Introduction to Industrial Engineering

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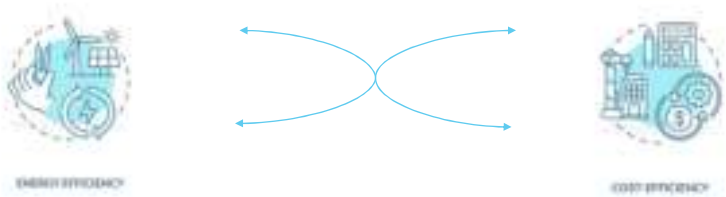
What is Industrial Engineering?

- According to American Institution of Industrial Engineering, Industrial Engineering is defined as:

  Engineering concerned with the design, improvement and installation of integrated systems of people, material, energy and equipment.

- The main objective of Industrial Engineering is maximum productivity, minimum wastage of resources, eliminating unproductive operations and increasing efficiency.
- So, it prioritizes balance between environment, economy, and the society.



More on Industrial Engineering

- Industrial engineering emerged as a profession as a result of the industrial revolution and the accompanying need for technically trained people who could plan, organize, and direct the operations of large complex systems.
- Since industrial engineering applies to all major fields, it is extremely diverse. An industrial engineer has a wide scope and can be employed from general retail establishments to manufacturing plants.
- As a result, they are more widely distributed than other engineers.

Role of an Industrial Engineer

- An industrial engineer is supposed to observe, analyze production methods and such, make conclusions and seek out various options for improvement.
- They decide on how to optimally use all the existing constraints (like resources etc.) to achieve the desired outcome.
- These points imply that an industrial engineer has to conduct meetings with higher-ups, make continuous supervisions on workflow and pay keen attention.

Role of an Industrial Engineer

- The most challenging aspect of being an industrial engineer is to achieve and maintain an effective communication, especially when dealing with executives as it is not an easy task to dissuade them from moving up against conventional methods of work and persuade to take an unorthodox approach.
- So a few key traits of a good industrial engineer are their deductive skills and their ability to convey and convince, that is charisma. These traits help identify and rectify problems very quickly.

Responsibilities of an Industrial Engineer

- Reviewing production schedules, processes, specifications, and related information.
- Designing production processes that maximize efficiency and reduce waste.
- Developing and implementing process improvements and technological upgrades.
- Designing control systems to minimize costs and production issues.
- Developing design and production standards in cooperation with management and user personnel.
- Preparing material and equipment lists, purchase orders, cost analyses, and estimated production costs.
- Designing the layout of facilities and determining personnel requirements.
- Training staff for new processes and providing instructions and manuals.
- Managing process documentation and preparing production reports.

History of the Concept of Industrial Engineering

- The Industrial Revolution:

  The emergence of Industrial Engineering as a profession rose thanks to the industrial revolution, which took place in the 18th century.

  The major aspect of the industrial revolution is technological advancement. Hand crafted operations were replaced by power tools and machines boosting productivity.

  New energy sources were developed to power the new machinery: water, steam, electricity, oil (gas, kerosene).

  So many small enterprises flourished thanks to these developments.

- This is the very basis of industrial engineering.

History of the Concept of Industrial Engineering

- Charles Babbage:

  An English mathematician, he visited factories in England and the US and began to systematically analyze the operations in the early 1800s.

  He then proceeded to tabulate his findings and stated that it is best to provide skill-intensive tasks **only** to highly skilled workers and those that don't to the lesser skilled and children.

  Simply put:
  Division of labor= right person for the right job

  This way cost can be optimized.

History of the Concept of Industrial Engineering

- Frederick W Taylor:

  A mechanical engineer, known to be the *father of scientific management* is credited for recognising improvements in methods of executing a job.

  He figured that simpler, more efficient measures exist for executing even the most simplest tasks. For instance, for shoveling operations, he proved that it is better to use a *comfortable* design than using the largest one. When his plan was implemented, he reduced the manpower by over 25%.

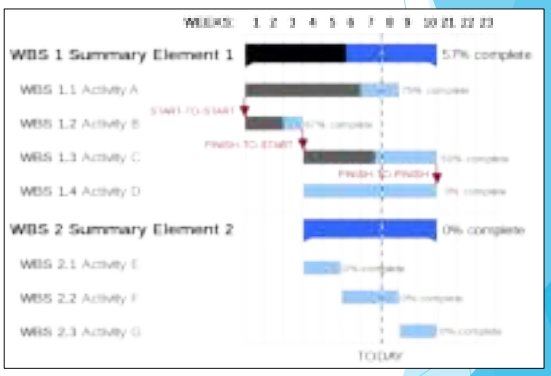
  His work was followed by Frank B Gilbert.

History of the Concept of Industrial Engineering

- Henry Gantt:

  Also a mechanical engineer, he developed the Gantt chart that was used to graphically convey procedures, scheduling progress etc.

  It is basically a project management tool designed to simplify complex projects and workflow.

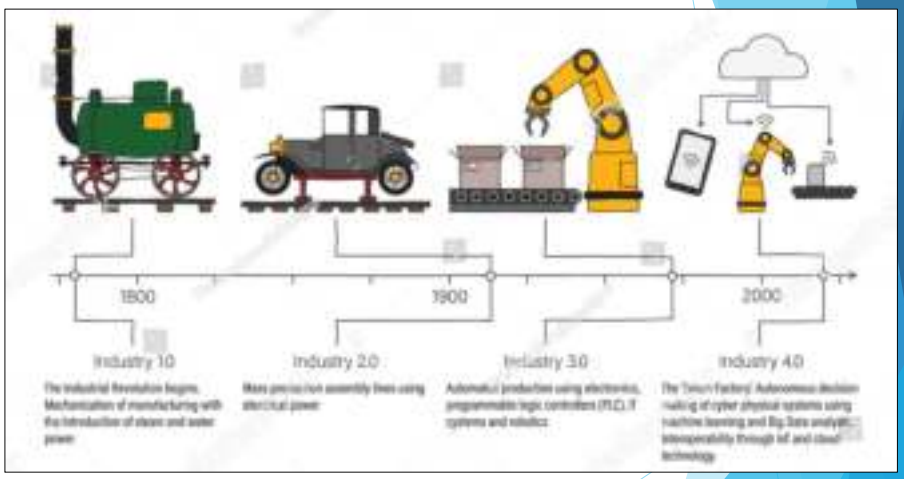


Gantt Chart

Few illustrations of the timelines of Industrial Engineering:

1764	James Watt	Steam Engine
1790	Eli Whitney	Cotton gin/Interchangeable parts
1810	Henry Maudsley	Accuracy in machine tools
1812	Faraday/Henry	Dynamo, motor
1835	Samuel Colt	Assembly Line
1876	Nikolaus Otto	Internal combustion
1876	Thomas Edison	Electric illumination
1924	Walter Schewhart	Quality control charts
1924	Henry Ford	Low cost mass production
1960's	John White	Materials Handling Handbook
1960's		Storage and retrieval of information
1960's		High-speed, stored program digital computer
1960	Alan Pritsker	Simulation modeling
1960	Joseph Orlicky	Material Requirement Planning (MRP)
1961	General Motors	Robot arm first used for welding on factory floor
1970	Toyota	50% defect reduction from quality control
1973	Toyota	Just-in-time production
1979	The PC	CIM integrated with CAD/CAM
1991		55 countries adopt ISO 9000 standards

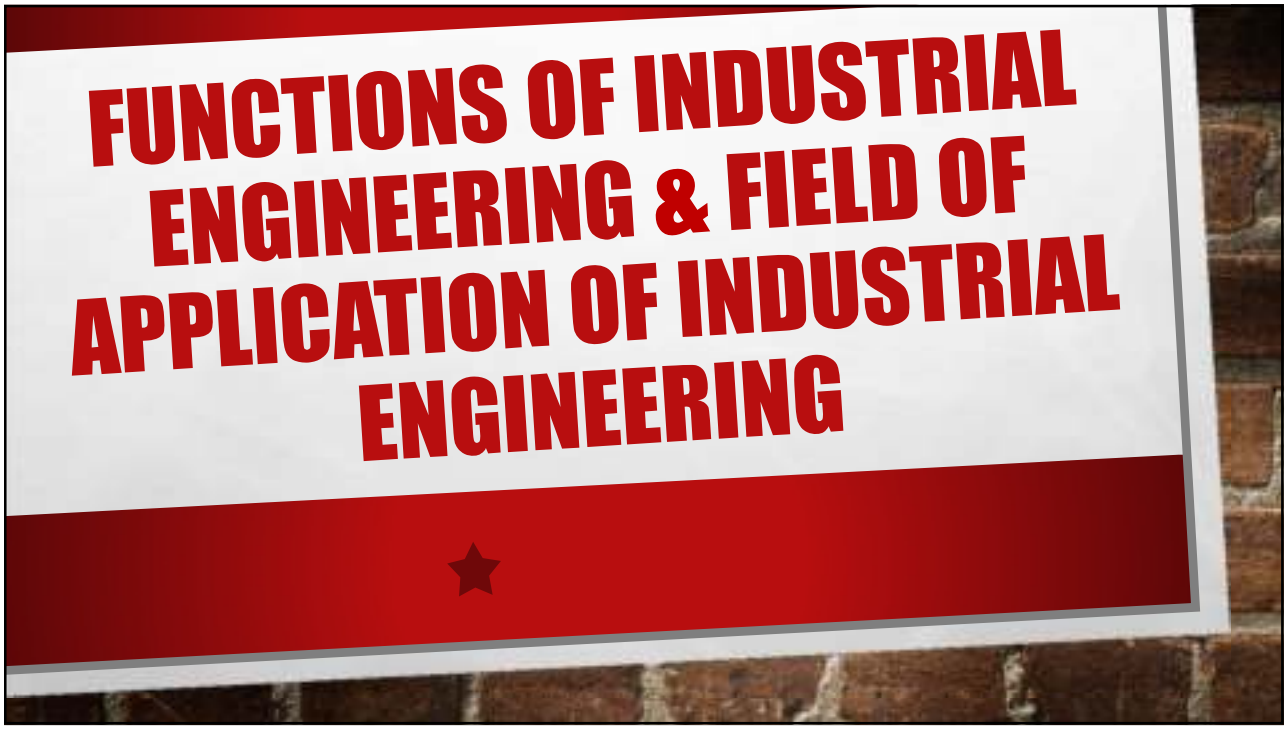
Few illustrations of the timelines of Industrial Engineering:



I	Introduction to Industrial Engineering - Evolution of modern Concepts in Industrial Engineering - Functions of Industrial Engineering - Field of application of Industrial Engineering Product Development and research- Design function - Objectives of design, - Manufacturing vs purchase- Economic aspects- C-V-P analysis – simple problems-Development of designs- prototype, production and testing - Human factors in design- Value Engineering .
II	Plant layout and Material handling- principles of material handling. Types of material handling equipments, Selection and application. Preventive and break- down maintenance - Replacement policy-- Methods of replacement analysis-Method of providing for depreciation- Determination of economic life - Simple problems.
III	Methods engineering: Analysis of work methods using different types of process chart and flow diagrams- Critical examination- Micro motion study and therbligs- Principles of motion economy – Work measurement-Performance rating-Determination of allowances and standard time. - Job evaluation and merit rating – Objectives and principles of job evaluation--Wages and Incentives- Primary wage systems- Wage incentive plans.
IV	Industrial relations- Psychological attitudes to work and working conditions - fatigue- Methods of eliminating fatigue- Effect of Communication in Industry-Industrial safety-personal protective devices-, causes and effects of industrial disputes- Collective bargaining- Trade union - Workers participation in management
V	Production planning and control- Importance of planning - job, batch and mass production-Introduction and need for a new product- product life cycle. - Functions of production control - Routing , Scheduling, dispatching and follow up- Gantt charts. Inventory Control, Inventory models -Determination of EOQ and reorder level- simple problems-- Selective inventory control techniques.
VI	Quality control and inspection- Destructive and non-destructive testing methods- process capability- Statistical quality control – causes of variation in quality- control charts for X and R. Reliability- causes of failures- Bath tub curve.-System reliability- life testing- Introduction to concepts of. TQM. ISO. Six Sigma and Quality circles (Brief description only).

Thank You

FUNCTIONS OF INDUSTRIAL ENGINEERING & FIELD OF APPLICATION OF INDUSTRIAL ENGINEERING



FUNCTIONS OF INDUSTRIAL ENGINEERING

1. Selection of processes and assembling methods

- To develop simplest work methods and establishing one best way for doing the assigned work.
- Process selection refers to deciding on the way production of goods or services will be organized.
- Process Selection affects the entire organization and its ability to achieve its mission, and affects the organization's supply chain.
- Assembling methods are the technique used to assemble a manufactured product, such as hand assembly, progressive line assembly, and automatic assembly.

2. Selection and design of tools and equipment

- To design and select suitable tool and equipment.
- This will help in decreasing the production cost and time.
- The equipment selection process is considered in the early stage of the design process since the equipment selection process decides the quality, cost, and reliability, which are important for customer satisfaction.
- The selection of equipment for a particular type of process can also provide competitive advantage. This advantage may result in added flexibility in meeting customer requirements, lower cost or higher quality.

3. Design of facilities

- Design of facilities including plant location, layout of buildings, machines and equipment material handling system, raw materials and finished goods storage facilities.
- Facilities Planning involves the determination of how the manufacturing facility best supports production.
- Facility layout is an arrangement of different aspects of manufacturing in an appropriate manner as to achieve desired production results.
- Facility layout considers available space, final product, safety of users and facility and convenience of operations.

4. Design and improvement of planning and control systems

- Industrial Engineering is concerned with the design, improvement, and installation of integrated systems of people, material and equipment.
- It draws upon specialized knowledge and skills in mathematics, physical and social science together with the principles and methods of engineering analysis and design.

5. Developing a cost control system

- Cost control improve efficiency of system and reducing cost by reducing waste products formed.
- Developing a cost control system such as budgetary control, cost analysis.
- Objective of cost control is to ensure that cost do not exceed beyond a certain pre decided level.
- Cost analysis by replacement of depreciation leading to cost reduction.

6. Development of time standards, costing, and performance standards

- To establish a standard time for a job or operation. This technique is referred to as Time study or work measurement.
- the standard time is the time required by an average skilled operator, working at a normal pace, to perform a specified task using a prescribed method.
- The standard cost is an expected amount paid for materials costs or labor rates.

7. Development and installation of job evaluation systems.

- To assist and aid in preparing a detailed job profile and thereafter a suitable job evaluation system by setting targets, scheduling and sequencing.

8. Installation of wage incentive schemes

- To develop a sound wage and incentive scheme so as to increase effective motivation to work effectively and efficiently.
- A wage incentive scheme is described as "a method of payment for work of an acceptable quality produced over and above a specified quantity or standard".
- In general, a wage incentive plan is designed to induce workers to increase their production rates by providing an incentive, in the form of higher wages, for increases in output.

9. Design and installation of value engineering and analysis system

- To design and adapt to value engineering which describes a value study on a product or project .
- Value engineering promotes the substitution of materials and methods with less expensive alternatives, without sacrificing functionality.
- It is focused solely on the functions of various components and materials, rather than their physical attributes. Value engineering is also called value analysis.

10. Operation research including mathematical and statistical analysis

- To apply Operation research techniques like mathematical analysis and statistical methods of forecast as nothing is static in business.
- Operations Research is an applied science that is concerned with quantitative decision problems that generally involve the allocation and control of limited resources.
- Engineer research is critical to an organization's productivity and competitiveness.
- Operations Research is the branch of applied mathematics concerned with applying analytical methods to help make better management decisions

11. Study the project feasibility

- A feasibility study is an analysis that considers all of a project's relevant factors - including economic, technical, legal, and scheduling considerations- to ascertain the likelihood of completing the project successfully.
- This will also lead to revision of production system with respect to the changing environment.
- Feasibility study is conducted in a stage prior to design, procurement and construction stages in order to determine the viability of project.
- This helps to decide whether to proceed with the project or not.

12. Performance evaluation

- To develop proper criteria of measuring output and to analyse performance of organization and individuals so as to achieve standardization of work.
- It is defined as a formal and productive procedure to measure an employee's work and results based on their job responsibilities.
- The goal of this entire process of performance evaluation is to improve the way a team or an organization functions, to achieve higher levels of customer satisfaction.

FIELD OF APPLICATION OF INDUSTRIAL ENGINEERING

- **The main aim of industrial engineering is to improve the productivity of organization by optimum utilization of organization's men,materials and machines.**

1. Top Management

- It assist management in designing strategic long range plans for decision
- It achieves this through the development of mathematical and stastistical models and use of computers.

2. Process and work design

- It aids in conducting research of all operating problems for improving productivity of the system.
- It also
  - increase production
  - minimise cost
  - improve quality
  - maximise profit

3. Technical areas

- It works with technical groups to ensure that instrumentation, system design human engineering and work analysis concepts are followed in factories and machinery design.

4. Marketing Analysis

- It provides assistance in the analysis of complex marketing systems and pricing.
- It facilitates the use of stastistics and computer to develop alternative course of action and their evaluation.

5. Finance

- It helps to design improved financial information flow system which can work in conjunction with programmed computers.
- Thus the system can be developed which can be used to control materials, labour and other expenses.

6. Production and quality assurance

- It aids to provide assistance to achieve maximum utilization of equipment, materials and labour to achieve optimum performance and high quality standards.

7.Production planning and control

- Production planning and control is defined as a work process which seeks to allocate human resources, raw materials, and equipment/machines in a way that optimizes efficiency.
- It involves taking a long-term view at overall production planning.
- Production planning takes care of two basic strategies - product planning and process planning. Production planning is done at three different time dependent levels:-

➢ ***long-range planning*** dealing with facility planning, capital investment, location planning.

➢ ***Medium-range planning*** deals with demand forecast and capacity planning

➢ ***Short term planning*** dealing with day to day operations.

- Production control looks to utilize different type of control techniques to achieve optimum performance out of the production system as to achieve overall production planning target.


THANK YOU

MANUFACTURING VS PURCHASE

C-V-P ANALYSIS

simple problems.

MANUFACTURING VS PURCHASE

Manufacturing vs purchase

- One of the key strategic issue in manufacturing is the decision regarding what to make and what to buy
- The make or buy decision is the act of making a strategic choice between producing an item internally or buying it externally.
- Companies rarely make their own products/services from start to end
- Make or buy analysis is conducted at strategic and operational level
- Government regulations, competing firms and market trends have a strategic impact on the make or buy decision
- Two most important factors to consider in a make or buy decision are cost and availability of production capacity.

REASONS FOR MANUFATURING

- The quantities are too small and/or no supplier is interested or available in providing the goods.
- Quality requirements may be so exacting or so unusual as to require special processing methods that suppliers cannot be expected to provide.
- There is greater assurance of supply.
- It is necessary to preserve technological secrets.
- It helps the organization obtain a lower cost as the purchase option is too expensive.
- It allows the organization to take advantage of or avoid idle equipment and/or labour.
- It ensures steady running of the corporation's own facilities, leaving suppliers to bear the burden of fluctuations in demand.

REASONS FOR MANUFATURING

- It avoids sole-source dependency.
- Competitive, political, social or environmental reasons may force an organization to make even when it might have preferred to buy.
- The distance from the closest available supplier is too great.
- A significant customer required it.
- Future market potential for the product or service is expanding rapidly and forecasts show future shortages in the market or rising prices.
- Management takes pride in size.

REASONS FOR PURCHASING

- The organization may lack managerial or technical expertise in the production of the items or services in question.
- The organization lacks production capacity.
- Certain suppliers have built such a reputation for themselves that they have been able to build a real preference for their component as part of the finished product.
- The challenges of maintaining long-term technological and economic viability for a noncore activity are too great.
- A decision to make, once made, is often difficult to reverse.
- It assures cost accuracy.

REASONS FOR PURCHASING

- There may not be sufficient volume to justify in-house production.
- Future forecasts show great demand or technological uncertainty and the firm is unable or unwilling to undertake the risk of manufacture.
- A highly capable supplier is available nearby.
- The organization desires to stay lean.
- Buying outside may open up markets for the firm's products or services.
- It provides the organization with the ability to b ring a product or service to market faster.
- A significant customer may demand it.
- It encourages superior supply management expertise

CONSIDERATIONS FAVOURING MANUFACTURING

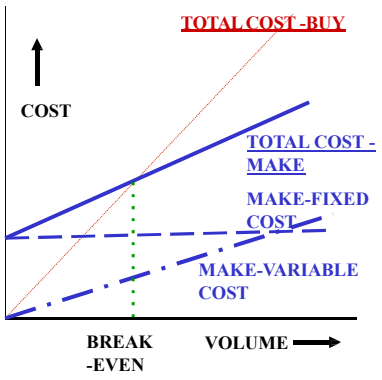
- Cost considerations (less expensive to make the part)
- Desire to integrate plant operations.
- Productive use of excess plant capacity to help absorb fixed overhead.
- Need to exert direct control over production and/or quality.
- Design secrecy required.
- Unreliable suppliers.
- Desire to maintain a stable work force (in periods of declining sales).

CONSIDERATONS WHICH FAVOUR PURCHASING

- Limited production facilities
- Cost considerations (less expensive to buy the part)
- Small volume requirements
- Suppliers' research and specialized know-how.
- Desire to maintain a stable work force (in periods of rising sales).
- Desire to maintain a multiple source policy.
- Indirect managerial control considerations.
- Procurement and inventory considerations.

MAKE OR BUY Choice

- **BREAK EVEN ANALYSIS**



Make or Buy

- Fixed cost = FC
- Variable cost = C
- Quantity = Q
- Total cost = FC + Q*C
- Decision to make or Buy is based on break even point

Make or Buy-Cost factors

Make :

1. Operating expenses :
   - Direct Labour
   - Direct material
   - Inbound freight
2. Facilities
3. Depreciation
4. Overhead
5. Direct management cost
6. Cost of Inventories
7. Working capital cost

BUY :

1. Purchase cost
2. Inbound Freight
3. Space
4. Administrative cost to manage supplies
5. Working capital cost
6. Inventories cost

Decision based on savings after taxes

COST FACTOR

Cost considerations indicate that a part should be made in-house; in others, they dictate that it should be purchased externally.

A make-or-buy cost analysis involves a determination of the cost to make an item – and a comparison of this cost with the cost to buy it.

To Make

- Delivered purchased material costs.
- Direct labour costs.
- Any follow-on costs stemming from quality and related problems.
- Incremental inventory carrying costs.
- Incremental factory overhead costs.
- Incremental managerial costs.
- Incremental purchasing costs.
- Incremental costs of capital.

To Buy

- Purchase price of the part.
- Transportation costs.
- Receiving and inspection costs.

Example 2.3. A manufacturer of motor cycles buys side box at ₹ 240 each. In case he makes it himself, the fixed and variable costs would be ₹ 300,000 and ₹ 90 per side box, respectively. Should the manufacturer make or buy the side box if there is a demand for 2500 side boxes?

Selling price/unit (SP) = ₹ 240
Variable cost/unit (VC) = ₹ 90
Fixed cost (FC) = ₹ 300,000

$$\text{B.E.P.} = \frac{300{,}000}{240 - 90} = 2000 \text{ units}$$

Since the demand (2500 units) is more than the break even point, the company can manufacture the side boxes.

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Example 2.4. There are three alternatives available to meet the demand of a particular product. They are as follows:

1. Making the product using process *A*.
2. Making the product using process *B*.
3. Buying the product.

The details are as follows:

Cost Elements	Making using Process *A*	Making using Process *B*	Buy
Fixed cost/year (₹)	100,000	300,000	—
Variable cost/unit (₹)	75	70	—
Purchase price/unit (₹)	—	—	80

The annual demand for the product is 10,000 units.

(a) Should the company make the product using process *A* or process *B*, or buy it?

(b) At what annual volume should the company switch from buying to making using process *A*?

(c) At what annual volume should the company switch from process *A* to *B*?

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Solution. (a) Compute the annual cost for each alternative.

$$\begin{aligned}
\text{Annual cost of process } A &= \text{FC} + \text{VC} \times \text{Volume} \\
&= 100{,}000 + 75 \times 10{,}000 \\
&= ₹\ 850{,}000 \\
\text{Annual cost of process } B &= \text{FC} + \text{VC} \times \text{Volume} \\
&= 300{,}000 + 70 \times 10{,}000 \\
&= ₹\ 1{,}000{,}000 \\
\text{Annual cost of buying} &= \text{Purchase price/unit} \times \text{Volume} \\
&= 80 \times 10{,}000 \\
&= ₹\ 800{,}000
\end{aligned}$$

Since, the annual cost of buy option is minimum among all the alternative costs, the company should buy the product.

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(b) Let Q be the volume at which the company switches from buying to making. using process A.

Hence, total annual cost of process $A \leq$ Total annual cost of buying

$$100{,}000 + Q \times 75 \leq Q \times 80$$

$$100{,}000 \leq 5\,Q$$

$$5\,Q \geq 100{,}000$$

$$Q \geq 20{,}000 \text{ units}$$

Thus, if the volume of production is more than 20,000 units the company should switch from buying to making option using process A.

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(c) Let Q be the volume at which the shift from making using process A to making using process B is preferable.

$$TC_A \geq TC_B$$

$$100{,}000 + 75\,Q \geq 300{,}000 + 70\,Q$$

$$5\,Q \geq 200{,}000$$

$$Q \geq 40{,}000 \text{ units}$$

Thus, if the production volume is more than 40,000 units, the company can shift from process A to process B.

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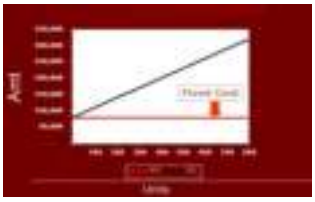
Cost-volume-profit (C-V-P) Analysis

C-V-P (Cost-volume-profit) Analysis

- CVP analysis is the analysis of three variable viz. Cost,volume, profit
- Such analysis explores the relationship existing amongst costs ,revenue, activity level and resulting profit
- It aims at measuring variations of cost with profit
  1.Fixed cost
  2.Variable cost
  3.Semi-variable cost

COST

- FIXED COST: Eg.Rent, Insurance
- VARIABLE COST: Eg.Labour cost, material cost



Objectives of CVP analysis

- Understand the interaction among :
  1. Prices of products
  2. Volume or level of activity
  3. Per unit variable cost
  4. Total fixed cost
  5. Mix of product sold

ASSUMPTIONS IN CVP ANALYSIS

CVP assumes the following:

- Constant sales price;
- Constant variable cost per unit;
- Constant total fixed cost;
- Units sold equal units produced.

These are simplifying, largely linearizing assumptions, which are often implicitly assumed in elementary discussions of costs and profits. In more advanced treatments and practice, costs and revenue are nonlinear and the analysis is more complicated, but the intuition afforded by linear CVP remains basic and useful.

Assumptions of CVP analysis

- Expenses can be classified as either variable or fixed
- CVP relationship are linear over a wide range of production and sales
- Sales price, unit variable cost and total fixed expenses will not vary within the relevant range
- Volume is the only cost driver
- It is used for predicting how the changes in cost and sales volume affect profit. It is also known as break even analysis

CVP ANALYSIS

- Total costs = fixed costs + (unit variable cost × number of units)

$$TC = TFC + V \times X$$

- Total revenue = sales price × number of unit

$$TR = S \times X$$

$$\begin{aligned} TR &= S \times X \\ &= ((S - V) + V) \times X \\ &= (C + V) \times X \\ &= C \times X + V \times X \end{aligned}$$

where

- C = Unit Contribution (Margin)

CVP ANALYSIS

- Profit is computed as TR-TC; it is a profit if positive, a loss if negative.

$$\begin{aligned} P &= TR - TC \\ &= (C + V) \times X - (TFC + V \times X) \\ &= C \times X - TFC \end{aligned}$$

$$\text{QUANTITY, } X = \frac{P + TFC}{C} = \frac{P + TFC}{S - V}$$

Example:

Suppose that Super Bikes wants to produce a new mountain bike called Hero1 and has forecast the following information.

- Price per bike = Rs 800
- Variable cost per bike = Rs 300
- Fixed costs related to bike production = Rs 55,00,000
- Target profit = Rs 2,00,000

Targeted Profit=Total Revenue-Total Cost

Find Total cost & Total Revenue

We determine the quantity of bikes needed for the target profit as follows:

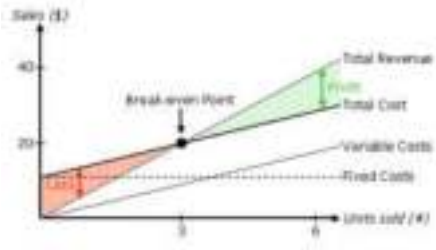
Ans: Quantity = (55,00,000 + 2,00,000) / (800 - 300) = 11,400 bikes

BEP analysis

- Breakeven analysis is used to find the minimum level of production required
- Evaluates both fixed and variable costs
- A CVP analysis can be used to determine the BEP, or level of operating activity at which revenues cover all fixed and variable costs, resulting in zero profit.

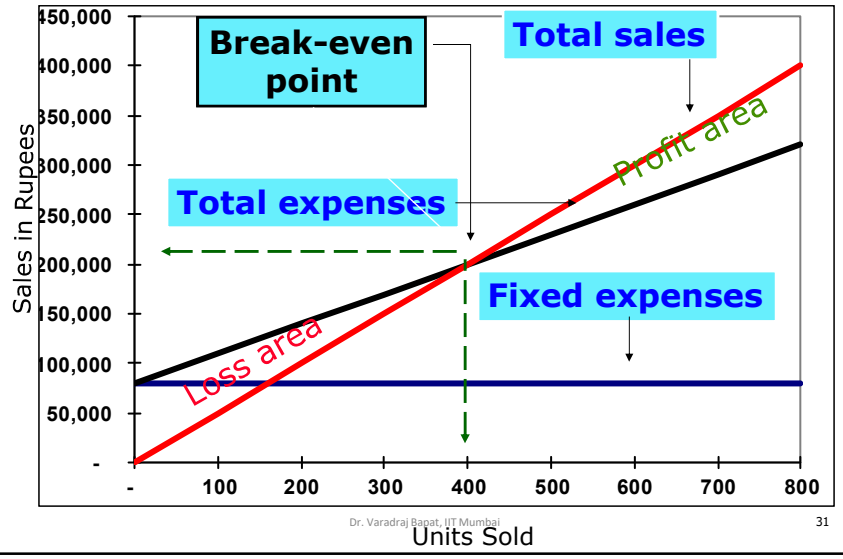
- Uses:
  1. To find a suitable product mix
  2. To find the sales required to reach a desired revenue.
  3. The profits at certain price level and sales

COST VOLUME PROFIT GRAPH



- The **break-even point** can be defined as a point where total costs (expenses) and total sales (revenue) are equal.
- Break-even point can be described as a point where there is no net profit or loss.
- Graphically, it is the point where the total cost and the total revenue curves meet

Cost-Volume-Profit Graph



BREAK EVEN POINT

- Break-even point is the number of units (N) produced which make zero profit.
- Total sales – Total costs = 0
- Total costs = Variable costs * X + Fixed costs
- Total selling price = Selling price per unit * X
- Selling price per unit * X – (Variable costs * X + Fixed costs) = 0
- So, break-even point (X) is equal
- X = Fixed costs / (Selling price per unit - Variable costs)
- Ie BREAK EVEN QUANTITY = $\frac{F}{S-V}$

P-V RATIO (PROFIT VOLUME RATIO)

- CONTRIBUTION MARGIN RATIO (CMR RATIO)
- It's the percentage by which Selling Price per unit exceeds the variable cost per unit.
- ie PV RATIO= $\frac{total\ selling\ price - total\ variable\ cost}{total\ selling\ price} \times 100\%$

$= \frac{S-V}{S} \times 100\% = {}^{C}/_{S} \times 100\%$

Profit Volume Ratio (PV)

The contribution margin ratio (CMR) i.e. PV ratio is the percentage by which the selling price (or revenue) per unit exceeds the variable cost per unit, or contribution margin as a percentage of revenue.

- The contribution margin ratio is the difference between a company's sales and variable costs, expressed as a percentage. This ratio shows the amount of money available to cover fixed costs.
- It is good to have a high contribution margin ratio, as the higher the ratio, the more money per product sold is available to cover all the other expenses.

Example

For Hero1 determine the contribution margin ratio, If forecasted information about volume =12,000 bikes.

- Total revenue = `800 * 12,000 = ` 96,00,000
  - Total variable cost
    = ` 300* 12,000 = ` 36,00,000
  - Total contribution margin = `9,600,000 - ` 3,600,000 = `6,000,000
  - Contribution margin ratio = `6,000,000 / `9,600,000 =0.625

or (800-300)/800

Break even Applications

- **New Product decisions :-** Enables to determine the sale volume required for a firm (or an individual product) to breakeven , given expected sales price and expected costs.
- **Pricing decisions:-** Enables to study the effect of changing price and volume relationship on total profits.
- **Modernizations or automation decisions:-** Analysis the profit in implication of a modernization or automation programme.
- **Expansion Decisions :-** studies the aggregate effect of a general expansion in production and sales.

CVP analysis could be helpful in the following situations

- Budget planning: for forecasting profit by considering cost and profit relation and volume of production .This will help in determining the sales volume required to make profit
- To make decision regarding pricing and sales volume
- Preparing flexibility budget considering costs at different levels of production

$$\text{BEP in sales value} = \frac{\text{Fixed cost}}{\text{PV Ratio}}$$

Example

- Sales 5000 units
- Sales price per unit Rs. 50
- Variable cost per unit Rs. 30
- Fixed cost Rs. 35000
- Therefore, contribution per unit = 50-30 =Rs. 20

BEP in units = 35000/20 = 1750 units

- BEP in sales value = 35000 /(250000 / 100000)
  = Rs. 87500
  Or
  1750 * 50 = Rs. 87500

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Margin of safety

- Represents the strength of the business
- Margin of Safety= Actual Sale – BEP Sale
- Margin of safety% = (Sales - BEP)/Sales x 100

- Margin of safety = $\frac{(5000-1750)}{5000}$

  =65%

- Hence even if the sales decrease by 65%, the business wont face any loss

VALUE ANALYSIS

MODULE 2

VALUE ANALYSIS

- Value Analysis is **a planned, scientific approach to cost reduction which reviews the material composition of a product and production design** so that modifications and improvements can be made which do not reduce the value of the product to the customer or to the user.
- The value of a function is defined as the relationship of cost to performance

$$Value^{max} = \frac{Performance^{max}}{Cost^{min}}$$

VALUE ANALYSIS

- Value, as defined, is the ratio of function to cost.
- Value engineering is a systematic method to improve the "value" of goods or products and services by using an examination of function.
- It is an organisational creative approach for the purpose of identification of unnecessary cost.
- Unnecessary costs are that which provides neither quality , nor use , not appearance , not life and customer features.

VALUE ANALYSIS

- Value is the price we pay for a product, process, material, or service required to perform a specific function or service with the required quality and reliability.
- Value analysis is an organized approach to identify unnecessary costs associated with any product, material, part, component, system or service by analysis of function and efficiently eliminating them (i.e. unnecessary costs) without impairing the quality, functional reliability or its capacity to give service.
- Thus, it enables to produce the products with the same performance, quality and efficiency with a less overall unit cost and consequently greater profits.

- According to Society of American Value Engineers (SAVE) "Value analysis is the systematic application of recognised techniques which identify the function of a product or services establish a monetary value for the function and provide the necessary function reliability at that lowest overall cost."
- Mr. Lorry D. Miles production engineer working at General Electricals of USA defined it as "Value analysis is the study of the relationship of design, function and cost of any material or service with an object of reducing its cost through modification of design or material specifications, manufacture by more efficient process, changes in sources of supply, elimination or incorporation into another item."

VALUE ANALYSIS

- It includes

1. Cost cutting
2. Design Review
3. Project elimination
4. Scope reduction
5. Quality reduction
6. Detailed cost estimating
7. Redesign

VALUE ANALYSIS

- Value is always increased by decreasing costs while maintaining essential performance.
- Value may also be increased if the customer needs, wants , and is willing to pay for grater performance.
- Most people who design a product over design the product by providing it features that are not useful to the customer.
- This happens often because designer is not sure of the real needs of the user.

VALUE ANALYSIS V/S VALUE ENGINEERING

- Value Analysis is applied to the existing product with a view to improve its value. It is analysis after the fact and it is a remedial procedure.
- Value Engineering is applied to the product at the design stage and thus ensures prevention rather than elimination.

USES OF VALUE ENGINEERING :

- It is a cost prevention as well as cost elimination technique thus reducing cost of the product.
- Helps employees for better understanding of their jobs and orients them towards creative thinking.
- Balance the cost and performance.
- Prevents over design of components.
- Motivates employees to come out with creative ideas.
- Increases the profits and deflates costs.
- Helps to satisfy the customer with company's products.

WHEN DO WE APPLY VALUE ANALYSIS ?

- Company's products are losing in the market and there is a decline in sales.
- Company's products are priced higher than the competitors.
- New design of products being undertaken.
- Symptoms of disproportionate increase in cost of production.
- Decreasing profitability and return on investment (ROI).
- Company failing to meet its delivery commitment.

TYPES OF VALUE :

- **Cost value:** It is the cost of manufacturing a product or a component. It is the measure of sum of all costs incurred in producing the product. The cost value, therefore, is the sum of raw material cost, labour cost, tool cost and overheads expended to produce the product.
- **Use value:** It is the price paid by the buyer (customer's view) in order to ensure that the product performs its intended functions (i.e. renders the required services) efficiently. Item without use value can have neither exchange value nor esteem value.

- **Esteem value:** It is the measure of properties, features, attractiveness, qualities, fancy, packaging, etc., which increases sales appeal, or which attracts persons and creates in them a desire to possess the product. Esteem value, therefore, is the price paid by the customer or the cost incurred by the manufacturer beyond the use value.
- **Exchange value:** A product is said to possess exchange value if the same (because of its qualities, usefulness) can be exchanged for another product or money. In a conventional sense, exchange value refers to the price that a customer will offer for the product, the price being dependent upon the satisfaction (value) which he derives from the product.

VALUE ENGINEERING

Value engineering is often done by systematically following a multi-stage job plan. It has the following eight steps:

1. Preparation
2. Information
3. Analysis
4. Creation
5. Evaluation
6. Development
7. Presentation
8. Verification phase

STEPS IN VALUE ANALYSIS :

- **Preparation/*Orientation phase:*** This phase involves identification of the problems very clearly, selection of projects, formation of teams, laying down objectives and targets and in-depth training of all the team members.
- ***Information phase:*** After clearly identifying what is to be accomplished, all the relevant information like drawings and technical specifications, manufacturing processes, detailed cost break up, performance/ failure reports, quality and production problems etc. is gathered.
- ***Functional analysis phase:*** This phase involves analysis and identification of functions.
- **Creative phase:** All the possible alternatives are generated. This can be achieved by application of brain storming and other creativity techniques in order to generate a large number of ideas for providing the functional requirements.

- ***Evaluation phase:*** In this phase the possible alternatives developed are analysed. The cost of each idea is estimated. Critical evaluation of all points of the solution is carried out.
- ***Investigation/Development phase****:* In this phase short listed ideas are investigated in- depth to arrive at optimum and practical solution.
- ***Presentation phase:*** In this phase the selected alternative is presented to the decision maker for approval and implementation.
- ***Implementation phase:*** As a result of all the above phases a definite, specific and tangible solution acceptable to all is reached
- ***Follow up phase:*** This is the last stage which compares the results with original expectations and suggests corrective action in the approach for the next project.

PRODUCT DEVELOPMENT AND RESEARCH, DEVELOPMENT OF DESIGNS, PROTOTYPE, HUMAN FACTORS IN DESIGN

Research and Development

- In research and development, a company conceptualizes entirely new products.
- R&D team tests the viability of a potential product.
- Companies invest in research and development when their product lines become outdated or competitors come out with similar or superior products.
- Research and development is vital for the sustained growth and success of a company.

Product Development

- Product development is the entire process of researching, designing, creating, marketing, and selling new products.
- It is the entire product life cycle, from conception to sale.
- Existing products can also go through product development to revamp old features or add new features so the product sells better or adds greater value to consumers.

DEVELOPMENT OF DESIGNS

- Design is the most creative part of engineering or Technology.
- Engineers have a wide spectrum of design requirements.
- The design function plays the lead role in defining the physical form of the product to best meet customer needs. The design function also generates information relating to many other aspects of the product prior to Manufacture, post-manufacture, and after the products life has expired.

DEVELOPMENT OF DESIGNS

- It is essential to design a product before starting its manufacture
- Designing is very important before actual transformation of raw materials into finished products

Functions refers to the way a technical system works

- Primary Function-It is the basic operational outcome of the device
- Secondary Required functions-It supports primary functions
- Secondary Unwanted Functions-Undesirable byproduct (eg.Generate heat,generate noise)

Development of design

- It is the design and engineering work process normally based on basic engineering information to the development of detailed Design
- The design development defines and describes all important aspects of the project focusing on the selection of materials; development of technical specifications for detailed engineering and construction.
- During design development, design issues should be resolved to fix and describe the size and character of the entire project including civil and structural, mechanical and electrical systems as well as materials and such other operatibility and maintainability requirement

Objectives of design

- The objective of product design is to create goods or services with excellent functional utility and sales appeal at an acceptable cost and within a reasonable time

Requirements/Objectives Of A Good Product Design

- Satisfy the customer needs.
- Profitable
- Should provide all functional requirements.
- Reliable
- Quality

Requirements/Objectives Of A Good Product Design

- Environmental friendly
- Safety
- Easy to handle
- Availability of spare parts
- Aesthetics
- Easy to store

Requirements/Objectives Of A Good Product Design

- Easy to assemble
- Variety-options for the customer.
- Possibility of add-on features.
- Competitive price.
- Easy to manufacture

PROTOTYPE

- A **prototype** is an early sample, model, or release of a product built to test a concept or process or to act as a thing to be replicated or learned from.
- Visualise our product or idea.
- Mechanism to demonstrate functionality

PROTOTYPES ADVANTAGES

- MAKING IT REAL
- WORK ON A PROBLEM
- DETECT UNINTENDED SCENARIOS
- DETECT USABILITY PROBLEMS
- ITERATE

Prototyping

- A Prototype is an original model that serves as a basis for future models.
- It Consists of building a prototype of the product
- It is not just a model but a full fledged product made as per the design
- They are tested in the same operating environments in which they are expected to function as final products
- At times, prototyping is done for some parts of a design to check certain requirements.
- Prototyping is done using the materials specified so that their performance is also taken into account

Prototyping

- Need of a prototype:
  - Cost and time effective
  - Feedback is obtained quickly so that product issues are resolved earlier in time.
  - Better product is built after testing and modifications based on the results of testing

Prototyping

- The decision to build a prototype depends on a number of things, including:
  - The size and type of the design space
  - The costs of building a prototype
  - The ease of building that prototype
  - The role that a full-size prototype might play in ensuring the widespread acceptance of a new design
  - The number of copies of the final design that are expected to be made or built

Production

- When the prototype is designed, manufactured and tested successfully the next stage is product manufacturing
- The time limit for production and the quantities needed at different points of time are also decided
- The production manager must plan and control the process of production so that it moves smoothly at the required level of output while meeting cost and quality objectives
- The production level might need to be adjusted from time to time to address fluctuating demand or changes in a company's market share.
- When more than one product is involved, complex industrial engineering or operations research procedures are required to analyze the many factors that impinge on the problem

Production

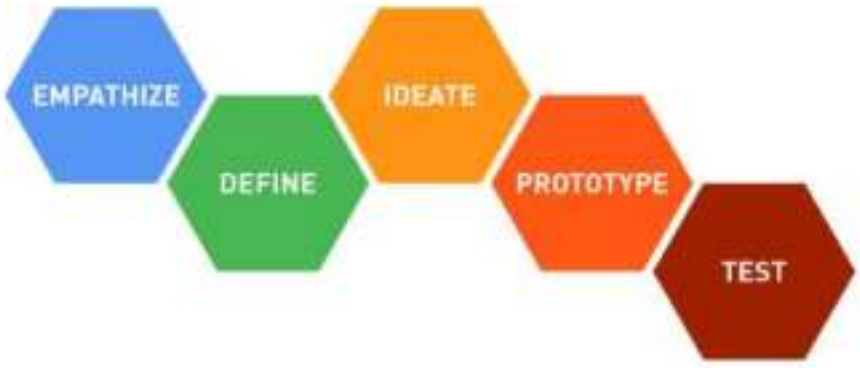
- Successful transformation of design into a saleable product is a challenge to the organization.
- This needs a close coordination of production and design department.
- The concept of DESIGN FOR PRODUCTION is the current trend

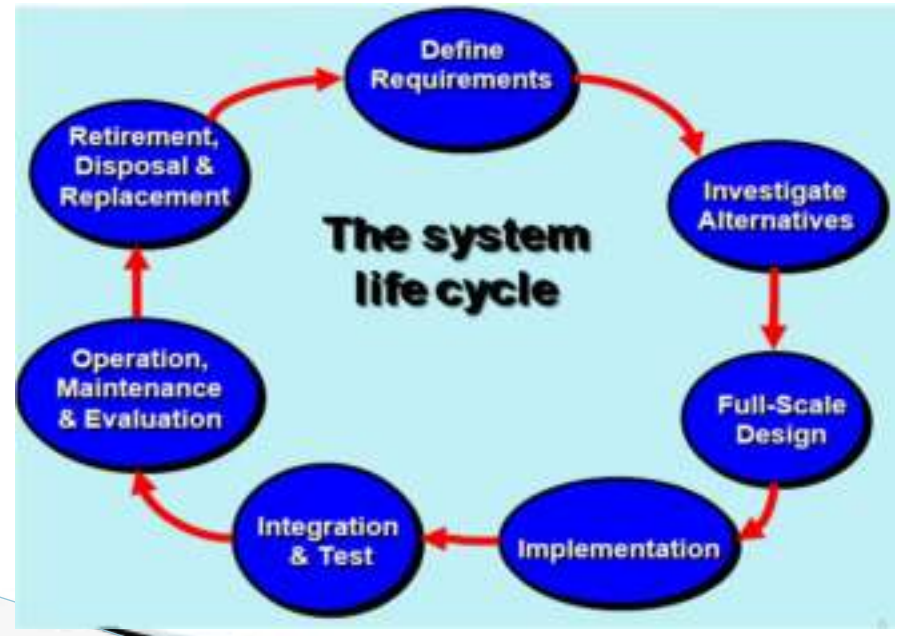
Testing and evaluation

- Before the product is introduced it is to be tested fully for all the designed function.
- Testing and evaluation ensures whether the product will work or does it require refinement.
- To identify potential faults
- Other requirements that are taken into account in the design are to be evaluated

Reasons For Testing And Evaluating The Prototype

- Testing and evaluation allows the Client or customer to view the prototype and give their opinions.
- Safety issues are identified by narrow testing and evaluation.
- The prototype can be tested against any relevant regulations and legislation.
- The prototype is evaluated in order to allow the production cost to be assessed and finalized.
- Component Failure is often identified during the testing process. This may mean that a component has to be redesigned and not the end product.





Steps in developing new products

- Technical and economical feasibility studies.
- Prototype design.
- Perfomance testing of prototype.
- Market sensing/evaluation and economic evaluation of prototype
- Design of production model.
- Market/perfomance/process testing and economic evaluation of production model.
- Continuous modification of production model.

KEY PRINCIPLES IN PRODUCT DESIGN

- Users should be involved in the design process. This should include different types of users including operatives, maintenance and systems support personnel.
- Consideration should be given to operator characteristics including body size, strength and mental capability.
- Plant and processes should be designed for operability and maintainability and other elements of the life cycle should not be neglected e.g. decommissioning.
- Consideration should be given to all foreseeable operating conditions including upsets and emergencies.
- Consideration should be given to the interface between the end user and the system

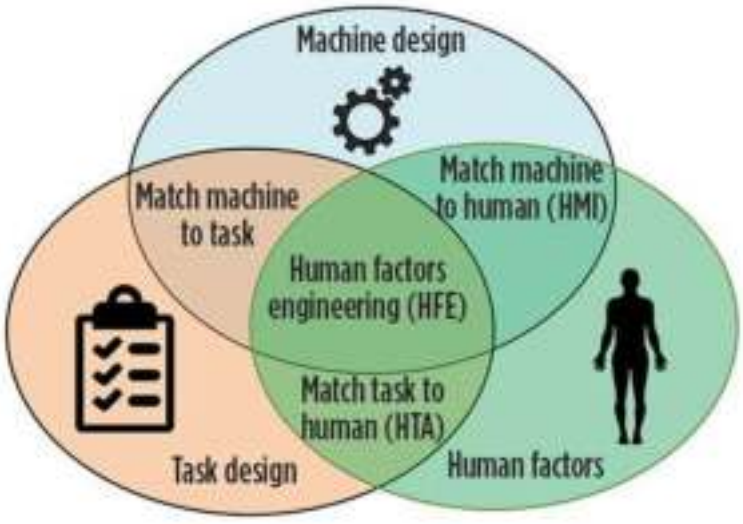
HUMAN FACTORS IN DESIGN

Human factors engineering (HFE) is a discipline concerned with the design of tools, machines, and systems that take into account human capabilities, limitations, and characteristics. The goals are to design for safe, comfortable, and effective human use.

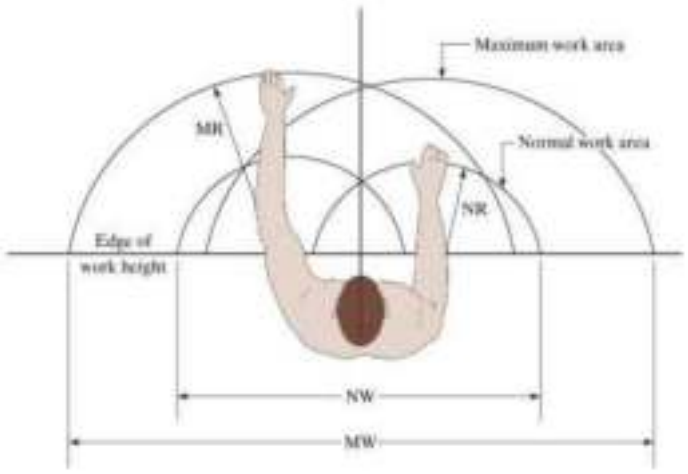
HUMAN FACTORS AND ERGONOMICS

Human factors and ergonomics (commonly referred to as **human factors**) is the application of psychological and physiological principles to the (engineering and) design of products, processes, and systems.

The goal of human factors is to reduce human error, increase productivity, and enhance safety and comfort with a specific focus on the interaction between the human and the thing of interest



PRINCIPLES OF MOTION ECONOMY



PLANT LAYOUT

PLANT LAYOUT

Plant layout is defined as the physical arrangement of men, material, machine and method to achieve best efficiency and minimized the overall cost.

Plant layout is **the arrangement of machines, work areas and service areas within a factory**.

Plant layout involves the development of physical relationship among building, equipment and production operations, which will enable the manufacturing process to be carried on efficiently.

FACTORS AFFECTING PLANT LAYOUT PLANNING

Material

Labour

Material Handling

Waiting time

Types of machines

Objectives/Advantages of Plant Layout

(i) Streamline flow of materials through the plant

(ii) Minimise material handling

(iii) Facilitate manufacturing progress by maintaining balance in the processes

(iv) Maintain flexibility of arrangements and of operation

(v) Maintaining high turnover of in-process inventory

(vi) Effective utilisation of men, equipment and space

(vii) Increase employee morale

(viii) Minimise interference (i.e. interruption) from machines

(ix) Reduce hazards affecting employees

SEVEN PRINCIPLES OF PLANT LAYOUT

TYPES OF LAYOUT

1. **Product Layout**
2. **Process Layout**
3. **Fixed Position Layout**
4. **Cellular Layout**

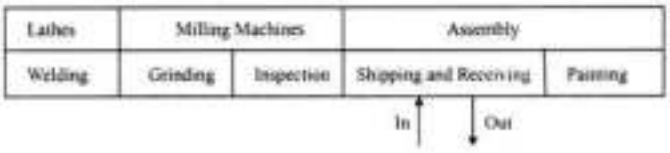
(a) Product Layout (or Line Layout):

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

(b) Process Layout (or Functional Layout):

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

A typical process layout is depicted below:



(c) Fixed Position Layout:
It is also called stationary layout. In this type of layout men, materials and machines are brought to a product that remains in one place owing to its size. Ship-building, air-craft manufacturing, wagon building, heavy construction of dams, bridges, buildings etc. are typical examples of such layout.

(d) Combination Layout:
In practice, plants are rarely laid out either in product or process layout form. Generally a combination of the two basic layouts is employed; to derive the advantages of both systems of layout.

Cellular manufacturing is a type of layout where machines are grouped according to the process requirements for a set of similar items (part families) that require similar processing. These groups are called cells.

PROCESS LAYOUT

Advantages

- **Flexibility of equipment and personnel**
- **Lower investments on account of reduced number of general purpose machines**
- **Higher utilization of production facilities**

Disadvantages

- **Material handling cannot be mechanised**
- **Process time is prolonged so reduces inventory turnover, hence increases investment**
- **More space requirement**

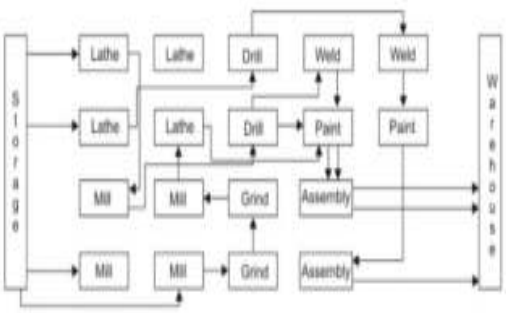


Fig. 18.1: Process Layout

PRODUCT LAYOUT

Advantages:

- **Reduced material handling cost**
- **Reduced work in process inventory**
- **Unskilled workers can easily learn the production process**

Disadvantages

- **Lack of flexibility**
- **Large capital investment**
- **Increased need for special purpose machine**

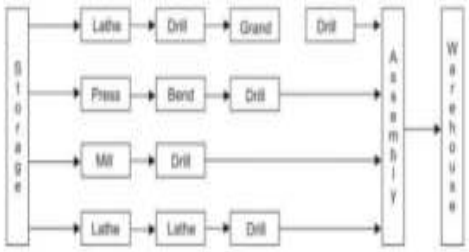


Fig. 18.4: Product Layout

FIXED POSITION LAYOUT

Advantages:

- **Minimal material movement**
- **Highly flexible**
- **Independent of production centers hence minimum total production time**

Disadvantages:

- **Increased movement of material and personnel may be expensive**
- **Equipment duplication can occur**
- **General supervision is required**

CELLULAR LAYOUT

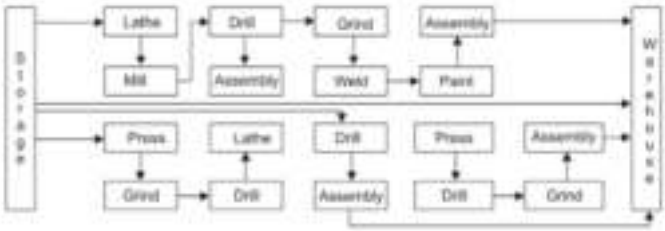


Fig. 18.6: Cellular layout

HOW TO SEPARATE THEM?

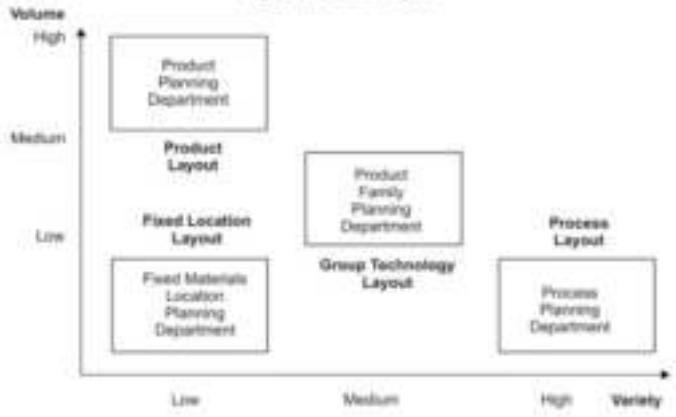


Fig. 18.7: Relationship between volume, variety with type of layout

Refer : https://www.yourarticlelibrary.com/industries/plant-layout/plant-layout-meaning-need-and-importance/90129

Material Handling

MODULE :2

MATERIAL HANDLING

- Material handling is the art and science of involving the **movement, handling and storage** of materials during different stages of manufacturing.
- Material handling means providing the right quantity of right quality materials in the right condition(ie; usable condition).
- Material handling ***does not add any value to the product*** but ***adds to the cost of the product*** and hence it ***will cost the consumer more***. So the material handling cost must be kept at minimum.
- Poor material handling may result in delays leading to idling of equipment.

IMPORTANCE OF MATERIAL HANDLING

1. Minimize the cost of material handling.

2. Minimize delays and interruptions by making available the materials at the point of use at right quantity and at right time.

3. Increase the productive capacity of the production facilities by effective utilization of capacity enhancing productivity.

4. Safety in material handling through improvement in working conditions.

5. Maximum utilization of material handling equipment.

6. Prevention of damages to materials.

7. Lower investment in process inventory.

PRINCIPLES OF MATERIAL HANDLING

Planning principle: All handling activities should be planned.

Systems principle: Plan a system integrating as many handling activities as possible and coordinating the full scope of operations (receiving, storage, production, inspection, packing, warehousing, supply and transportation).

Space utilization principle: Make optimum use of cubic space.

Unit load principle: Increase quantity, size, weight of load handled.

Gravity principle: Utilize gravity to move a material wherever practicable.

Material flow principle: Plan an operation sequence and equipment arrangement to optimize material flow.

Simplification principle: Reduce combine or eliminate unnecessary movement and/or equipment.

PRINCIPLES OF MATERIAL HANDLING

Safety principle: Provide for safe handling methods and equipment.

Mechanization principle: Use mechanical or automated material handling equipment.

Standardization principle: Standardize method, types, size of material handling equipment.

Flexibility principle: Use methods and equipment that can perform a variety of task and applications.

Equipment selection principle: Consider all aspect of material, move and method to be utilized.

Dead weight principle: Reduce the ratio of dead weight to pay load in mobile equipment.

Motion principle: Equipment designed to transport material should be kept in motion.

Idle time principle: Reduce idle time/unproductive time of both MH equipment and man power.

PRINCIPLES OF MATERIAL HANDLING

Maintenance principle: Plan for preventive maintenance or scheduled repair of all handling equipment.

Obsolescence (out dated/ no longer used) principle: Replace obsolete handling methods/equipment when more efficient method/equipment will improve operation.

Capacity principle: Use handling equipment to help achieve its full capacity.

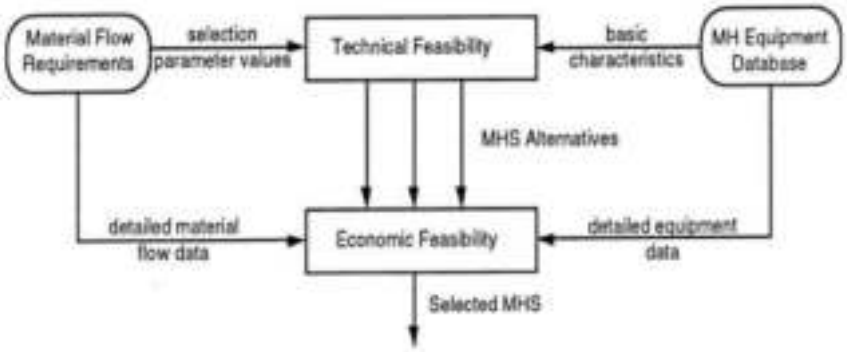
Control principle: Use material handling equipment to improve production control, inventory control and other handling.

Performance principle: Determine efficiency of handling performance in terms of cost per unit handled which is the primary criterion.

Notes – plant layout and Material handling
https://mrcet.com/downloads/digital_notes/ME/IV%20year/PLMH%20NOTES.pdf

Factors Affecting the selection of Materials Handling Equipment

The selection of materials handling equipment requires the attaining of proper balance between the production problem, the capabilities of the equipment available, and the human element involved. The ultimate aim is to arrive at the lowest cost per unit of material handled.



Advantages of correct materials handling

- Savings in storage and operating space
- Better stock control
- Improved working conditions
- Improved quality
- Lower risk of accidents
- Reduced processing time
- Lower production costs
- Less waste of time and materials

- In order to perform the activities of materials handling the basic goal is to minimize the production costs. This general objective can be further subdivided into specific objectives as follows:
- To reduce the costs by decreasing inventories, minimizing the distance to be handled and increasing productivity.
- To increase the production capacity by smoothing the work flow,
- To minimize the waste during handling.
- To improve distribution through better location of facilities and improved routing.
- To increase the equipment and space utilization.
- To improve the working conditions.
- To improve the customer service.

The essential requirements of a good materials handling system may be summarized as:

(i) Efficient and safe movement of materials to the desired place.

(ii) Timely movement of the materials when needed.

(iii) Supply of materials at the desired rate.

(iv) Storing of materials utilising minimum space.

(v) Lowest cost solution to the materials handling activities.

Objectives of Material Handling

The primary objective of a material handling system is to reduce the unit cost of Production. The other subordinate objectives are:

1. Reduce manufacturing cycle time
2. Reduce delays, and damage
3. Promote safety and improve working conditions
4. Maintain or improve product quality
5. Promote productivity

i. Material should flow in a straight line ii. Material should move as short a distance as possible

iii. Use gravity iv. Move more material at one time v. Automate material handling

6. Promote increased use of facilities

i. Promote the use of building cube ii. Purchase versatile equipment

iii. Develop a preventive maintenance program iv. Maximize the equipment utilization etc.

7. Reduce tare weight
8. Control inventory

Material Handing Equipments may be classified in five major categories.

1. Conveyors
2. Industrial Trucks
3. Cranes and Hoists
4. Containers
5. Robots

Selection of Material Handling equipment is an important decision as it affects both cost and efficiency of handling system. The following factors are to be taken into account while selecting material handling equipment.

1. **Properties of the Material**
2. **Layout and characteristics of the building**
3. **Production Flow**
4. **Cost considerations**
5. **Nature of Operations**
6. **Engineering Factors**
7. **Equipment Reliability**

Material Handling Equipments

Hoisting equipment

CRANE

- Used for lifting and lowering bulky items and packages or cases.
- Generally used in Intermittent prod uction.
- Provide overhead movements
- E.g. Bridge crane (Overhead crane), jib crane, etc.

JIB CRANE

- Jib cranes are usually permanently installed over a work stati on area.
- They can be mounted to the floor, or wall hung from an appr oved building column.
- They can give rotational movements

BRIDGE CRANE

- An overhead crane, commonly called a bridge crane, is a type of crane found in industrial environments.
- An overhead crane consists of parallel runways with a traveli ng bridge spanning the gap.
- A hoist, the lifting component of a crane, travels along the br idge.

GANTRY CRANE

- The general premise is the same, but the operation is different from bridge crane
- Gantry cranes have a bridge that is supported by two frame rigid steel legs that rest on the floor.
- The legs are commonly equipped with casters so crane can be moved to different parts of a building.
- Gantry cranes are usually less expensive than an overhead bridge crane.

CONVEYORS

- They are employed to transport material over a fixed path which may be horizontal or inclined (up or down) to different locations in the factory.
- They prove economical if the flow of material is continuous.

- Belt conveyor
- Roller conveyor
- Bucket conveyor
- Modular conveyor

FLAT BELT CONVEYOR

- The belt may be flat or trough shape to hold material which may tend to fall from the flat belt.
- The belt material may be rubber covered canvas, steel etc
- Flat belt systems are often the conveyor of choice for industrial environments, wash down areas, and slow assembly lines

MODULAR CONVEYOR

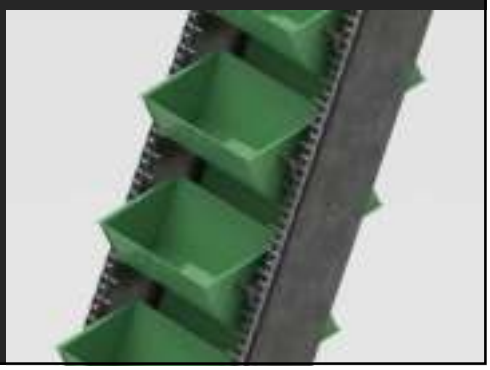
- While flat belt conveyors use a single, continuous loop of material, modular conveyor belt systems use a single loop made of countless interlocked pieces, usually made of hard plastic.
- These segments can be removed and replaced individually, in contrast to having to discard the entire belt.
- This type of conveyor belt can be used to carry food products because it is easy to clean

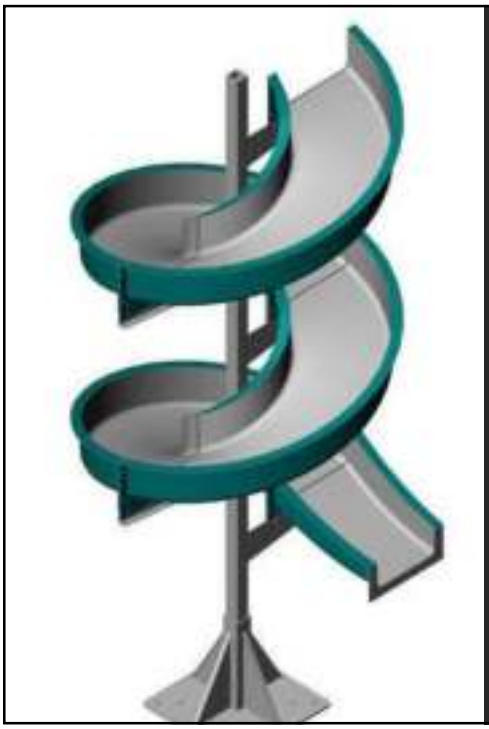
ROLLER CONVEYOR

- Roller conveyors may be gravity aided or powered.
- Used for transporting products having flat bottoms.
- Small items are put in boxes before being transported.
- They can move the material along straight or curved path.

BUCKET CONVEYOR

- The buckets remain in carrying position until they are tipped to discharge the material.
- Bucket conveyors consists of endless chains or belts to which are attached buckets to convey bulk material in horizontal, inclined, and vertical paths.
- The **conveyors** are used in food, agricultural, pharmaceutical, cosmetics, chemical, ceramic and glass industry, but also for transportation of bulk materials in heavy industry





CHUTES

- Chutes transfer small jobs which can slide down under gravity.
- Chutes have sheet metal base for transporting components down.
- Commonly seen in railway and airline terminal for handling Baggage.
- Chutes may be in spiral form to move stock from the upper floors to lower floors.

TRANSPORT EQUIPMENTS

- These devices are mainly for for horizontal movement of material.
- These devices include trucks and other similar vehicles.
- These vehicles or machines are powered by hand, or electric power and have the capability of transporting material and manpower in a horizontal direction
- These also include variable path equipments and can be utilized so long as travelling surfaces are available and the route is obstruction free.
- simplest among these are wheel barrow and hand truck.

INDUSTRIAL TRUCK

- **Industrial truck**, carrier designed to transport materials within a factory area with maximum flexibility in making moves.
- Most industrial trucks permit mechanized pickup and deposit of the loads, eliminating manual work in lifting as well as transporting.
- Used when there is insufficient (or intermittent) flow volume such that the use of a conveyor cannot be justified
- Depending on their means of locomotion, industrial trucks may be classified as Manual or power trucks.

TYPES OF INDUSTRIAL TRUCK

In Manual truck operator provides the force needed for lifting loads and/or pushing the vehicle

Power trucks are propelled by batteries and an electric-motor drive or by an internal-combustion engine with either a mechanical drive or a generator and electric-motor drive.

PALLET TRUCK

SINGLE WHEEL BARROW

DOUBLE WHEEL BARROW

HAND TRUCK

WALKIE STAKER

MANUAL INDUSTRIAL TRUCK

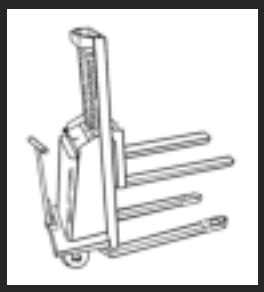
Walkie Stacker

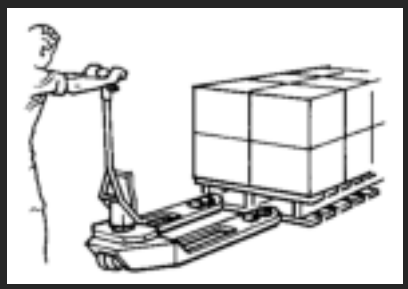
- Pallet + walk + stack + manual
- Manual lifting and/or travel (and straddle load support

Pallet Jack

- Pallet + walk + no stack
- Front wheels are mounted inside the end of the forks and extend to the floor as the pallet is only lifted enough to clear the floor for subsequent travel
- Manual lifting and/or travel

WALKIE STAKER

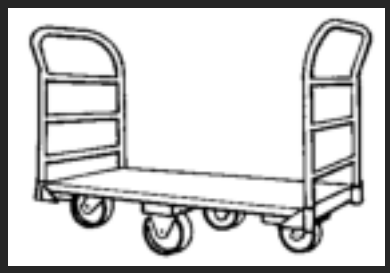


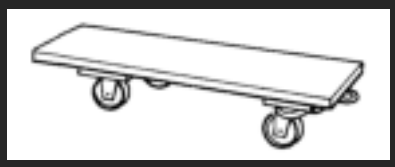


PALLET JACK

TWO WHEELED HAND TRUCK

FLOOR HAND TRUCK





DOLLY

Hand Truck

Non-pallet + manual + no stack

- **Two-Wheeled Hand Truck**

Load tilted during travel

- **Dolly**

Three or more wheeled hand truck with a flat platform in which, since it has no handles, the load is used for pushing

- **Floor Hand Truck**

Four or more wheeled hand truck with handles for pushing or hitches for pulling

STRADDLE CARRIER TRUCK

TURRET TRUCK

CRANE TRUCK

TRAILER

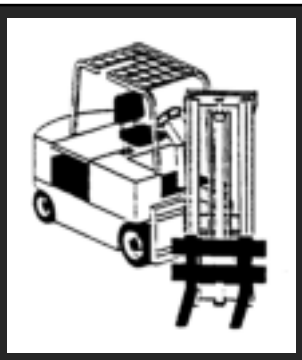
POWERED INDUSTRIAL TRUCK

Turret Truck

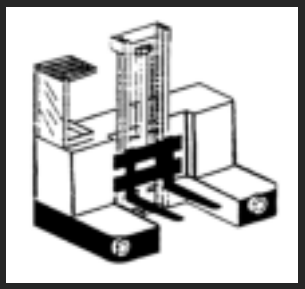
- Forks rotate to allow for side loading and, since truck itself does not rotate during stacking, the body of the truck can be longer to increase its counterbalance capability and to allow the operator to sit
- Can function like a sideloader for transporting greater-than-pallet-size load

Sideloader

- ❖ Forks mounted perpendicular to direction of travel to allow for side loading and straddle load support
- ❖ Can be used to handle greater-than-pallet-size loads (e.g., bar stock)



TURRET TRUCK



SIDE LOADER

FORKLIFT TRUCK

- **In forklift truck** the forks are attached to a column on the truck.
- They are designed to transport materials within a factory area with maximum flexibility in making moves.
- Eliminates manual work in lifting as well as transporting.
- Forks can be lifted to desired height along with the material on them and the material can be stacked at the proper place.
- Provide more flexibility in movement than conveyors and cranes

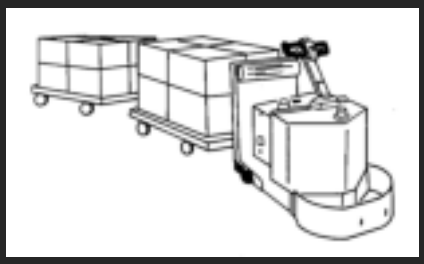
Tractor-Trailer

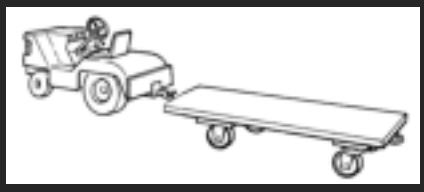
- ❖ Non-load-carrying tractor used to pull a train of trailers (i.e., dollies or floor hand trucks)
- ❖ Extends the transporting capacity of floor hand trucks
- ❖ Typically used at airports for baggage handling, transporting raw materials etc

Tow AGV

- Used to pull a train of trailers
- Automated version of a tractor trailer
- Trailers usually loaded manually

TOW AGV





TRAILER

HOISTING EQUIPMENTS

What are Hoisting equipments...?

- The hoisting is a device used for lifting or lowering a load by means of drum or lift – wheel around which rope or chain wraps.
- It may be done with a wide range of equipment from the small hand operated simple screw or hydraulic – jack to modern high powered cranes and elevators.
- Hoisting equipment can be a stationary, portable or travelling.

A hoist is powered in one of these three ways:-

1. ***Manual hoists*** lift a load under the direction of an operator who typically raises and lowers a lever to activate a ratchet and pawl configuration that incrementally lifts or lowers the load.
2. ***Air hoists or pneumatic hoists*** are powered by pneumatically driven motors.
3. ***Electric hoists*** are powered by electrically driven motors.

A variety of different, application-specific, attachments can be added to the hoist:-

1. ***C hook*** is a device that enables the lifting of a coil by through the insertion of a hook into the coil's inner diameter.
2. ***Vacuum lifters*** utilize an electric-powered extraction pump and sealed pads to create a vacuum to attach the lifter to an object.
3. ***Gripping lifters*** use either friction or indentation-causing pressure to hold a load.
4. ***Pallet lifters*** use forks to lift pallets from underneath.

Technical specifications of a Hoisting equipment

- Lifting capacity : the maximum safe load a machine is designed to handle.
- Dead weight of the machine : the total weight of the machine without load.
- Speed of various movements: this may be the hoisting speed, the bridge travel speed and the trolley traveling speed.
- lifting height : the height to which the load is intended to be raised.

Types of Hoisting Equipments

1. Cranes - a combination of separate hoisting mechanism with a frame for lifting and/or moving loads.

- A crane is a type of machine, generally equipped with a hoist rope, wire ropes, or chains, and sheaves.
- It can be used both to lift and lower materials and move them horizontally. It is mainly used for lifting heavy things and transporting them to other places.
- It uses one or more simple machines to create mechanical advantage and thus move loads beyond the normal capability of a human.

Types of cranes

- ***Bridge Crane***

An overhead crane consisting of parallel runways with travelling bridge spanning the gap.

- ***Gantry Crane***

Same as Bridge crane but, the bridge is supported on two rigid steel legs that rest on the floor. The legs are provided with casters or on rails to aid movevment.

- ***Jib Crane***

It is a permanently installed crane with rotational movement.

They can be mounted on floor, or wall hung from a column.

2. Conveyer

- Used to transport material along a horizontal or inclined path.
- They are economical if the material flow is continuous.

- ***Belt Conveyer*** - Here, a flaat or trough shaped belt is used to hold the material. The belt material maybe rubber covered steel, woven wire etc..

- ***Roller conveyer*** - These may be gravity aided or mechanically powered.
- Mainly used to transfer products with flat bottoms.

- ***Bucket Conveyer*** - These consists of endless chains or belts to which buckets are attached to convey material transfer in vertical, inclined, or horizontal direction.

3. Elevators - a group of periodic action machine intended for raising loads with guide ways.

- The Material Handling Lift Elevators are used for various industrial applications like tool handling, pallet handling and vehicle & unloading in construction, engineering, automotive industries.
- These lift elevators are provided with rope hoist that efficiently capable of lowering and raising the cage.
- It is a fast and flexible equipment for floor to floor movement.

4. Chutes

- They transfer small jobs that can slide down under gravity.
- They have a sheet metal base for material transfer.
- They can be spiral for material transfer from floor to floor.

PREVENTIVE AND BREAKDOWN MAINTENANCE

What is MAINTENANCE?

- Maintenance is a set of organised activities that are carried out in order to keep an item in its best operational condition with minimum cost acquired.
- Activities of maintenance function could be either repair or replacement activities, which are necessary for an item to reach its acceptable productivity condition and these activities, should be carried out with a minimum possible cost.

TYPES OF MAINTENANCE

- Preventive Maintenance
- Breakdown Maintenance
- Condition-Based Maintenance
- Predictive Maintenance

Preventive Maintenance

- **Preventive maintenance (PM) is the regular and routine maintenance of equipment and assets in order to keep them running and prevent any costly unplanned downtime from unexpected equipment failure.**
- A successful maintenance strategy requires planning and scheduling maintenance of equipment before a problem occurs.
- A good preventive maintenance plan also involves keeping records of past inspections and the servicing of equipment.
- Because of the complexity of maintaining a preventive maintenance schedule for a large amount of equipment, many companies use preventive maintenance software to organise their required preventive maintenance tasks.

Types of Preventive Maintenance

Time-based preventive maintenance

A typical example of a time-based preventive maintenance trigger is a regular inspection on a critical piece of equipment that would severely impact production in the event of a breakdown.

Usage-based preventive maintenance

Usage-based triggers fire after a certain amount of kilometres, hours, or production cycles. An example of this trigger is a motor-vehicle which might be scheduled for service every 10,000km.

Advantages of Preventive Maintenance

- Improved Safety
- Greater Equipment Lifespan
- Improved Productivity
- Reduced Costs
- Reduced Energy Consumption

Disadvantages of Preventive maintenance

- Budget Constraints
- Additional Resources Required
- Time-Consuming
- Organisational Difficulties

BREAKDOWN MAINTENANCE

- Maintenance performed during Break Down
- Done when the failure of equipment does not affect the operation or production or generates any loss other than repair cost
- Feasible for small factories where the machine are simple and does not requires any type of specialist

Types of Breakdown Maintenance

Planned Breakdown Maintenance

- Machine is **Run To Failure(RTF)**
- Planning is done on which parts are maintained by this strategy

Unplanned Breakdown Maintenance

- Done when there is **Unplanned Downtime Event**
- Can happen in any industry
- Resources have to be ready

Applicability

- Inexpensive and easy to replace parts
- Non critical parts of machine
- Parts meant to be disposed at end of their life
- Short life assets

Advantage of Breakdown Maintenance

- Minimizes maintenance cost by cutting out unnecessary preventive maintenance
- Lowers cost of replacing disposable items frequently
- Low staffing needs
- Simple and easy to understand when maintenance is required

Disadvantages of Breakdown Maintenance

- Safety issues with unplanned failures.
- Requires precise planning and execution.
- Difficult to pin the source of the issue.
- Increase chance of accident and less safety for both workers and machines.

Condition-Based Maintenance

- Condition-based maintenance is sometimes considered to be a more advanced alternative to preventive maintenance. Rather than being inspected according to a schedule, machines and systems are carefully observed for changes that could indicate upcoming failure.
- With condition-based maintenance, technicians observe the system running and identify variables that could affect functioning, like temperature, vibration speed, power, the presence or absence of moisture, and more.
- Another strategy within condition-based maintenance is predictive maintenance.

Predictive Maintenance

- Predictive maintenance refers to a specific type of condition-based maintenance in which systems are constantly observed via sensor devices. These devices are attached to components of the system and feed constant, real-time data to software. The software then interprets this data and warns maintenance technicians of approaching danger.
- Predictive maintenance is generally considered to be the most advanced and intensive type of maintenance. This is because there is a lot of data to interpret – and the sensor devices themselves need to be regularly maintained and checked.

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REPLACEMENT POLICY

REPLACEMENT OF EQUIPMENTS

- Equipment and machines used in industries and other manufacturing processes deteriorate with time, as a result their efficiency decreases and may incur more maintenance cost and production delays.
- Hence, there arise a need to formulate a replacement policy which would enable us in deciding the age at which the replacement of the old equipment by new one is most economical than continuing the activities with older equipment at increased costs.

Need for replacement arises when:

- The existing items or system has become inefficient or require more maintenance
- The equipment has failed due to accident or other reasons
- Existing equipment is expected to fail shortly
- Existing equipment has become obsolete due to availability of equipment with latest technology and better design.

Types of failures

- Gradual Failure : Failure mechanism is progressive. As equipment ages, its performance deteriorates.
- Sudden Failure: The equipment fails suddenly after a period of service. The time period between installation and failure is not constant.
- Progressive failure : progressive failure occurs when probability of failure increases with age of item.
- Retrogressive failure : Certain items have more probability of failure in early years of their life and probability of failure decreases with time.
- Random failure : Random causes such as physical shocks or accidents that are independent of age.

Types of Replacement Problems

Replacement study can be classified into two categories:

(a) Replacement of assets that deteriorate with time (Replacement due to gradual failure, or wear and tear of the components of the machines).

This can be further classified into the following types:

(i) Determination of economic life of an asset.

(ii) Replacement of an existing asset with a new asset.

(b) Simple probabilistic model for assets which fail completely (replacement due to sudden failure)

Reasons for Replacement of Equipments

1. **Deterioration:**
   Decline in performance due to wear and tear
   - increases maintenance cost
   - reduction in product quality and rate of production
   - increased labour costs
   - Loss of operating time to breakdown
2. **Obsolescence:**
   Equipment gets obsolete due to advancement in technology and unwarranted manufacturing costs arising will:
   - reduce profits
   - impair competition

3. Inadequacy:

When the existing equipment becomes inadequate to meet the demand or is not able to increase the production rate to desired level, the question of replacement arises.

4. Working Conditions:

Old equipments are to be replaced when it creates unpleasantness (Smoke, noise etc)in work environment.

5. Economy:

The existing units/equipments have outlived their effective life and is not economical to continue with them.

Factors necessary for Replacement of Equipments

- **Technical Factors**

  These include the factors related to working condition, efficiency, new technological advancements etc
- **Financial/Cost Factors**

  Includes the maintenance cost, repair cost, cost of new machineries, Salvage value of existing equipment, running costs
- **Tangible Factors**

  These factors involve sociological and humanitarian considerations like working environment, safety etc.

Determination of Economic Life of an Asset

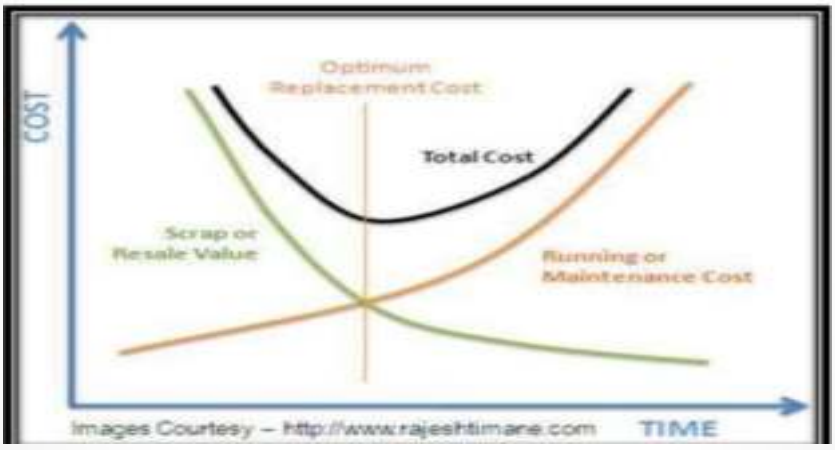
Any asset will have the following cost components:

✓ Capital recovery cost (average first cost), computed from the first cost (purchase price) of the machine.

✓ Average operating and maintenance cost (O & M cost)

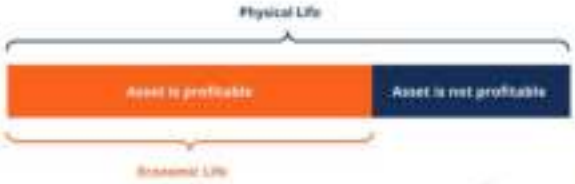
Total cost which is the sum of capital recovery cost (average first cost) and average maintenance cost.

Optimum Period for Replacement



ECONOMIC LIFE OF AN ASSET

- Economic life of an asset is time interval that **minimizes asset's total equivalent annual cost** or **maximizes it's equivalent net income .**
- It is an estimation of the period of time over which an asset can reasonably be used to generate income and beneficial to the company.
- It is also called as USEFUL LIFE.

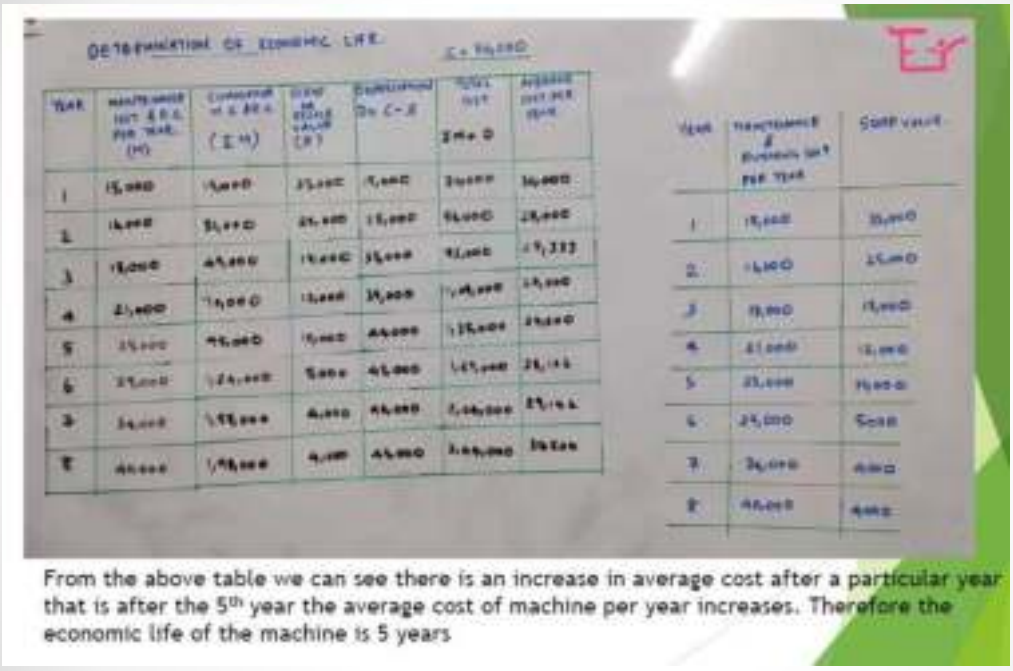


DETERMINATION OF ECONOMIC LIFE

Problem :

Q1. The cost of the machine is Rs. 50,000. The life of the machine is 8 years and the various costs associated with the machine are as follows. Suggest the optimum policy.

YEAR	1	2	3	4	5	6	7	8
Maintenance & running cost per year	15000	16000	18000	21000	25000	29000	34000	40000
Scrap value	35000	25000	17000	12000	10000	5000	4000	4000



From the above table we can see there is an increase in average cost after a particular year that is after the 5th year the average cost of machine per year increases. Therefore the economic life of the machine is 5 years

	Maint	Cumu	Avg	Scrap	Depreciation	avg	Total avg	Total cost	Average
0	0	0		50000	50000				
1	15000	15000	15000	35000	15000	15000	30000	30000	30000
2	16000	31000	15500	25000	25000	12500	28000	56000	28000
3	18000	49000	16333.33	17000	33000	11000	27333.33	82000	27333.33
4	21000	70000	17500	12000	38000	9500	27000	108000	27000
5	25000	95000	19000	10000	40000	8000	27000	135000	27000
6	29000	124000	20666.67	5000	45000	7500	28166.67	169000	28166.67
7	34000	158000	22571.43	4000	46000	6571.429	29142.86	204000	29142.86
8	40000	198000	24750	4000	46000	5750	30500	244000	30500

EXAMPLE

A firm is considering replacement of an equipment, whose first cost is Rs. 4,000 and the scrap value is negligible at the end of any year. Based on experience, it was found that the maintenance cost is zero during the first year and it increases by Rs. 200 every year thereafter.

(a) When should the equipment be replaced if $i = 0\%$?

(b) When should the equipment be replaced if $i = 12\%$?

(a) When $i = 0\%$. In this problem

(i) First cost = Rs. 4,000

(ii) Maintenance cost is Rs. 0 during the first year and it increases by Rs. 200 every year thereafter.

https://www.youtube.com/watch?v=5WRvyR7CM1k

Determination Economic life of an Asset

- A firm is considering replacement of an equipment, whose first cost is Rs.4,000 and the scrap value is negligible at the end of any year. Based on experience, it was found that the maintenance cost is zero during the first year and it increases by Rs.200 every year thereafter.

i.When should the equipment be replaced if i = 0%, ii. When should the equipment be replaced if i = 12%

i. When should the equipment be replaced if i = 0%

END OF YEAR (N)	MAINTENANCE COST AT END OF YEAR	SUMMATION OF MAINTENANCE COST	FIRST COST OF EQUIPMENT	TOTAL COST	AVERAGE TOTAL COST THROUGH YEAR GIVEN
		$\sum$ B		C + D	E / A
A	B (Rs.)	C (Rs.)	D (Rs.)	E (Rs.)	F (Rs.)
1	0	0	4000	4000	4000
2	200	200	4000	4200	2100
3	400	600	4000	4600	1533.33
4	600	1200	4000	5200	1300
5	800	2000	4000	6000	1200
6	1000	3000	4000	7000	1166.67
7	1200	4200	4000	8200	1171.43

Economic Life of the equipment = 6 Years

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Two Types of Replacement policies

- **Individual Replacement policy:**
  Whenever any item fails, it should be immediately replaced.

- **Group Replacement policy:**
  All items are replaced after a certain period of time T in spite of these being in working condition. This approach decreases the probability of breakdown in the system.

Example: Lets consider example of street lights. If a particular light is beyond repairs, then it is replaced. This kind of policy of replacement is called as "replacement of items as-and-when they fail" or 'Individual Replacement'. On the other hand, if all the street lights in a particular cluster are replaced simultaneously in groups, then the policy is called as 'Group Replacement'.

For Group Replacement Policies, the period for which total cost (individual and group replacement costs) is considered as optimal.

Following information is required to take decision in this procedure in such cases :

- Probability of failure at different period of time
- Loss incurred due to failures
- Cost of individual replacement
- Cost of group replacement

Methods of Replacement Analysis & Methods of providing for Depreciation

Pay-Back Period Method

- This method of equipment replacement studies determines as to how long it will take (in years) to pay back invested capital

- P = Pay-back period in years.
- C = Original capital investment.
- R = Annual return expected (i.e. total annual earning after deducting taxes).
- Then P = C/R

- This method is not much reliable as it does not take into account its insurance, interest and maintenance

- This method does not consider depreciation and obsolescence

Total Life Average Method

- •In this method of equipment replacement studies, all the costs involved in buying, operating, and maintaining equipment or asset are added together into one total figure and this sum is divided by the total estimated life to get an average annual cost
- If the average cost of the existing product is less than that of the proposed one, the item isn't replaced

- Q) An existing piece of equipment has its market value of Rs.10,000, maintenance cost is Rs.1000 per year, and has a life of 10 years and no salvage value. The interest rate is 10%. The proposed equipment has an installed cost of Rs.100,000, a maintenance cost of Rs.800 per year, a life of 50 years, and a salvage value of Rs.15,000. Suggest, whether proposed equipment should be purchased or not.

Total Life Average Method

Factor	*Existing Equipment*	*Proposed Equipment*
1. Depreciation	Rs. 10000	Rs. (100000 – 15000) = Rs. 85000
2. Maintenance	Rs. 1000 × 10 = Rs. 10000	Rs. 800 × 50 = Rs. 40000
3. Interest 10%	= Rs. 5000	= Rs. 215750 (see calculations below)
4. Total life cost	Rs. 25,500	Rs. 341750.
5. Average cost/year	25,500 ÷ 10 = Rs. 2550	341750 ÷ 50 = Rs. 5835.

Total life = 10 years

Hence yearly reduction in cost $= \frac{10,000}{10} = \text{Rs. } 1000.$

Interest for the first year @ 10% $= \frac{10,000 \times 10}{100} = \text{Rs. } 1000.$

Now cost of equipment in second year is equal to
Total cost-Yearly reduction in cost i.e. (10,000 – 1000) = Rs. 9000.

∴ Interest for 2nd year @ 10% $= \frac{9000 \times 10}{100} = \text{Rs. } 900.$

Similarly, cost of equipment in 3rd year = Rs. 9000 – 1000
= Rs. 8000.

Similarly, interest for the proposed equipment :

Total life = 50 years

Yearly cost reduction $= \frac{85000}{50} = \text{Rs. } 1700$

Interest for the first year @ 10% $= \frac{85000 \times 10}{100} = \text{Rs. } 8500.$

Now cost of equipment in second year = Rs. (85,000 – 1700) = Rs. 83,300.

∴ Interest for second year @ 10% = $\frac{83,300 \times 10}{100} = \text{Rs. } 8330.$

Similarly cost of equipment for the 3rd year
= (83,300 – 1700) = Rs. 81,600

Interest for 3rd year $= \frac{81,600 \times 10}{100} = \text{Rs. } 8160.$

∴ Total interest for 50 years $= \frac{n}{2}\{2a - (n-1)d\}$

Here $n = 50, a = 8500$
$d = (8500 - 8330) = \text{Rs. } 170$

∴ Total interest $\frac{50}{2}\{2 \times 8500 - (50-1)\,170\} = 25 \times 8670 = \text{Rs. } 216,750$

Since average cost per year of existing equipment is much lower than the proposed equipment, hence new equipment should not be purchased

Equivalent Annual Method

- Equivalent annual cost (EAC) is the annual cost of owning, operating and maintaining an asset over its entire life.
- EAC is often used by firms for capital budgeting decisions, as it allows a company to compare the cost-effectiveness of various assets that have unequal lifespans.

The cost details of two equipment's are given below, find out the most economical one:

S. No.	*Factor*	*Equipment I*	*Equipment II*
1.	Initial cost (P)	Rs. 15000	Rs. 25000
2.	Annual operating cost	Rs. 800	Rs. 500
3.	Life *n*	6 years	6 years
4.	Interest rate *i*	5%	5%
5.	Salvage value (L)	1000	4000

Equivalent Annual Method

Annual cost = Capital recovery + Operating costs ...(1)

In equation (1) capital recovery is denoted by *C.R.*

$$C.R. = (P - L) \times \text{Capital recovery factor} + L \times i$$

$$= (P - L)\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right] + L \times i$$

where P = Cost of equipment, n = Life of equipment in years, i = Interest rate.
L = Salvage value

Here, $\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right]$ is called capital recovery factor, denoted by *C.R.F.*

- When we put i= 5% and n=6, we get CRF=0.1970

Equipment 1	*Equipment 2*
C.R. = (15,000 – 1000) × 0.1970	C.R. = (25,000 – 4000) × 0.1970
+ 1000 × 5/100	+ 4000 × 5/100
= 14,000 × 0.1970 + 50	= 21,000 × 0.1970 + 200
= Rs. 2808	= Rs. 4337
Total annual cost	Total annual cost
= C.R. + Operating costs	= C.R. + Operating cost
= 2808 + 800 = Rs. 3608	= 4337 + 500 = Rs. 4837

Hence equipment 1 is selected owing to the lower cost involved.

Present Worth Method

- This method of equipment replacement studies is accurate and reasonable and is used to evaluate the present value of new equipment.
- A "*present worth of currency*" is today's value of money invested at a certain interest rate after a given number of years from today.
- All the costs must be translated into present worth and they must be compared for an equal length of services. If both alternatives are used in identical capacities for the same time period, they are termed *equal-service alternatives*.
- In this method, it is very easy to see the economic advantage of one alternative over another.

Present Worth Method

- Machine A, operated manually costs Rs.2000, has a life of 2 years. While an automatic machine B costs Rs.3000 but has a life of 4 years. The operating cost for machine A is Rs.4000 per year, while that of machine B is Rs.3000 only. Which of the machines should be purchased? Consider 10% interest.

Machine A

Expenses converted in terms of present worth :

(i) Present worth of cost of first piece = Rs. 2000 of machine A.

(ii) Present worth of operating cost of first piece,

(a) in first year $P = F\left[\frac{1}{(1+i)^n}\right] = \frac{4000}{(1+0.10)} = 4000 \times 0.909 = \text{Rs. } 3636$

(b) in second year $= \frac{4000}{(1+0.10)^2} = 4000 \times 0.8264 = \text{Rs. } 3305$

(iii) Present worth of operating cost of second piece of machine A, purchased after the expiry of life of first piece, i.e. 2 years.

$= \frac{2000}{(1+0.10)^2} = 2000 \times 0.8264 = \text{Rs. } 1652$

(iv) Present worth of operating cost of second piece

(a) in third year $= \frac{4000}{(1+0.10)^3} = 4000 \times 0.7513 = \text{Rs. } 3005$

(b) in fourth year $= \frac{4000}{(1+0.10)^4} = 4000 \times 0.6830 = \text{Rs. } 2732$

Thus total expenditure in terms of present worth required if machine A is used = 2000 + 3636 + 3305 + 1652 + 3005 + 2732 = **Rs. 16,331.**

Machine B

Expenses converted in terms of present worth :

(i) Present worth of cost of machine B = **Rs. 3000**

(ii) Present worth of operating cost

(a) in first year $= \frac{3000}{(1+0.10)} = 3000 \times 0.909 = \text{Rs. } 2727$

(b) in second year $= \frac{3000}{(1+0.10)^2} = 3000 \times 0.8264 = \text{Rs. } 2479$

(c) in third year $= \frac{3000}{(1+0.10)^3} = 3000 \times 0.7513 = \text{Rs. } 2254$

(d) in fourth year $= \frac{3000}{(1+0.10)^4} = 3000 \times 0.6830 = \text{Rs. } 2049$

Machine B is economical as its expenses are less and hence machine B must be purchased.

Rate of Return Method

- In this method, average annual net income after tax and depreciation deductions is expressed as a percentage of capital investment.
- The formula used – Percentage rate of return Earnings per year/Net investment × 100.
- The drawback is that earnings of all these years cannot have a value equal to that of today (**present worth**). Hence the method will be more useful and practical if the earnings of all years are first converted to present worth and then calculations are made for the rate of return.
- This is rectified through a method called ***Discounted Rate of Return***.

MAPI Method

- MAPI stands for Machinery and Allied Products Institute of Washington, which has developed this method. This method was conceived by *George Terborgh*, the Director of MAPI.
- All types of equipment are subjected to deterioration and obsolescence in varying degree with the passage of time. Thus with the passage of time operating inferiority increases. A new machine will have operating inferiority minimum and cost, at a maximum.
- The existing equipment which is to be replaced is known as **DEFENDER** and the new which will replace the old one is known as the **CHALLENGER**.

MAPI Method

- For estimating as to whether the proposed replacement is profitable, the ***"adverse minimum"*** of the defender and the challenger are found and compared.
- "*Adverse minimum*" of the defender or the challenger is the lowest sum of the time adjusted average of capital cost and operating inferiority (expressed in terms of money) obtainable from a machine.
- The calculations are simple and are done using MAPI charts.
- This method can be applied to a single as well as a combination of several machines for replacement.
- There is full provision for future deterioration and obsolescence on the new machines.

Method of providing Depreciation

- Meaning of Depreciation:
- The term Depreciation means a fall in the value of an asset with use and passage of time for the fixed assets like plant, machinery, building, furniture fixtures, etc. there is a decline in the value due to use and it is termed as Depreciation.
- Most of the fixed assets are worn out while in use over a period of time. This wear and tear are bound to occur but it can be minimized up to some extent by proper care and maintenance.
- Some of the important reasons for the decline in the value of the assets may be:

Method of providing Depreciation

- Lapse of time
- Wear and tear due to use over a period of time
- Lack of proper repair and maintenance
- Mishandling and accidents and
- Introduction of new improved equipment in the market

TYPES OF DEPRECIATION

- Depreciation may be classified under the following types:
- Physical depreciation.
- Functional depreciation.
- Accidental depreciation.

Method of providing Depreciation

Straight Line Method

- This method assumes that depreciation is a function of time rather than use.

Advantages:

- It is simple to use.
- It realistically matches cost and revenue and determines the income of each period easily.
- There is no change either in the rate or the amount of depreciation over the useful life of the assets.

Disadvantages:

- It ignores the cost of capital.
- It is based on the wrong assumption of the equal utility of the assets during the useful life.
- It is also wrong to consider depreciation as a function of time rather than use.

Method of providing Depreciation

Diminishing Balance Method

Under this method, a fixed percentage is applied to the book value of the assets (cost of assets). In other words, the depreciation is calculated on the reducing balance (assets cost-depreciation) and not on the original cost.

Advantages:
It is easy to use.
It facilitates the replacement of fixed assets as it makes more funds available at an early stage.
Disadvantages:
Under this method, the value of assets can never be zero.
It is difficult to calculate the proper rate of deprecation.

$$\text{Rate of depreciation} = 1 - n\sqrt{s/c}$$

Method of providing Depreciation

Sum of the Digits Method

- Under this method, the amount of the depreciation to be written off each year is calculated by the following formula:
- Depreciation = Remaining Life of the Asset (including the Current Year) / Sum of all the Digits of the Life of the Asset in Years x Cost of the Asset
- Suppose the life of an asset costing Rs.50,000 is 10 years. The sum of all the digits from 1 to 10 comes to 55 i.e., 10+9+8+7+6+5+4+3+2+1 = 55
- The depreciation to be provided in the first year will be = 10 / 55 x 50,000 or Rs.9,091 .In the second year, it will be: 9 /55 x 50,000 or Rs.8,181

Method of providing Depreciation

Unit of Production Method:

- Under this method, depreciation expense is allocated in proportion to the degree of the asset used for production because estimation of useful life is done in terms of units of output or services hour and not a calendar time period. A machine can produce a limited number of quantities or run for a limited hour. As a result of this limitation, the depreciation is related to usage and not to time.
- Depreciation Per annum = Dep. expense Per unit x No. of units produced during the year
- Dep. per unit = Cost – Scrap value/Total estimated unit of output or service hrs.

Method of providing Depreciation

Sinking Fund Method:

- Under this method, the amount of depreciation goes on accumulating till the asset is completely worn out.
- This method provides the necessary cash to replace the asset at end of its useful life. The amount of depreciation is fixed and remains the same for every year and is charged to P&L A/c.

Revaluation Method:

- This method is used only in case of small items like cattle (Livestock), or loose tools where it may be too much to maintain an account of every single item. The amount of depreciation to be written off is
- determined by comparing the value at the end of the year (valuation being done by someone having
- expert knowledge of the valuation of the asset) with the value in the beginning.

THANK YOU