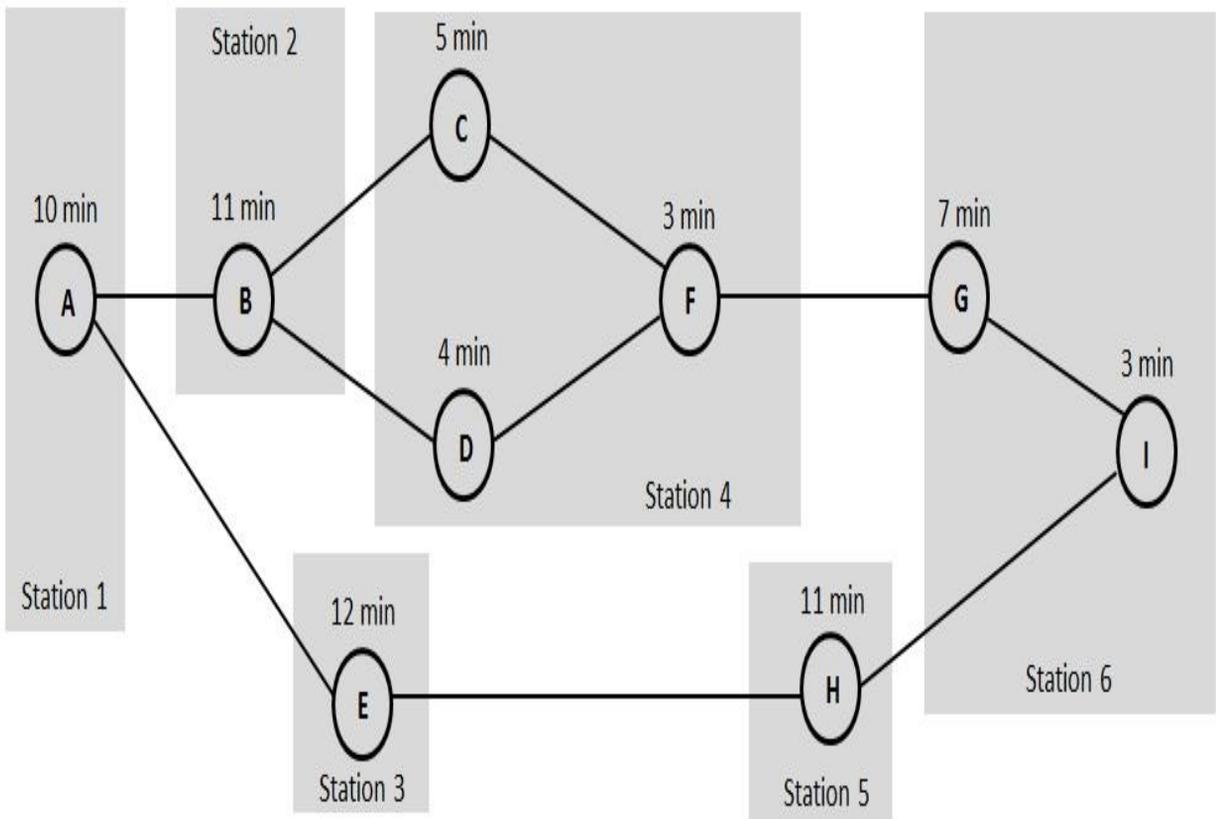
## EXAMPLE 1

**A six-station solution to the Line-Balancing Problem**

- As soon as feasible, set a timer for 12 minutes. The first workstation takes 10 minutes to complete and has a 2-minute idle time.

- The second workstation takes 11 minutes, and the third takes the entire 12 minute period. The fourth workstation consists of three little activities that are nicely balanced at 12 minutes. The fifth cycle has 3 minutes of idle time, whereas the sixth (which includes tasks G and 1) has 2 minutes. This solution has a total idle time of 6 minutes each cycle.

- By multiplying the entire task time by the product of the number of workstations times the assigned cycle time, we may get line balance efficiency:

- Efficiency $= \dfrac{\sum task\ time}{(number\ of\ workstations)\times(assigned\ cycle\ time)}$

- Different degrees of efficiency for varying numbers of workstations are frequently compared by management. This allows the company to identify the line's sensitivity to changes in production rate and workstation allocations.

## EXAMPLE 1

o   Varying degrees of efficiency for different numbers of workstations are frequently compared by management. The company may then determine the line's sensitivity to changes in production rate and workstation allocations.

o   We can calculate the balance efficiency for Example 2 as follow:

$$\text{Efficiency} = \frac{66\ minutes}{(6\ stations) \times (12\ minutes} = \frac{66}{72} = 91.7\%$$

o   For whatever reason, opening the seventh workstation would reduce the balance's efficiency to 78.6%:

$$\text{Efficiency} = \frac{66\ minutes}{(7\ stations) \times (12\ minutes} = 78.6\%$$

o   Similar to large-scale process layout problems, computers are routinely utilised to solve large-scale line balance concerns. A variety of computer systems can be used to allocate assembly line workstations with 100 (or more) distinct work tasks. Both computer routines are known as COMSOAL.

**EXAMPLE 2**

○ An assembly line's cycle time is eight minutes, as demonstrated in the acts below. Make a precedence graph to see how many workstations you can get away with. Divide the work tasks among workstations to keep the line balanced. What is the efficiency of the line balance?

| TASK | PERFORMANCE TIME (MINUTES) | TASK MUST FOLLOW THIS TASK |
|---|---|---|
| A | 5 | – |
| B | 3 | A |
| C | 4 | B |
| D | 3 | B |
| E | 6 | C |
| F | 1 | C |
| G | 4 | D,E,F |
| H | 2 | G |
| TOTAL | 28 | |

## SOLUTION

○ The theoretical minimum number of workstations is:

$$\frac{\sum t}{Cycle\ time} = \frac{28\ minutes}{8\ minutes} = 3.5\ or\ 4\ stations$$

○ The precedence graph and one good layout are shown in figure below.

$$\text{Efficiency} = \frac{Total\ task\ time}{(Number\ of\ workstations) \times (cycle\ time)} = \frac{28}{(4)(8)}$$

$$= 87.5\%$$
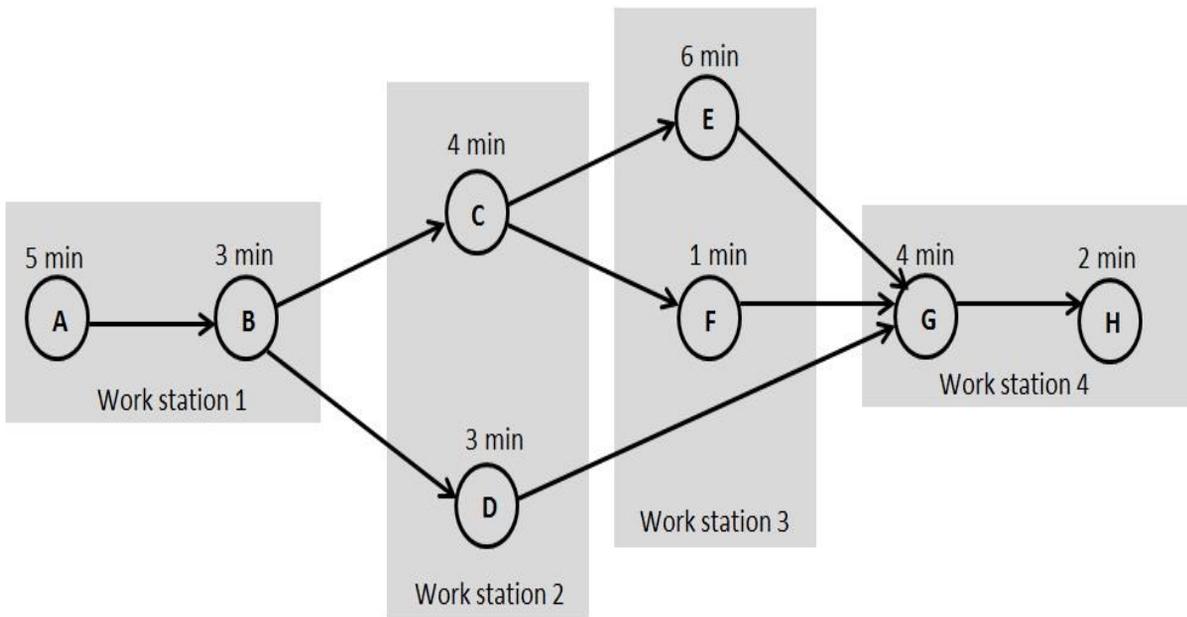
## EXERCISES

1. Identify and define the component that influences plant location.

2. For extensive analysis, why are plant placement selections so important?

3. The table below depicts a work line and the time required to create product R. Given that the daily production rate is 540 minutes and the daily production quality is 60 units, the daily production rate is 540 minutes.

| TASK | DURATION (MIINUTES) | PRECEDES TASK |
|------|---------------------|---------------|
| A | 0.3 | C |
| B | 0.4 | D |
| C | 0.6 | E |
| D | 1.2 | F |
| E | 0.2 | G |
| F | 0.6 | H |
| G | 0.1 | H |
| H | 0.5 | I |
| I | 0.3 | end |

i. Draw a balancing production line.

ii. Calculate the length of the production cycle.

iii. Calculate the production's minimal number of workstations.

iv. Determine the number of workstations in a group.

## ANSWER

1. 1. Country decision
   - Political risk, government regulations, public perceptions, and incentives
   - Issues between culture and commerce
   2. Region/community decision
   - Corporate desire
   - Attractiveness of region
   3. Site decision
   - Site, size and cost
   - Air, rail, highway and water spray system

2. Because a significant investment is made in plant machinery, the location chosen is critical. Before deciding on a location, a long-term prognosis should be prepared to predict the company's future demands. The goal of picking a location is to reduce manufacturing costs while increasing revenue.
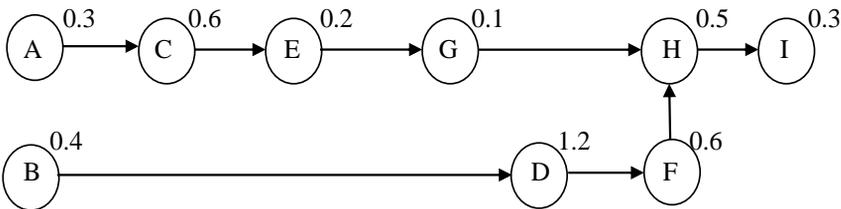
ii.



Cycle time (CT) = $\dfrac{\text{Available time period}}{\text{Output units required/period}}$ = $\dfrac{AT}{\text{Output}}$

= $\dfrac{440}{275}$

iii.

= 1.6 minutes

The minimum number of work station = $\dfrac{\text{Total time}}{\text{Cycle time}}$

= $\dfrac{0.3 + 0.6 + 0.4 + 1.2 + 0.2 + 0.6 + 0.1 + 0.5 + 0.3}{1.6}$

iv.

= 2.625 ≈ 3 work stations
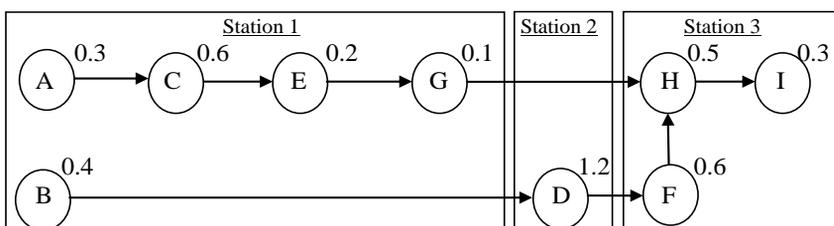
# Inventory Control Management

**INVENTORY CONTROL AND MANAGEMENT CONCEPT**

○ What is inventory?
- Inventory is a holding stock of physical commodities with economic worth that is held in various forms by an organisation in its custody awaiting packing, processing, transformation, use, or sale at a later date.

○ Inventory management is a critical function that determines the supply chain's health as well as the impact on the balance sheet's financial health.

○ From the above definition the following points stand out regarding inventory:

> All organizations engaged in production or sale of products hold inventory in one form or other

> Inventory can be in complete state or incomplete state

> Inventory is held to facilitate future consumption, sale or further processing / value addition

> All inventoried resources have economic value and can be considered as assets of the organization

**INVENTORY CONTROL AND MANAGEMENT CONCEPT**

o   List objective of inventory control and management:

- To ensure that customers have an appropriate supply of items and to avoid shortages as much as feasible.
- Ensure that the financial investment in inventories is as little as possible
- Materials are purchased, stored, consumed, and accounted for in an efficient manner.
- To keep a timely record of all item inventories and to keep the stock within the required limits.
- To guarantee that replenishment is done in a timely manner
- To have a reserve stock of materials in case of material delivery delays.
- To provide a scientific foundation for both short–term and long–term material planning.

o   Benefits of inventory control

- It has been demonstrated that by using scientific inventory control, stockpiles may be reduced by 10% to 40%. The following are some of the advantages of inventory control:
  o Customer relations have improved as a result of prompt delivery of goods and services.
  o Production runs smoothly and without interruption.
  o Working capital management that is effective
  o Reduces the amount of money lost due to deterioration, obsolescence, and proliferation.
  o Purchases are more cost effective.
  o Removes the option of ordering twice.

- **Types of inventory**

1. Raw Materials
   - Raw materials are unprocessed materials that have not undergone any processing since being received from vendors. (For example, round bars, angles, channels, pipe, and so on.)

2. Bought Out Parts
   - These parts are finished parts and subassemblies that are obtained from outside vendors and are manufactured to the company's specifications.

3. Work-In-Process (WIP)
   - These are objects or materials that are in the process of being manufactured but are not yet finished. (For example, a semi-finished product at various phases of production.)

**INVENTORY CONTROL AND MANAGEMENT CONCEPT**

○ Types of inventory (Continued)

4. Finished Goods Inventories
   - These refer to the completed products ready for dispatch.

5. Maintenance, Repair, and Operating Stores
   - Typically, these inventories refer to products that are not part of the finished product but are used throughout the manufacturing process. (For example, machine spares, oil, and grease.)

6. Tools Inventory
   - Includes both standard tools and special tools.

7. Miscellaneous Inventories
   - Office stationaries and other consumable stores.

**INVENTORY COST**

○ Holding cost (also known as carrying cost), ordering cost, and setup cost are the three main expenditures connected with inventories.

1. Holding cost
   - The costs of storing objects are known as holding costs. These fluctuate depending on the amount of inventory and, in some cases, the length of time an item is stored; the higher the inventory level over time, the higher the holding cost.

   - The cost of losing the usage of monies locked up in inventories might be included in the holding cost. Direct storage costs include rent, heating, cooling, lighting, security, refrigeration, record keeping, and logistics, as well as interest on inventory loans, depreciation, obsolescence as the market for inventory products declines, product deterioration, and spoilage, as well as breakage, taxes, and pilferage.

**INVENTORY COST**

2. Ordering cost
   - Ordering expenses are the costs of refilling merchandise that has been retained in stock. These are normally indicated in dollars per order and are not affected by the quantity of the order. As a result, the cost of placing an order varies based on the amount of orders placed (as the number of orders increases, the ordering cost increases)
   - Requisition costs, buy orders, transportation, and shipping, receiving, inspection, handling, and storage, accounting, and auditing are some of the costs incurred each time an order is placed.

3. Setup Cost
   - The cost of preparing an equipment or a process for the production of an order.

**INVENTORY MODELS FOR INDEPENDENT DEMAND**

o The finished products that are not a function of, or dependent on, internal production activity are known as independent demand items.

o Independent demand is frequently external to the organisation and thus outside its direct control.

**ECONOMIC ORDER QUANTITY MODEL (EOQ)**

o   The Economic Order Quantity (EOQ) model is the most extensively used and traditional method for deciding how much to order in a continuous system.

o   The EOQ model's purpose is to calculate the best order size for minimising overall inventory costs.

o   Important Assumptions
   - Demand is predictable, consistent, and self-contained.
   - The lead time is well-known and consistent.
   - Inventory receipt is immediate and thorough.
   - There are no quantity discounts available.
   - The setup and holding expenses are the only variables.
   - Stock-outs can be prevented entirely.

o   The Inventory Order Cycle
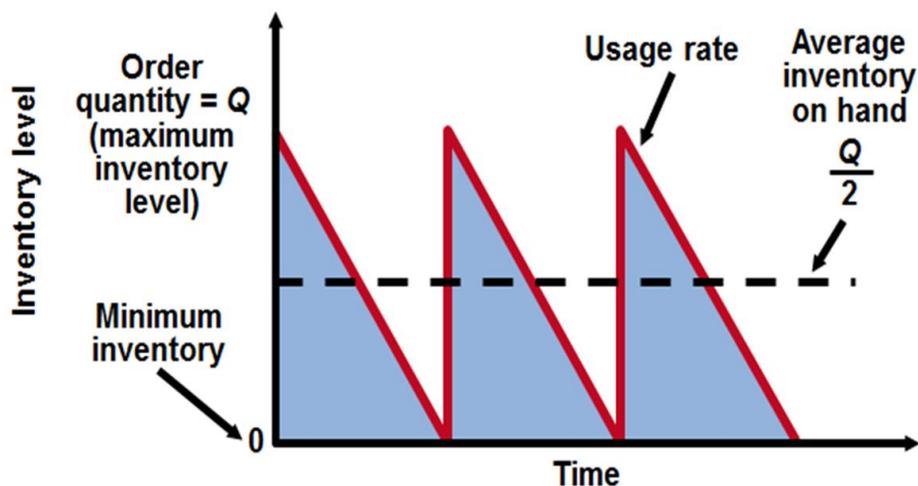
## ECONOMIC ORDER QUANTITY MODEL (EOQ)

o  The EOQ Cost Model

## Objective is to minimize total costs
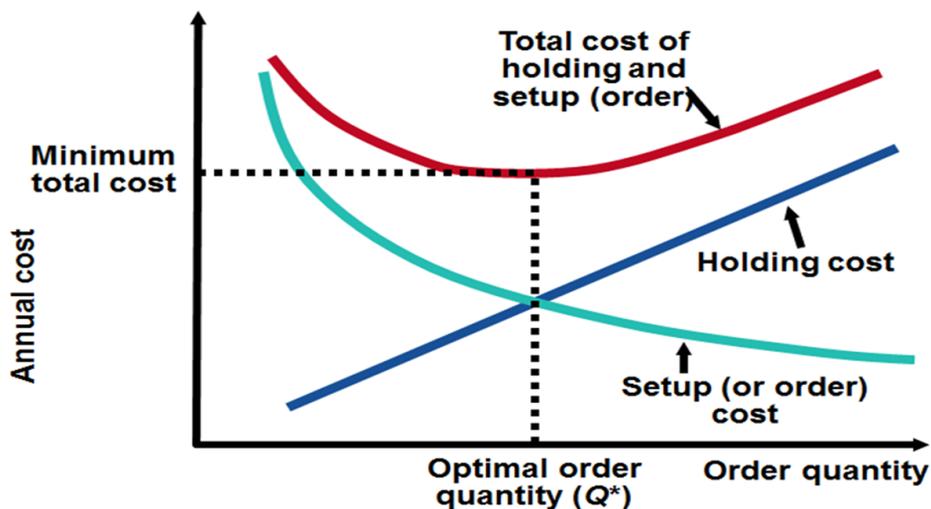


o  Annual Setup Cost (Ordering Cost)

$Q$ = Number of pieces per order
$Q^*$ = Optimal number of pieces per order (EOQ)
$D$ = Annual demand in units for the inventory item
$S$ = Setup or ordering cost for each order
$H$ = Holding or carrying cost per unit per year

$$\textbf{Annual setup cost} = \left[\frac{D}{Q}\right](S)$$

### ECONOMIC ORDER QUANTITY MODEL (EOQ)

o   Annual Holding Cost (Carrying Cost)

$Q$ = Number of pieces per order
$Q^*$ = Optimal number of pieces per order (EOQ)
$D$ = Annual demand in units for the inventory item
$S$ = Setup or ordering cost for each order
$H$ = Holding or carrying cost per unit per year

$$\text{Annual holding cost} = \frac{Q}{2}H$$

o   **Optimum Order Quantity**

o   Optimal order quantity is found when annual setup cost equals annual holding cost

o   Solving for $Q\_opt$ =    $\therefore \quad \frac{D}{Q}S = \frac{Q}{2}H$

$$2DS = Q^2H$$
$$Q^2 = 2DS/H$$
$$Q^* = \sqrt{2DS/H}$$

### ECONOMIC ORDER QUANTITY MODEL (EOQ)

○ **Reorder Points**

○ EOQ answers the "how much" question.

○ The reorder point (ROP) tells "when" to order.
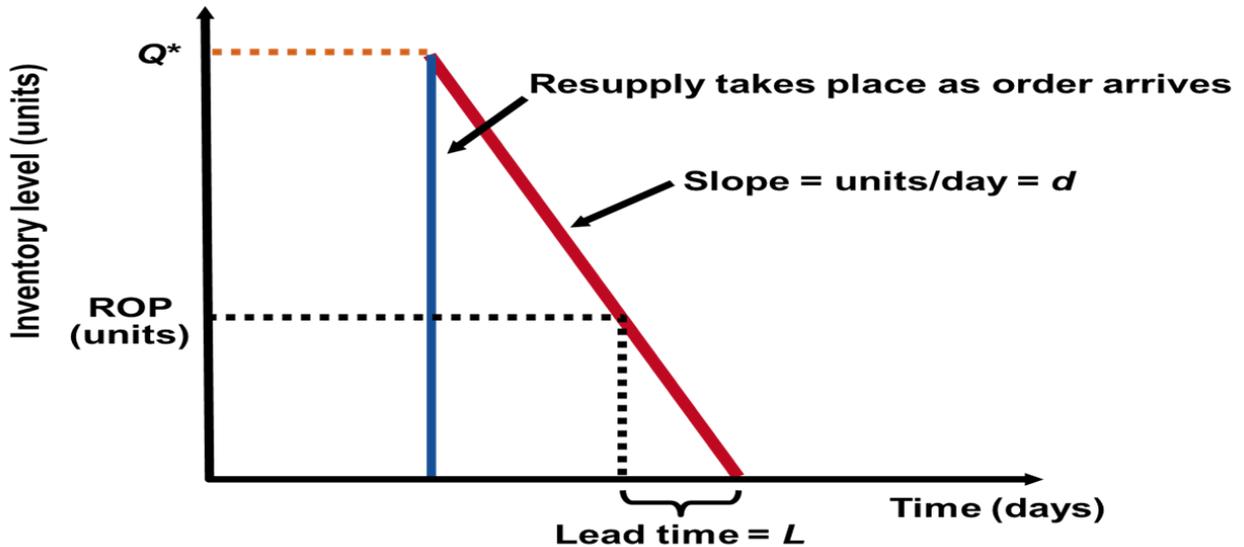


○ Reorder Points

$$\text{ROP} = \left(\begin{array}{c}\text{Demand}\\ \text{per day}\end{array}\right)\left(\begin{array}{c}\text{Lead time for a}\\ \text{new order in days}\end{array}\right)$$

$$= d \times L$$

○ How to find d?

$$d = \frac{D}{\text{Number of working days in a year}}$$

**ECONOMIC ORDER QUANTITY MODEL (EOQ)**

○ Formula That You Must Know in (EOQ)

$$\text{Optimal Quantity, } Q_{opt} = \sqrt{\frac{2DS}{H}}$$

$$\text{Total Annual Inventory Cost, } = \frac{Q*}{2}H + \frac{D}{Q*}S$$

$$\text{Average Annual Inventory Cost (Minimum), } = \sqrt{2 \times D \times S \times H}$$

$$\text{Length of Order Cycle, } = \frac{Q*}{D}$$

$$\text{Optimum Number of Order, } = \frac{D}{Q*}$$

$$\text{Reorder Points, (ROP)} = d \times L$$

○ *Example 1*

○ *Every year, SaveMart requires 1000 coffee makers. Each coffee maker will set you back RM78. The fee of placing an order is RM100 per order. The carrying cost is RM20 per unit. There is a 5-day lead time. SaveMart is open every day of the year. Calculate:*

    i.    *The Model of EOQ*

    ii.    *How often does the store replenish each year?*

    iii.    *How long does the order cycle last?*

    iv.    *If the EOQ quantity is ordered, what is the total annual cost?*

    v.    *What is the quantity of reorder points?*

## ECONOMIC ORDER QUANTITY MODEL (EOQ)

○ Example 2

○ A manufacturer must deliver 3600 units of his product to a customer each year. There are no exceptions to this rule. The carrying cost of inventory is RM1.20 per unit. The setup fee for each run is RM80. Find:

   i.     Economic order quantity
   ii.    The optimum number of orders per unit
   iii.   Average annual inventory cost (minimum)

## PRODUCTION ORDER QUANTITY MODEL (EPQ)

○ Used when inventory builds up over a period of time after an order is placed.

○ Used when units are produced and sold simultaneously.
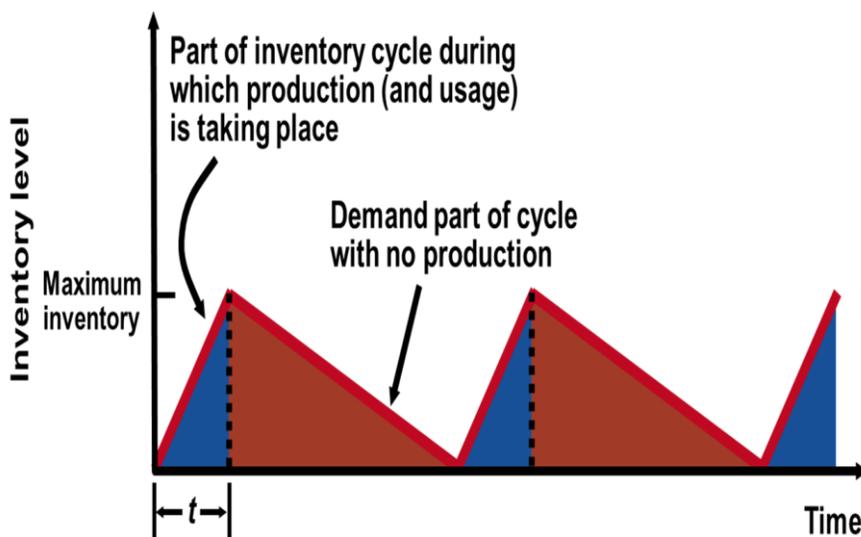
## PRODUCTION ORDER QUANTITY MODEL (EPQ)

$Q$ = Number of pieces per order     $p$ = Daily production rate
$H$ = Holding cost per unit per year     $d$ = Daily demand/usage rate
$D$ = Annual demand

$$\text{Setup cost} = (D/Q)S$$

$$\text{Holding cost} = \frac{1}{2} HQ[1 - (d/p)]$$

$$(D/Q)S = \frac{1}{2} HQ[1 - (d/p)]$$

$$Q^2 = \frac{2DS}{H[1 - (d/p)]}$$

$$Q^* = \sqrt{\frac{2DS}{H[1 - (d/p)]}}$$

○ Formula That You Must Know in (EPQ)

Optimum Quantity for EPQ, $Q^* = \sqrt{\dfrac{2DS}{H[(1-\frac{d}{p})]}}$

Maximum Inventory Level, $= pt - dt$

Total minimum Annual Inventory Cost, $= S\dfrac{D}{Q^*} + H\dfrac{Q^*}{2}(1-\frac{d}{p})$

Production Run Length, $= \dfrac{Q^*}{p}$

Cycle Time, $= \dfrac{Q^*}{d}$

Optimum Number of Order, $= \dfrac{D}{Q^*}$

Maximum Inventory Level, $= Q(1-\frac{d}{p})$

## PRODUCTION ORDER QUANTITY MODEL (EPQ)

o    Example

$$D = 1,000 \text{ units} \qquad\qquad p = 8 \text{ units per day}$$
$$S = \$10 \qquad\qquad\qquad\qquad d = 4 \text{ units per day}$$
$$H = \$0.50 \text{ per unit per year}$$

$$Q^* = \sqrt{\frac{2DS}{H[1 - (d/p)]}}$$

$$Q^* = \sqrt{\frac{2(1,000)(10)}{0.50[1 - (4/8)]}} = \sqrt{80,000}$$

$$= 282.8 \text{ or } 283 \text{ hubcaps}$$

Note:

$$d = 4 = \frac{D}{\text{Number of days the plant is in operation}} = \frac{1,000}{250}$$

When annual data are used the equation becomes

$$Q^* = \sqrt{\frac{2DS}{H\left(1 - \dfrac{\text{annual demand rate}}{\text{annual production rate}}\right)}}$$

o    Example 3

o    I-75 Carpet Store has its own manufacturing facility where Super Slag carpet is produced. The cost of starting up the manufacturing process is RM150. The carrying cost per yard is RM0.75, with a requirement of 10,000 yards per year. The production facilities are open 311 days a year and produce 150 yards of carpet every day. Compute:

i.      The optimal order size

ii.     Total inventory cost

iii.    The length of time to receive an order

iv.    The number of orders per year and,

v.     The maximum inventory level

**QUANTITY DISCOUNT MODEL**

○ Reduced prices are often available when larger quantities are purchased

○ The trade-off is between reduced product cost and increased holding cost

○ Total cost = Setup cost + Holding cost + Product cost ( Demand x Actual Cost )

$$TC = \frac{D}{Q}S + \frac{Q}{2}H + PD$$

○ Steps in analyzing a quantity discount

1. For each discount, calculate Q*.
2. If Q* for a discount doesn't qualify, choose the smallest possible order size to get the discount.
3. Compute the total cost for each Q* or adjusted value from Step 2.
4. Select the Q* that gives the lowest total cost.

○ A typical quantity discount schedule

| Discount Number | Discount Quantity | Discount (%) | Discount Price (P) |
|---|---|---|---|
| 1 | 0 to 999 | no discount | $5.00 |
| 2 | 1,000 to 1,999 | 4 | $4.80 |
| 3 | 2,000 and over | 5 | $4.75 |

○ Calculate Q* for every discount.

○ $Q^* = \sqrt{\dfrac{2DS}{IP}}$

$$Q_1^* = \sqrt{\frac{2(5,000)(49)}{(.2)(5.00)}} = 700 \text{ cars/order}$$

$$Q_2^* = \sqrt{\frac{2(5,000)(49)}{(.2)(4.80)}} = 714 \text{ cars/order}$$

$$Q_3^* = \sqrt{\frac{2(5,000)(49)}{(.2)(4.75)}} = 718 \text{ cars/order}$$

Total cost $

Total cost curve for discount 1

Total cost curve for discount 2

Total cost curve for discount 3

*b*

*a*

Q* for discount 2 is below the allowable range at point *a* and must be adjusted upward to 1,000 units at point *b*

1st price break

2nd price break

0      1,000      2,000
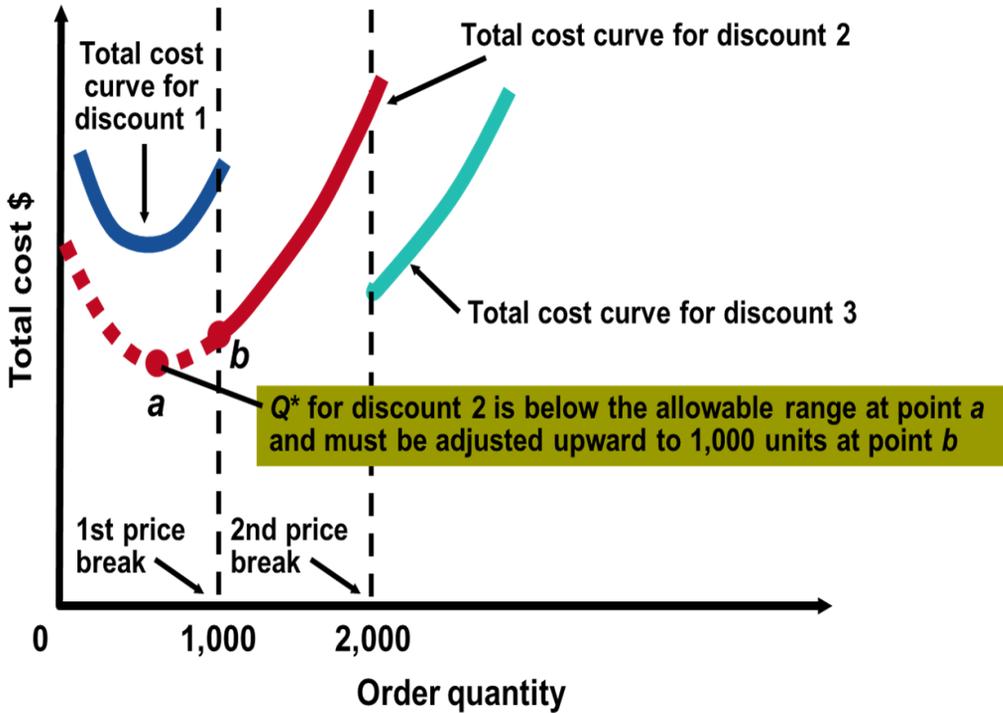
Order quantity

## Calculate $Q^*$ for every discount

$$Q_1^* = \sqrt{\frac{2(5,000)(49)}{(.2)(5.00)}} = 700 \text{ cars/order}$$

$$Q_2^* = \sqrt{\frac{2(5,000)(49)}{(.2)(4.80)}} = \cancel{714} \text{ cars/order}$$
$$1,000 \text{ — adjusted}$$

$$Q_3^* = \sqrt{\frac{2(5,000)(49)}{(.2)(4.75)}} = \cancel{718} \text{ cars/order}$$
$$2,000 \text{ — adjusted}$$

**QUANTITY DISCOUNT MODEL**

| Discount Number | Unit Price | Order Quantity | Annual Product Cost | Annual Ordering Cost | Annual Holding Cost | Total |
|---|---|---|---|---|---|---|
| 1 | $5.00 | 700 | $25,000 | $350 | $350 | $25,700 |
| 2 | $4.80 | 1,000 | $24,000 | $245 | $480 | $24,725 |
| 3 | $4.75 | 2,000 | $23.750 | $122.50 | $950 | $24,822.50 |

**Choose the price and quantity that gives the lowest total cost**

**Buy 1,000 units at $4.80 per unit**

o Example 4

o A large hospital's maintenance department consumes around 180 containers of liquid cleanser per year. The cost of ordering is RM25, and the cost of carrying a case is RM5 each year. According to the new schedule, orders of less than 45 cases will cost RM2, 45 to 69 cases will cost RM1.70, and more than 70 cases will cost RM1.40 per case. Calculate the most cost-effective order quantity and total cost.

## MASTER PRODUCTION SCHEDULING (MPS)

- Is a precise plan that specifies how many finished things will be produced over a set period of time.

- End items might be final products or the highest level assemblies that are used to create shippable products.

- It outlines what should be made and when it should be done.

- It's important to stick to the production schedule.

- In general terms, the production plan determines the total level of output.

- Each phase of the process must be checked for viability as it progresses from planning to implementation.

- It outlines what should be made and when it should be done.

- The aggregate production plan must be followed.

- In broad terms, an aggregate production plan establishes the overall level of output.

Given the *product structure tree* for "A" and the lead time and demand information below, provide a materials requirements plan that defines the number of units of each component and when they will be needed

Product Structure Tree for Assembly A
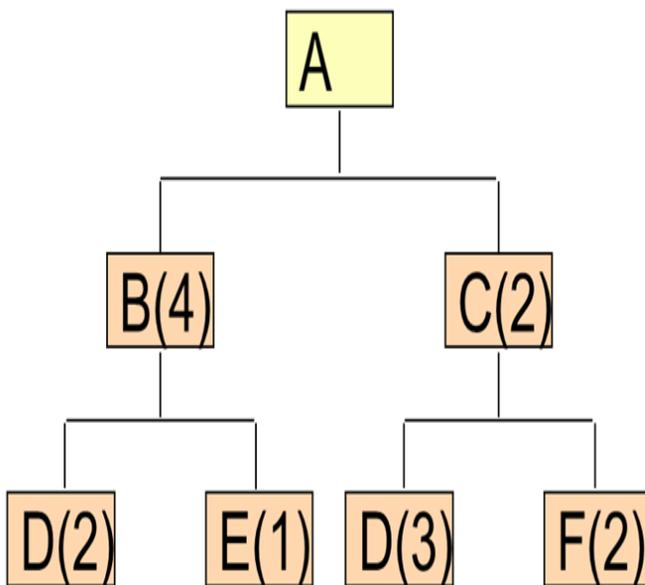


| Lead Times | |
|---|---|
| A | 1 day |
| B | 2 days |
| C | 1 day |
| D | 3 days |
| E | 4 days |
| F | 1 day |

| Total Unit Demand | |
|---|---|
| Day 10 | 50 A |
| Day 8 | 20 B (Spares) |
| Day 6 | 15 D (Spares) |

105

First, the number of units of "A" are scheduled backwards to allow for their lead time. So, in the materials requirement plan below, we have to place an order for 50 units of "A" on the 9th day to receive them on day 10.

| | Day: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A | Required | | | | | | | | | | 50 |
| | Order Placement | | | | | | | | | 50 | |

LT = 1 day

Next, we need to start scheduling the components that make up "A". In the case of component "B" we need 4 B's for each A. Since we need 50 A's, that means 200 B's. And again, we back the schedule up for the necessary 2 days of lead time.

| | Day: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A | Required | | | | | | | | | | 50 |
| | Order Placement | | | | | | | | | 50 | |
| B | Required | | | | | | | | | 20 | 200 |
| | Order Placement | | | | | | 20 | 200 | | | |

$LT = 2$

Spares

A

B(4)        C(2)

D(2)   E(1)   D(3)   F(2)

4x50=200
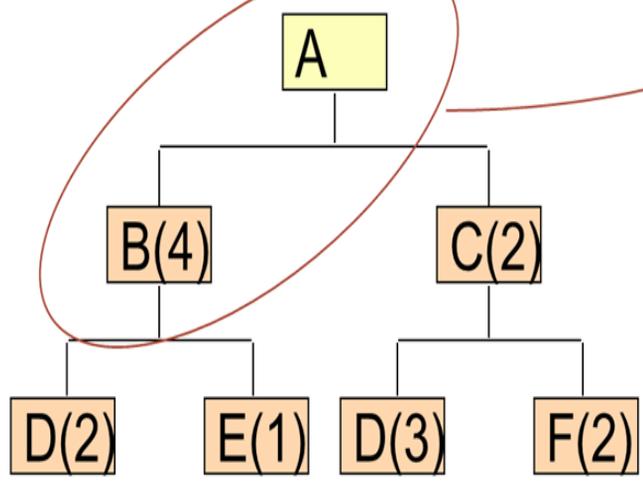
# EXAMPLE OF MRP LOGIC AND PRODUCT STRUCTURE TREE

**Finally, repeating the process for all components, we have the final materials requirements plan:**

| | Day: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A | Required | | | | | | | | | | 50 |
| LT=1 | Order Placement | | | | | | | | | 50 | |
| B | Required | | | | | | | | 20 | 200 | |
| LT=2 | Order Placement | | | | | | 20 | 200 | | | |
| C | Required | | | | | | | | | 100 | |
| LT=1 | Order Placement | | | | | | | | 100 | | |
| D | Required | | | | | | 55 | 400 | 300 | | |
| LT=3 | Order Placement | | | 55 | 400 | 300 | | | | | |
| E | Required | | | | | | 20 | 200 | | | |
| LT=4 | Order Placement | | 20 | 200 | | | | | | | |
| F | Required | | | | | | | | 200 | | |
| LT=1 | Order Placement | | | | | | | 200 | | | |



A

B(4)    C(2)

D(2)   E(1)  D(3)   F(2)
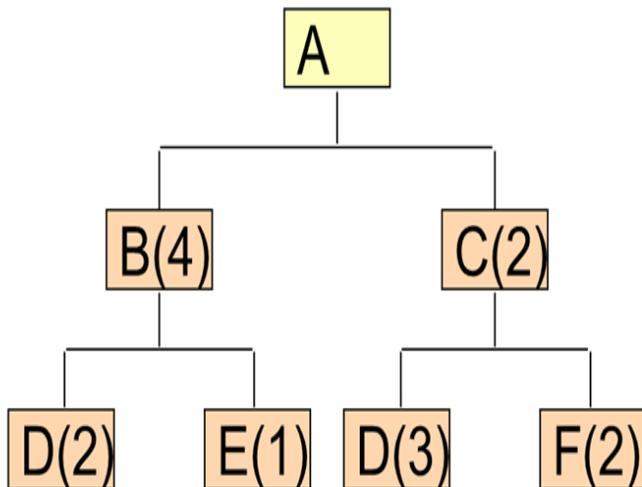
Part D: Day 6

40 + 15 spares

## MATERIAL REQUIREMENT PLANNING (MRP) EXAMPLE
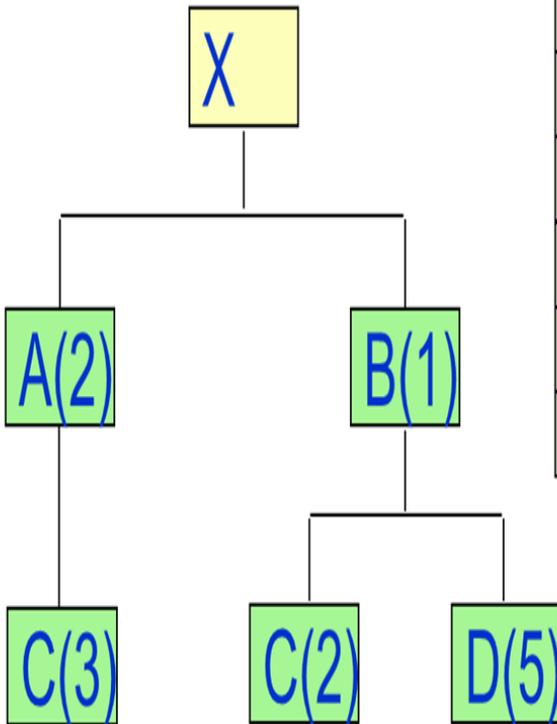


| Item | On-Hand | Lead Time (Weeks) |
|------|---------|-------------------|
| X | 50 | 2 |
| A | 75 | 3 |
| B | 25 | 1 |
| C | 10 | 2 |
| D | 20 | 2 |

Requirements include 95 units (80 firm orders and 15 forecast) of X in week 10

| | Day: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| X | Gross requirements | | | | | | | | | | 95 |
| LT=2 | Scheduled receipts | | | | | | | | | | |
| | Proj. avail. balance | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| On- | Net requirements | | | | | | | | | | 45 |
| hand | Planned order receipt | | | | | | | | | | 45 |
| 50 | Planner order release | | | | | | | | 45 | | |
| A | Gross requirements | | | | | | | | 90 | | |
| LT=3 | Scheduled receipts | | | | | | | | | | |
| | Proj. avail. balance | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | | |
| On- | Net requirements | | | | | | | | 15 | | |
| hand | Planned order receipt | | | | | | | | 15 | | |
| 75 | Planner order release | | | | | 15 | | | | | |
| B | Gross requirements | | | | | | | | 45 | | |
| LT=1 | Scheduled receipts | | | | | | | | | | |
| | Proj. avail. balance | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | | |
| On- | Net requirements | | | | | | | | 20 | | |
| hand | Planned order receipt | | | | | | | | 20 | | |
| 25 | Planner order release | | | | | | | 20 | | | |
| C | Gross requirements | | | | | 45 | | 40 | | | |
| LT=2 | Scheduled receipts | | | | | | | | | | |
| | Proj. avail. balance | 10 | 10 | 10 | 10 | 10 | | | | | |
| On- | Net requirements | | | | | 35 | | 40 | | | |
| hand | Planned order receipt | | | | | 35 | | 40 | | | |
| 10 | Planner order release | | | | 35 | 40 | | | | | |
| D | Gross requirements | | | | | | | 100 | | | |
| LT=2 | Scheduled receipts | | | | | | | | | | |
| | Proj. avail. balance | 20 | 20 | 20 | 20 | 20 | 20 | 20 | | | |
| On- | Net requirements | | | | | | | 80 | | | |
| hand | Planned order receipt | | | | | | | 80 | | | |
| 20 | Planner order release | | | | | 80 | | | | | |

X
LT=2

A(2)

It takes 2 A's for each X

# MATERIAL REQUIREMENT PLANNING (MRP) EXAMPLE



| Item | | Day: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X | | Gross requirements | | | | | | | | | | 95 |
| LT=2 | | Scheduled receipts | | | | | | | | | | |
| | | Proj. avail. balance | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| On- | | Net requirements | | | | | | | | | | 45 |
| hand | | Planned order receipt | | | | | | | | | | 45 |
| 50 | | Planner order release | | | | | | | | 45 | | |
| A | | Gross requirements | | | | | | | | 90 | | |
| LT=3 | | Scheduled receipts | | | | | | | | | | |
| | | Proj. avail. balance | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | | |
| On- | | Net requirements | | | | | | | | 15 | | |
| hand | | Planned order receipt | | | | | | | | 15 | | |
| 75 | | Planner order release | | | | | 15 | | | | | |
| B | | Gross requirements | | | | | | | | 45 | | |
| LT=1 | | Scheduled receipts | | | | | | | | | | |
| | | Proj. avail. balance | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | | |
| On- | | Net requirements | | | | | | | | 20 | | |
| hand | | Planned order receipt | | | | | | | | 20 | | |
| 25 | | Planner order release | | | | | | | 20 | | | |
| C | | Gross requirements | | | | | 45 | | 40 | | | |
| LT=2 | | Scheduled receipts | | | | | | | | | | |
| | | Proj. avail. balance | 10 | 10 | 10 | 10 | 10 | | | | | |
| On- | | Net requirements | | | | | 35 | | 40 | | | |
| hand | | Planned order receipt | | | | | 35 | | 40 | | | |
| 10 | | Planner order release | | | | 35 | 40 | | | | | |
| D | | Gross requirements | | | | | | | 100 | | | |
| LT=2 | | Scheduled receipts | | | | | | | | | | |
| | | Proj. avail. balance | 20 | 20 | 20 | 20 | 20 | 20 | 20 | | | |
| On- | | Net requirements | | | | | | | 80 | | | |
| hand | | Planned order receipt | | | | | | | 80 | | | |
| 20 | | Planner order release | | | | | 80 | | | | | |

It takes 1 B for each X

# MATERIAL REQUIREMENT PLANNING (MRP) EXAMPLE

X
- A(2)
  - C(3)
- B(1)

It takes 3 C's for each A

| | | Day: 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| X | Gross requirements | | | | | | | | | | 95 |
| LT=2 | Scheduled receipts | | | | | | | | | | |
| | Proj. avail. balance | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| On- | Net requirements | | | | | | | | | | 45 |
| hand | Planned order receipt | | | | | | | | | | 45 |
| 50 | Planner order release | | | | | | | | 45 | | |
| A | Gross requirements | | | | | | | | 90 | | |
| LT=3 | Scheduled receipts | | | | | | | | | | |
| | Proj. avail. balance | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | | |
| On- | Net requirements | | | | | | | | 15 | | |
| hand | Planned order receipt | | | | | | | | 15 | | |
| 75 | Planner order release | | | | | 15 | | | | | |
| B | Gross requirements | | | | | | | | 45 | | |
| LT=1 | Scheduled receipts | | | | | | | | | | |
| | Proj. avail. balance | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | | |
| On- | Net requirements | | | | | | | | 20 | | |
| hand | Planned order receipt | | | | | | | | 20 | | |
| 25 | Planner order release | | | | | | | 20 | | | |
| C | Gross requirements | | | | | 45 | | 40 | | | |
| LT=2 | Scheduled receipts | | | | | | | | | | |
| | Proj. avail. balance | 10 | 10 | 10 | 10 | 10 | | | | | |
| On- | Net requirements | | | | | 35 | | 40 | | | |
| hand | Planned order receipt | | | | | 35 | | 40 | | | |
| 10 | Planner order release | | | 35 | | 40 | | | | | |
| D | Gross requirements | | | | | | | 100 | | | |
| LT=2 | Scheduled receipts | | | | | | | | | | |
| | Proj. avail. balance | 20 | 20 | 20 | 20 | 20 | 20 | 20 | | | |
| On- | Net requirements | | | | | | | 80 | | | |
| hand | Planned order receipt | | | | | | | 80 | | | |
| 20 | Planner order release | | | | | 80 | | | | | |

## MATERIAL REQUIREMENT PLANNING (MRP) EXAMPLE

Product structure tree:
- X (LT=2)
  - A(2) (LT=3)
    - C(3)
  - B(1)
    - C(2)

It takes 2 C's for each B

| | | Day: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X | Gross requirements | | | | | | | | | | | 95 |
| LT=2 | Scheduled receipts | | | | | | | | | | | |
| | Proj. avail. balance | | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| On- | Net requirements | | | | | | | | | | | 45 |
| hand | Planned order receipt | | | | | | | | | | | 45 |
| 50 | Planner order release | | | | | | | | | 45 | | |
| A | Gross requirements | | | | | | | | | 90 | | |
| LT=3 | Scheduled receipts | | | | | | | | | | | |
| | Proj. avail. balance | | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | | |
| On- | Net requirements | | | | | | | | | 15 | | |
| hand | Planned order receipt | | | | | | | | | 15 | | |
| 75 | Planner order release | | | | | | 15 | | | | | |
| B | Gross requirements | | | | | | | | | 45 | | |
| LT=1 | Scheduled receipts | | | | | | | | | | | |
| | Proj. avail. balance | | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | | |
| On- | Net requirements | | | | | | | | | 20 | | |
| hand | Planned order receipt | | | | | | | | | 20 | | |
| 25 | Planner order release | | | | | | | | 20 | | | |
| C | Gross requirements | | | | | | 45 | | 40 | | | |
| LT=2 | Scheduled receipts | | | | | | | | | | | |
| | Proj. avail. balance | | 10 | 10 | 10 | 10 | 10 | | | | | |
| On- | Net requirements | | | | | | 35 | | 40 | | | |
| hand | Planned order receipt | | | | | | 35 | | 40 | | | |
| 10 | Planner order release | | | | | 35 | 40 | | | | | |
| D | Gross requirements | | | | | | | | 100 | | | |
| LT=2 | Scheduled receipts | | | | | | | | | | | |
| | Proj. avail. balance | | 20 | 20 | 20 | 20 | 20 | 20 | 20 | | | |
| On- | Net requirements | | | | | | | | 80 | | | |
| hand | Planned order receipt | | | | | | | | 80 | | | |
| 20 | Planner order release | | | | | | 80 | | | | | |

## MATERIAL REQUIREMENT PLANNING (MRP) EXAMPLE

Tree diagram:
- X
  - A(2)
    - C(3)
  - B(1)
    - C(2)
    - D(5)

It takes 5 D's for each B

| Item | Row | Day: 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| X | Gross requirements | | | | | | | | | | 95 |
| LT=2 | Scheduled receipts | | | | | | | | | | |
| | Proj. avail. balance | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| On- | Net requirements | | | | | | | | | | 45 |
| hand | Planned order receipt | | | | | | | | | | 45 |
| 50 | Planner order release | | | | | | | | 45 | | |
| A | Gross requirements | | | | | | | | 90 | | |
| LT=3 | Scheduled receipts | | | | | | | | | | |
| | Proj. avail. balance | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | | |
| On- | Net requirements | | | | | | | | 15 | | |
| hand | Planned order receipt | | | | | | | | 15 | | |
| 75 | Planner order release | | | | | 15 | | | | | |
| B | Gross requirements | | | | | | | | 45 | | |
| LT=1 | Scheduled receipts | | | | | | | | | | |
| | Proj. avail. balance | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | | |
| On- | Net requirements | | | | | | | | 20 | | |
| hand | Planned order receipt | | | | | | | | 20 | | |
| 25 | Planner order release | | | | | | | 20 | | | |
| C | Gross requirements | | | | | 45 | | 40 | | | |
| LT=2 | Scheduled receipts | | | | | | | | | | |
| | Proj. avail. balance | 10 | 10 | 10 | 10 | 10 | | | | | |
| On- | Net requirements | | | | | 35 | | 40 | | | |
| hand | Planned order receipt | | | | | 35 | | 40 | | | |
| 10 | Planner order release | | | | 35 | 40 | | | | | |
| D | Gross requirements | | | | | | | 100 | | | |
| LT=2 | Scheduled receipts | | | | | | | | | | |
| | Proj. avail. balance | 20 | 20 | 20 | 20 | 20 | 20 | 20 | | | |
| On- | Net requirements | | | | | | | 80 | | | |
| hand | Planned order receipt | | | | | | | 80 | | | |
| 20 | Planner order release | | | | | 80 | | | | | |

## EXAMPLE

A popular dump truck needs 48k rubber wheels per year, according to a toy manufacturer. The company manufactures wheels at a rate of 800 per day. The toy trucks are built in a consistent manner throughout the year. The cost of transporting a wheel is $1 per year. The company is open 240 days a year. Identify the:

i.      Optimal run size

ii.     Minimum total amount cost for carrying and setup

iii.    Cycle time for optimum run size

iv.     Run time

## ANSWER

Given:-

D = 48,000 wheels per year

S = $45

H = $1 per wheel per year

p = 800 wheels per day

d = 48,000 wheels per 240 days or 200 wheels per day

(i)     $Q_p = \sqrt{\dfrac{2DS}{H} \cdot \dfrac{p}{p-d}} = \sqrt{\dfrac{2(48000)45}{1} \cdot \dfrac{800}{800-200}} = 2400$ wheels

(ii)    $TC_{min} = \dfrac{I_{max}}{2} \cdot H + \dfrac{D}{S} \cdot S$   so we first must find $I_{max}$

The maximum inventory level $= \dfrac{Q_p}{p} \cdot (p-d) = \dfrac{2400}{800} \cdot (800-200) = 1800$ wheels

So $TC_{min} = \dfrac{I_{max}}{2} \cdot H + \dfrac{D}{S} \cdot S = \dfrac{1800}{2}(1) + \dfrac{4800}{2400}(45) = \$1800$

(iii)   Cycle Time $= \dfrac{Q_p}{d} = \dfrac{2400}{200} = 12\ days$

(iv)    Run time $= \dfrac{Q_p}{p} = \dfrac{2400}{800} = 3\ days$

## EXERCISES

Q1 Every year, Ikhwan Mart need 1000 toasters. Each toaster will set you for RM78. The cost of ordering is RM100 per order. The carrying cost per unit is RM20. There is a 5-day lead time. The Ikhwan Mart is open every day of the year.

i.     Write the formula and calculate EOQ Model?

ii.    How many times per year does the store reorder?

iii.   What is the length of the order cycle?

iv.   What is the total annual cost if the EOQ quantity is ordered?


Q2. For the coming year, A Wira Holding Company expects to sell about 1000 goggles of a specific size and style. The cost of carrying a tyre is RM18.00 each year, while the cost of ordering a tyre is RM90.00. The distributor is open for business 288 days a year. Solve the following problem using the economic order quantity model (EOQ):

i.     Calculate the optimal order quantity

ii.    Calculate the number of orders per year

iii.   Calculate the length of the order cycle

iv.   Calculate the total cost.

**ANSWER**

Q1. i. $EOQ = \sqrt{\dfrac{2 \times D \times S}{H}} = \sqrt{\dfrac{2 \times 1000 \times 100}{20}} = \dfrac{Q}{2} \cdot H = 100 \; units$

ii. $Number\ of\ orders = \dfrac{D}{Q} = \dfrac{1000}{100} = 10 \; times$

iii. $Cycle\ Length = \dfrac{Q}{D} = \dfrac{100}{1000} = 0.1 \; per \; year = 0.1 \times 360 \dfrac{days}{year} = 36 \; days$

iv. $Total\ Annual\ Inventory\ Cost = \dfrac{Q}{2} \cdot H + \dfrac{D}{Q} \cdot S = \dfrac{100}{2} \times 20 + \dfrac{1000}{100} \times 100$

$$= MYR2000$$

Q2 i. $Q_o = \sqrt{\dfrac{2DS}{H}} = \sqrt{\dfrac{2(1000)(90)}{18}} = 100$

ii. $N = \dfrac{D}{Q} = \dfrac{1000}{100} = 10$

iii. $\dfrac{Q}{D} = \dfrac{100}{1000} = \dfrac{1}{10}$ of a year

$\dfrac{1}{10} \times 288 = 29$ workdays

iv. $TC = \dfrac{Q}{2}H + \dfrac{D}{Q}S$

$= \dfrac{100}{2}18 + \dfrac{1000}{100}90$

$= RM\,900 + RM\,900$

$= RM\,1800$

Terbitan

**POLITEKNIK**
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