

## Fundamental principles

### • Definition of Engineering

Engineering is the profession in which knowledge (math and natural sciences gained by study, experience and practice) is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind.

- Two environments are needed for the work of an engineer – physical and – economical environments
- An engineer needs to establish efficiency in both environments that are not independent

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- **EXAMPLES:** – Infrastructure expenditure decision – Replace versus repair decisions – Selection of inspection method – Selection of a replacement for an equipment
- Economics deals with the behavior of people
- Utility – “Utility is the power of a good or service to satisfy human needs”
- Value – Value designate the worth that a person attaches to an object or service – Value is a measure or appraisal of utility in some medium of exchange. – Value is not the same as cost or price

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### • Engineering Process

- Determination of objectives
- Identification of strategic factors
- Determination of means (engineering proposals)
- Evaluation of engineering proposals
- Assistance in decision making
- Engineering Economic Studies
- Creative step
- Definition step
- Conversion step to same scale to facilitate comparative evaluation
- Decision step

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### • Consumer and Producer Goods

- Consumer goods are the goods and services that directly satisfy human wants. For example, TV, shoes, houses.
- Producer goods are the goods and services that satisfy human wants indirectly as a part of the production or construction process. For example, factory equipment, industrial chemicals and materials
- **The Utilities of Goods**
- Consumer goods: Basic human needs of food, clothing and shelter. In commercial advertisements, emphasis is given to senses not reasoning. The utility in this case is considered objectively and/or subjectively.
- Producer goods: The utility stems for their means to get to an end. The utility in this case is considered objectively.

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### *• Economy of Exchange*

- Economy of exchange occurs when utilities are exchanged by two or more people.
  - It is possible because consumer utilities are evaluated subjectively.
  - Mutual benefit in exchange
  - Persuasion in exchange. Salesperson
- ### *• Economy of Organization*
- Through organizations, ends can be attained or attained more economically by: 1. Labor saving 2. Efficiency in manufacturing or capital use

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### *• The Interest Rate*

- Called also the rate of capital growth, it is the rate of gain received from an investment.
  - It is expressed on an annual basis:
  - For the lender, it consists, for convenience, of (1) risk of loss, (2) administrative expenses, and (3) profit or pure gain.
  - For the borrower, it is the cost of using a capital for immediately meeting his or her needs.
- ### *• The Time Value of Money (TVM)*
- As a result of the earning power of money (through interest), time increases the purchasing power of money by its increase through earning

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### *• The Time Value of Money (TVM)*

- Money has a time value
- One dollar today is worth more than \$1 tomorrow (exchange rate)
- Failure to pay the bills results in additional charge termed interest
- The earning power of money
- This power is there because money can be exchanged by production tools
- *The purchasing power of money*
- The prices of goods and services can go upward or downward, therefore the purchasing power of money can change with time

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### **Introduction to Engineering Economics**

- Efficient functioning of any business organization would enable it to provide goods/services at a lower price.
- In the process of managing organizations, the managers at different levels should take appropriate economic decisions which will help in minimizing investment, operating and maintenance expenditures besides increasing the revenue, savings and such other gains of the organization.
- These can be achieved through Engineering Economics which deals with the methods that enable one to make economic decisions towards minimizing costs and/or maximizing benefits to business organizations.

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• Economics - is a study of economic problems of the people concerning production, consumption, exchange and distribution of wealth.

• Economics is the science that deals with the production and consumption of goods and services and the distribution and rendering of these for human welfare.

• The following are the economic goals:

➤ A high level of employment

➤ Price stability

➤ Efficiency

➤ An equitable distribution of income

➤ Growth

## Laws of supply and demand

• Laws of supply - states that the quantity of a commodity supplied varies directly with the price, other determinants of supply remaining constant.

➤ If the cost of inputs increases, then naturally, the cost of the product will go up. In such a situation, at the prevailing price of the product the profit margin per unit will be less.

➤ The producers will then reduce the production quantity, which in turn will affect the supply of the product.

## Demand and Supply

➤ Demand curve shows the number of units people are willing to buy and cost per unit (decreasing curve).

➤ Supply curve shows the number of units that vendors will offer for sale and unit price (increasing curve).

➤ The intersection defines the exchange price.

➤ Elasticity of demand. Price changes and their effect on demand changes. It depends on whether the consumer product is a necessity or a luxury.

➤ Law of diminishing return. A process can be improved at a rate with a diminishing return. Example: cost of inspection to reduce cost of repair and lost production.

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## Laws of supply contd.

➤ For instance, if the prices of fertilizers and cost of labour are increased significantly, in agriculture, the profit margin per bag of paddy will be reduced.

➤ So, the farmers will reduce the area of cultivation, and hence the quantity of supply of paddy will be reduced at the prevailing prices of the paddy.

➤ If there is an advancement in technology used in the manufacture of the product in the long run, there will be a reduction in the production cost per unit.

➤ This will enable the manufacturer to have a greater profit margin per unit at the prevailing price of the product. Hence, the producer will be tempted to supply more quantity to the market.

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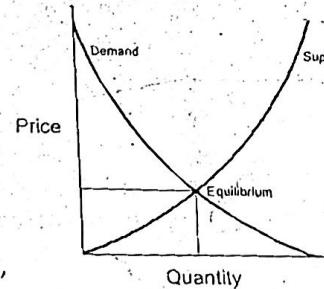
### Laws of supply contd.

- Weather also has a direct bearing on the supply of products. For example, demand for woollen products will increase during winter. This means the prices of woollen goods will be increased in winter.
- So, naturally, manufacturers will supply more volume of woollen goods during winter.

- Factors influencing supply
- Cost of the inputs
- Technology
- Weather
- Prices of related goods

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- ✓ Also, the product is more in demand and hence the demand of the product increases.
- ✓ At the same time, lowering of the price of the product makes the producers restrain from releasing more quantities of the product in the market.
- ✓ Hence, the supply of the product is decreased. The point of intersection of the supply curve and the demand curve is known as the equilibrium point.
- ✓ At the price corresponding to this point, the quantity of supply is equal to the quantity of demand. Hence, this point is called the equilibrium point.



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- Law of demand states that other things being equal demand which price falls and contracts when price rises.
- Market demand is the total quantity demanded by all the purchasers together.
- Elasticity of Demand - Elasticity of demand may be defined as the degree of responsiveness of quantity demanded to a Change in price.
- ✓ An interesting aspect of the economy is that the demand and supply of a product are interdependent and they are sensitive with respect to the price of that product.
- ✓ From Fig. it is clear that when there is a decrease in the price of a product, the demand for the product increases and its supply decreases.

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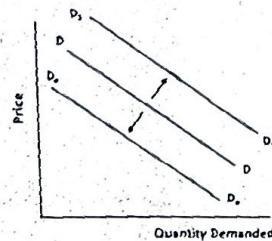
### Factors influencing demand

- Price of the product
- The consumers' income
- Prices of related goods
- Tastes and preferences of consumers
- Consumers' expectations/Expectation of future change in price
- Number of consumers in the market
- Weather condition
- Advertisement
- Government policy (taxation)
- Availability of credit facilities

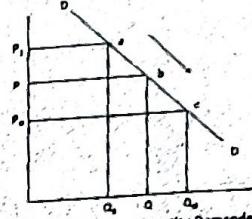
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## Shift in Demand

- A shift in demand occurs when the determinants of demand change. When taste, preferences and income are altered, the basic relationship between price and quantity demanded changes (shifts). The shift in the entire demand curve upward and is called increase while a downward shift is called decrease in demand.



- The movement along a demand curve can take place due to price rise or fall. When price falls, more of the commodity is purchased and vice versa.



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## Types of Demand

- Direct and Indirect
- Derived and autonomous
- Durable and non durable goods demand
- Firm and Industry demand
- Total market / Segment demand
- Short run / Long run demand
- Joint / Composite demand
- Price demand / Income demand / Cross demand

## Elasticity of Demand

- Elasticity of demand is the degree of responsiveness of quantity demanded of a commodity to slight changes in factors that affect demand.

$$\text{Price elasticity} = \frac{\% \text{ change in quantity demanded}}{\% \text{ change in price}}$$
$$= \frac{\Delta Q/Q}{\Delta P/P}$$

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## Cross Elasticity

- Cross Elasticity = Percentage Change in Quantity Demanded of A / Percentage Change in Price of B
- Theories of elasticity is useful in making decisions on:

- Production
- Price Fixation
- Distribution
- International Trade
- Public Finance

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## Class activity 1

The demand for a product rises from 500 units to 600 units where the price of a particular product reduces from N25 000 to N22 000. Find the cross elasticity of demand for the two products. What is the nature of their relationship?

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## Production

### • Definition

The principal aim of any economic activity is creation of utility (satisfaction); hence, all activities that provide utility or which assist to provide satisfaction in the future time are regarded as production. Firms are involved in production processes and they refer to entities created by persons to organize and spur production. A firm makes use of factors of production to transform resources into good and services and which eventually create utility.

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### • Types of Production

- Primary Production: This is done by extractive industries like agriculture, mining, oil industry. The activities involve extraction of ores and other natural resources from beneath the earth crust, water bodies etc.
- Secondary Production: This is largely manifested in manufacturing activities in the various industries involved in making finished and semi finished products from crude materials.
- Tertiary Production: The production activities involved here include all services which cause finished goods to reach final consumers. Activities in this category include warehousing, wholesales, retailing, haulage, communication, banking, insurance, law, health etc

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## • Factors of Production

These are resources that are combined together to achieve creation of utility. Each factor gets rewarded based on its contribution to the production process. These factors include:

### ➤ Entrepreneur:

An individual or group of individuals which forms an entity called firm. The reward of an enterprise or entrepreneur is profit. This factor is concerned with decision making, management control, division of income, risk taking and bearing of uncertainties, innovations etc

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## Elements Of Costs

- Cost can be broadly classified into variable cost and overhead cost.
- Variable cost varies with the volume of production while overhead cost is fixed, irrespective of the production volume.
- Variable cost can be further classified into direct material cost, direct labour cost, and direct expenses.
- The overhead cost can be classified into factory overhead, administration overhead, selling overhead, and distribution overhead.
- Direct material costs are those costs of materials that are used to produce the product.
- Direct labour cost is the amount of wages paid to the direct labour involved in the production activities.

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### ➤ Capital:

These are man made resources whose rewards manifest as interests. They can be classified as fixed or circulating.

➤ Land: Refers to any natural resource. The reward of land is rent. The supply of land is limited although reclamation is possible in some sense. Although fixed in supply, lands have alternative uses. Land is not homogenous and values vary from place to place. It may be subject to diminishing returns and it is not mobile.

➤ Labour : These are skilled and unskilled persons employed to create utility and whose rewards manifest as wages.

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## Elements Of Costs Contd.

- Direct expenses are those expenses that vary in relation to the production volume, other than the direct material costs and direct labour costs.
- Overhead cost is the aggregate of indirect material costs, indirect labour costs and indirect expenses.
- Administration overhead includes all the costs that are incurred in administering the business.
- Selling overhead is the total expense that is incurred in the promotional activities and the expenses relating to sales force.
- Distribution overhead is the total cost of shipping the items from the factory site to the customer

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### Other Costs/Revenues

- First (or initial) cost: Cost to get activity started such as property improvement, transportation, installation, and initial expenditures
- Operation and maintenance cost: They are experienced continually over the useful life of the activity
- Incremental or marginal cost: Cost per unit or production increase. It is determined from the variable cost.
- Sunk cost: It cannot be recovered or altered by future actions. Usually this cost is not a part of engineering economic analysis.
- Life-cycle cost: Feasibility, design, construction, operation and disposal costs

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### Cost Functions

Cost – output relations are normally determined by cost functions. Cost functions include: linear, quadratic and cubic curves.

- Linear Cost functions

$$TC = a + bQ \quad \text{Where } a = \text{Total fixed cost}$$
$$bQ = \text{Total variable cost}$$

Average and marginal cost functions are obtained as

$$AC = \frac{TC}{Q} = \frac{a + bQ}{Q} = a/Q + b$$
$$MC = \frac{dTC}{dQ} = b$$

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### Cost Function Contd.

- Quadratic cost Function

$$AC = \frac{TC}{Q} = \frac{a + bQ + Q^2}{Q} = a/Q + b + Q$$

$$MC = \frac{dTC}{dQ} = b + 2Q$$

### Example

$$TC = C = 150 + 10Q + Q^2$$

### Cubic Cost Function

$$TC = C = a + bQ - cQ^2 + dQ^3$$

$$AC = a/Q + b - cQ + dQ^2$$

$$MC = b - 2cQ + 3dQ^2$$

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## Class activity 2: Cost Minimization

It is the desire of all firms to increase revenue by minimizing cost. To minimize cost, set the derivative of the cost function to zero and solve for the output level that will give minimum cost.

Example

$$AVC = 6 - 0.9Q + 0.05Q^2$$

$$= \frac{dAVC}{dQ} - 0.9 + 0.10Q$$

At minimum average cost  $\frac{dAVC}{dQ} = 0$

$$-0.9 + 0.10Q = 0$$

$$Q = 9$$

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## Break-Even Analysis

- The main objective of break-even analysis is to find the cut-off production volume from where a firm will make profit.
- Let  $s$  = selling price per unit  $v$  = variable cost per unit  $FC$  = fixed cost per period  $Q$  = volume of production
- The total sales revenue ( $S$ ) of the firm is given by the following formula:  $S = sQ$
- The total cost of the firm for a given production volume is given as  $TC = \text{Total variable cost} + \text{Fixed cost} = vQ + FC$
- Profit = Sales - (Fixed cost + Variable costs) =  $sQ - (FC + vQ)$
- Break-even point (BEP) = 
$$\frac{\text{Fixed costs}}{\text{Selling price} - \text{Variable cost}} = \frac{\text{Fixed costs}}{\text{contribution margin}}$$
- Margin of safety = actual sales - breakeven sales
- Profit/ volume ration = 
$$\frac{\text{contribution}}{\text{sales}} = \frac{\text{Selling price} - \text{Variable cost}}{\text{Selling price}}$$

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## Class activity 3: Output optimization in short run

The optimum level of output in the short run is the level of output for which the average cost (AC) of production equals the marginal cost (MC). i.e for optimum output,  $AC = MC$  in the short run

Example: Given the cost function.

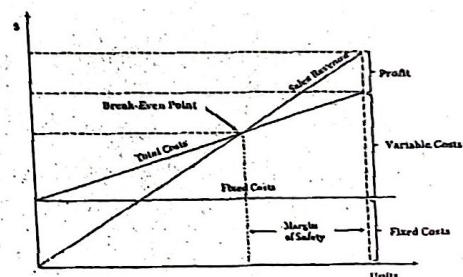
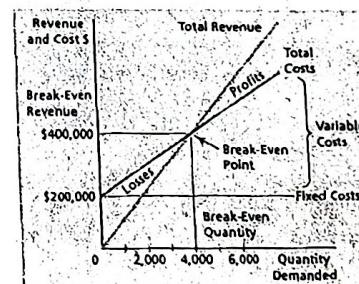
$$TC = C = 200 + 5Q + 2Q^2 \text{ then,}$$

$$AC = \frac{200}{Q} + 5 + 2Q$$

$$MC = \frac{dC}{dQ} = 5 + 4Q$$

For, optimum output,  $AC = MC$  i.e  $Q = 10$

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## Elementary Economic Analysis

- Whether it is a business situation or a day-to-day event in somebody's personal life, there are a large number of economic decision making involved. One can manage many of these decision problems by using simple economic analysis. For example, an industry can source its raw materials from a nearby place or from a far-off place. In this problem, the following factors will affect the decision:
  - ❖ Price of the raw material
  - ❖ Transportation cost of the raw material
  - ❖ Availability of the raw material
  - ❖ Quality of the raw material

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## Elementary Economic Analysis Contd.

- Consider the alternative of sourcing raw materials from a nearby place with the following characteristics:
  - ❖ The raw material is more costly in the nearby area.
  - ❖ The availability of the raw material is not sufficient enough to support the operation of the industry throughout the year.
  - ❖ The raw material requires pre-processing before it is used in the production process. This would certainly add cost to the product.
  - ❖ The cost of transportation is minimal under this alternative

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## Elementary Economic Analysis Contd.

- On the other hand, consider another alternative of sourcing the raw materials from a far-off place with the following characteristics:
  - ❖ The raw material is less costly at the far off place.
  - ❖ The cost of transportation is very high.
  - ❖ The availability of the raw material at this site is abundant and it can support the plant throughout the year.
  - ❖ The raw material from this site does not require any pre-processing before using it for production

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## Material Selection For A Product/Substitution Of Raw Material

- The cost of a product can be reduced greatly by substitution of the raw materials. Among various elements of cost, raw material cost is most significant and it forms a major portion of the total cost of any product. So, any attempt to find a suitable raw material will bring a reduction in the total cost in any one or combinations of the following ways:
  - ❖ Reduced machining/process time
  - ❖ Enhanced durability of the product
  - ❖ Cheaper raw material price
- Therefore, the process of raw material selection/substitution will result in finding an alternate raw material which will provide the necessary functions that are provided by the raw material that is presently used. In this process, if the new raw material provides any additional benefit, then it should be treated as its welcoming feature. This concept is demonstrated with numerical problem given below:

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- Example: In the design of a jet engine part, the designer has a choice of specifying either an aluminium alloy casting or a steel casting. Either material will provide equal service, but the aluminium casting will weigh 1.2 kg as compared with 1.35 kg for the steel casting. The aluminium can be cast for \$80.00 per kg, and the steel one for \$35.00 per kg. The cost of machining per unit is \$150.00 for aluminium and \$170.00 for steel. Every kilogram of excess weight is associated with a penalty of \$1,300 due to increased fuel consumption. Which material should be specified and what is the economic advantage of the selection per unit?

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- Solution (a) Cost of using aluminium metal for the jet engine part:

Weight of aluminium casting/unit = 1.2 kg;

Cost of making aluminium casting = \$80.00 per kg;

Cost of machining aluminium casting per unit = \$150.00

Total cost of jet engine part made of aluminium/unit = Cost of making aluminium casting/unit + Cost of machining aluminium casting/unit =  
 $80 \times 1.2 + 150 = 96 + 150 = \$246$

- (b) Cost of jet engine part made of steel/unit:

Weight of steel casting/unit = 1.35 kg;

Cost of making steel casting = \$35.00 per kg;

Cost of machining steel casting per unit = \$170.00;

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Solution Contd.

Penalty of excess weight of steel casting = \$1,300 per kg

Total cost of jet engine part made of steel/unit = Cost of making steel casting/unit + Cost of machining steel casting/unit + Penalty for excess weight of steel casting =  $35 \times 1.35 + 170 + 1,300 \times (1.35 - 1.2) = \$412.25$

- DECISION The total cost/unit of a jet engine part made of aluminium is less than that for an engine made of steel.
- Hence, aluminium is suggested for making the jet engine part.
- The economic advantage of using aluminium over steel/unit is Rs.  $412.25 - \text{Rs. } 246 = \text{Rs. } 166.25$

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#### • Design Selection for a Product

- a. The design modification of a product may result in reduced raw material requirements, increased machinability of the materials and reduced labour.
- b. Design is an important factor which decides the cost of the product for a specified level of performance of that product.

Assignment 1: (Design selection for a process industry). The chief engineer of refinery operations is not satisfied with the preliminary design for storage tanks to be used as part of a plant expansion programme. The engineer who submitted the design was called in and asked to reconsider the overall dimensions in the light of an article in the Chemical Engineer, entitled "How to size future process vessels?" The original design submitted called for 4 tanks 5.2 m in diameter and 7 m in height. From a graph of the article, the engineer found that the present ratio of height to diameter of 1.35 is 111% of the minimum cost and that the minimum cost for a tank was when the ratio of height to diameter was 4 : 1. The cost for the tank design as originally submitted was estimated to be Rs. 9,00,000. What are the optimum tank dimensions if the volume remains the same as for the original design? What total savings may be expected through the redesign?

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Hint: (Diameter of the new design, cost of the new design and expected savings by the redesign).

- Process Planning /Process Modification
- ❖ While planning for a new component, a feasible sequence of operations with the least cost of processing is to be considered.
- ❖ The process sequence of a component which has been planned in the past is not static.
- ❖ It is always subject to modification with a view to minimize the cost of manufacturing the component.
- ❖ So, the objective of process planning/process modification is to identify the most economical sequence of operations to produce a component.

Example: The process planning engineer of a firm listed the sequences of operations to produce a component as: (1) Turning – Milling – Shaping – Drilling (2). Turning – Milling – Drilling (3). All operations are performed with CNC machine (computer numerical controlled)

# VALUE ENGINEERING

- Value analysis is one of the major techniques of cost reduction and cost prevention.
- It is a disciplined approach that ensures necessary functions for minimum cost without sacrificing quality, reliability, performance, and appearance.
- It is an organized approach to identify unnecessary costs associated with any product, material part, component, system or service by analyzing the function and eliminating such costs without impairing the quality, functional reliability, or the capacity of the product to give service.

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## When to Apply Value Analysis

If one or more of the following symptoms are present, starting a VA program will almost certainly produce excellent results:

- Company's products show decline in sales.
- Company's prices are higher than those of its competitors.
- Raw materials cost has grown disproportionate to the volume of production.
- New designs are being introduced.
- The cost of manufacture is rising disproportionate to the volume of production.
- Rate of return on investment has a falling trend.
- Inability of the firm to meet its delivery commitments.

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## Aims of Value Engineering

- Simplify the product.
- Use (new) cheaper and better materials.
- Modify and improve product design.
- Use efficient processes.
- Reduce the product cost.
- Increase the utility of the product by economical means.
- Save money or increase the profits.

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## Value Engineering Procedure

The basic steps of value engineering are as follows:

- (a) Blast
  - (i) Identify the product
  - (ii) Collect relevant information
  - (iii) Define different functions
- (b) Create
  - (iv) Different alternatives
  - (v) Critically evaluate the alternatives
- (c) Refine
  - (vi) Develop the best alternative
  - (vii) Implement the alternative

## MAKE OR BUY DECISIONS

- In the process of carrying out business activities of an organization, a component/product can be made within the organization or bought from a subcontractor; each decision involves its own costs.
- The Organization should evaluate the costs and benefits of manufacturing a product or product component against purchasing it and then select the alternative which results in the lower cost.

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## Criteria for Make or Buy

### Criteria for make

- The finished product can be made cheaper by the firm than by outside suppliers.
- The finished product is being manufactured only by a limited number of outside firms which are unable to meet the demand.
- The part has an importance for the firm and requires extremely close quality control.
- The part can be manufactured with the firm's existing facilities and similar to other items in which the company has manufacturing experience.

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### Criteria for buy

- Requires high investments on facilities which are already available at suppliers plant.
- The company does not have facilities to make it and there are more profitable opportunities for investing company's capital.
- Existing facilities of the company can be used more economically to make other parts.
- The skill of personnel employed by the company is not readily adaptable to make the part.
- Patent or other legal barriers prevent the company for making the part.
- Demand for the part is either temporary or seasonal.

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## Make or Buy Decision Approaches

### Simple Cost Analysis

- Example: A company has extra capacity that can be used to produce a sophisticated fixture which it has been buying for ₦400 each. If the company makes the fixtures, it will incur materials cost of ₦300 per unit, labour costs of ₦1,250 per unit, and variable overhead costs of ₦100 per unit. The annual fixed cost associated with the unused capacity is ₦1,000,000. Demand over the next year is estimated at 5,000 units. Would it be profitable for the company to make the fixtures?

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- Solution:* assume that the unused capacity has alternative use.

- Cost to make:

$$\begin{aligned}\text{Variable cost} &= \text{material} + \text{labour} + \text{overhead} \\ &= N(300 + 250 + 100) = N650\end{aligned}$$

$$\begin{aligned}\text{Total variable cost} &= (5,000 \text{ units}) (N650/\text{unit}) \\ &= N3,250,000\end{aligned}$$

Add fixed cost associated with unused capacity

$$\begin{aligned}\text{Total cost} &= N3,250,000 + N1,000,000 \\ &= N4,250,000\end{aligned}$$

- Cost to buy:

$$\begin{aligned}\text{Purchase cost} &= (5,000 \text{ units}) (N900/\text{unit}) \\ &= N4,500,000\end{aligned}$$

Add fixed cost associated with unused capacity

$$\begin{aligned}\text{Total cost} &= N4,500,000 + N1,000,000 \\ &= N5,500,000\end{aligned}$$

- Decision: The organization should make the fixtures since the cost of making fixtures is less than the cost of buying fixtures from outside.

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## Economic analysis

- The economic order quantity (EOQ) is a model that is used to calculate the optimal quantity that can be purchased or produced to minimize the cost of both the carrying inventory and the processing of purchase orders or production set-ups.

$$\text{Purchase model: } Q_1 = \sqrt{\frac{2C_o D}{C_c}}, \quad TC = DP + \frac{DC_o}{Q_1} + \frac{Q_1 C_c}{2}$$

$$\begin{aligned}\text{Manufacturing model: } Q_2 &= \sqrt{\frac{2CD}{C_c(1 - D/k)}} \\ C_c(k - D) \frac{Q_2}{2k} &\quad , \quad TC = DP + \frac{DC_o}{Q_2} + \end{aligned}$$

Where:

$D$  = demand/year

$P$  = purchase price/unit

$C_c$  = carrying cost/unit/year (holding cost)

$C_o$  = ordering cost/order or set-up cost/set-up

$k$  = production rate (No. of units/year)

$Q_1$  = economic order size

$Q_2$  = economic production size

$TC$  = total cost per year

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- Example: An item has a yearly demand of 2,000 units. The different costs in respect of make and buy are as follows. Determine the best option.

	Buy	Make
Item cost/unit	8 naira	5 naira
Procurement cost/order	120 naira	
Set-up cost/set-up:		60 naira
Annual carrying cost/item/year	1.60 naira	1 naira
Production rate/year		8,000 units

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• Solution

Buy Option:  $D = 2,000 \text{ units/year}$ ;  $C_o = N120/\text{order}$

$$Cc = N1.60/\text{unit/year}$$

$$Q_1 = \sqrt{\frac{2C_oD}{Cc}} = \sqrt{\frac{2 \times 2,000 \times 120}{1.60}} = 548 \text{ units approx}$$

$$TC = D \times P + \frac{DC_o}{Q_1} + \frac{Q_1 C_c}{2} = 2,000 \times 8 + \frac{2,000 \times 120}{548} + \frac{548 \times 1.60}{2}$$

$$TC = N16,876.36$$

• Make option:  $C_o = N 60/\text{set-up}$ ;  $D = 2,000 \text{ units/year}$

$$Cc = N 1/\text{unit/year}, \quad k = 8,000 \text{ units/year}$$

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$$\cdot Q_2 = \sqrt{\frac{2CD}{Cc(1 - \frac{D}{k})}} = \sqrt{\frac{2 \times 60 \times 2,000}{1.0[1 - (2,000/8,000)]}} = 566 \text{ units (approx.)}$$

$$\cdot TC = D \times P + \frac{DC_o}{Q_2} + C_c(k - D) \frac{Q_2}{2k} = 2,000 \times 5 + \frac{2,000 \times 60}{566} + 1(8,000 - 2,000) \frac{566}{2 \times 8,000} = N10,424.26$$

Decision: the firm should go in for the making option since the cost of making is less than the cost of buying.

### Break-even Analysis

$TC$  = total cost

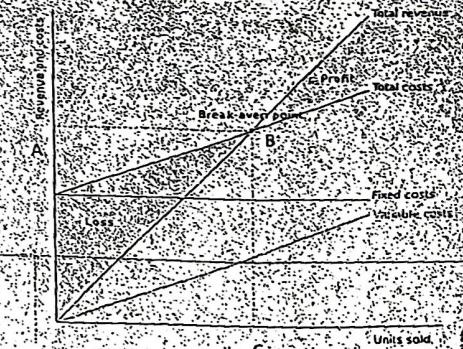
$FC$  = fixed cost

$TC = FC + \text{variable cost}$

$B$  = the intersection of  $TC$  and sales (no loss or no gain situation)

$A$  = break-even sales

$C$  = break-even quantity/break-even point (BEP)



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$$\cdot BEP = \frac{FC}{\text{Selling price/unit} - \text{Variable cost/unit}}$$

- Example: There are three alternatives available to meet the demand of a particular product:

- Manufacturing the product by using process A
- Manufacturing the product by using process B
- Buying the product

The details are as given in the following table; if The annual demand of the product is 8,000 units. Should the company make the product using process A or process B or buy it?

Cost elements	Manufacturing the product by process A	Manufacturing the product by process B	Buy
Fixed cost/year (N)	500,000	600,000	
Variable/unit (N)	175	150	
Purchase price/unit (N)			125

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### Solution

$$\text{Annual cost of process A} = FC + VC = 500,000 + 175 * 8,000 \\ = N1,900,000$$

$$\text{Annual cost of process B} = FC + VC = 600,000 + 150 * 8,000 \\ = N1,800,000$$

$$\text{Annual cost of buy} = \text{Purchase price/unit} \times \text{Volume} \\ = 125 * 8,000 = N1,000,000$$

Decision, since the annual cost of buy option is the minimum among all the alternatives, the company should buy the product.

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**Interest Formulas:** Interest rate can be classified into simple interest rate and compound interest rate.

- ✓ In simple interest, the interest is calculated, based on the initial deposit for every interest period. In this case, calculation of interest on interest is not applicable.
- ✓ In compound interest, the interest for the current period is computed based on the amount (principal plus interest up to the end of the previous period) at the beginning of the current period.

The notations which are used in various interest formulae are as follows:

$P$  = principal amount

$n$  = No. of interest periods

$i$  = interest rate (It may be compounded monthly, quarterly, semiannually or annually)

$F$  = future amount at the end of year  $n$

$A$  = equal amount deposited at the end of every interest period

$G$  = uniform amount which will be added/subtracted period after period to/from the amount of deposit  $A_1$  at the end of period 1

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**Time Value of Money** - It represents the growth of capital per unit period. The period may be a month, a quarter, semiannual or a year.

- An interest rate 15% compounded annually means that for every hundred naira invested now, an amount of N15 will be added to the account at the end of the first year. So, the total amount at the end of the first year will be N115.
- At the end of the second year, again 15% of N115, i.e. N17.25 will be added to the account.
- Hence the total amount at the end of the second year will be N132.25. The process will continue thus till the specified number of years.
- If an investor invests a sum of N100 in a fixed deposit for five years with an interest rate of 15% compounded annually, the accumulated amount at the end of every year will be as shown in the following Table:

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Year end	Interest (N)	Compound interest (N)
0		100
1	15	115
2	17.25	132.25
3	19.84	152.09
4	22.81	174.90
5	26.24	201.14

$$F = P(1 + i)^n, \text{ where}$$

$P$  = principal amount invested at time 0,

$F$  = future amount,

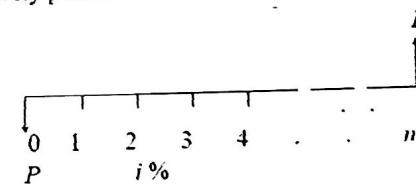
$i$  = interest rate compounded annually,

$n$  = period of deposit.

This explanation assumes that the inflation is at zero percentage.

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**Single-Payment Compound Amount** - Here, the objective is to find the single future sum ( $F$ ) of the initial payment ( $P$ ) made at time 0 after  $n$  periods at an interest rate  $i$  compounded every period.



Cash flow diagram of single-payment compound amount

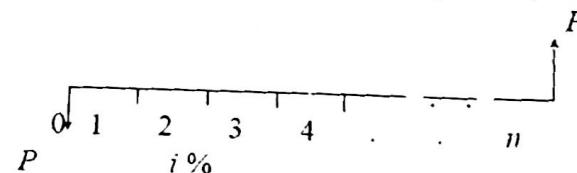
The formula to obtain the single-payment compound amount is:

$$F = P(1 + i)^n = P(F/P, i, n);$$

Where  $(F/P, i, n)$  is called as single-payment compound amount factor.

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**Single-Payment Present Worth Amount** - Here, the objective is to find the present worth amount ( $P$ ) of a single future sum ( $F$ ) which will be received after  $n$  periods at an interest rate of  $i$  compounded at the end of every interest period.



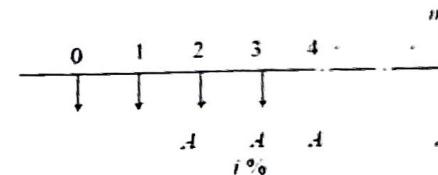
Cash flow diagram of single-payment present worth amount.

The formula to obtain the present worth is:  $P = \frac{F}{(1+i)^n} = F(P/F, i, n)$

Where  $(P/F, i, n)$  is termed as *single-payment present worth factor*.

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**Equal-Payment Series Sinking Fund:** In this type of investment mode, the objective is to find the equivalent amount ( $A$ ) that should be deposited at the end of every interest period for  $n$  interest periods to realize a future sum ( $F$ ) at the end of the  $n$ th interest period at an interest rate of  $i$ .



$A$  = equal amount to be deposited at the end of each interest period

$n$  = No. of interest periods

$i$  = rate of interest

$F$  = single future amount at the end of the  $n$ th period

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The formula to get  $F$  is

$$A = F \frac{i}{(1+i)^n - 1} = F(A/F, i, n)$$

Where  $(A/F, i, n)$  is called as *equal-payment series sinking fund factor*.

**Equal-Payment Series Present Worth Amount** The objective of this mode of investment is to find the present worth of an equal payment made at the end of every interest period for  $n$  interest periods at an interest rate of  $i$  compounded at the end of every interest period.

$P$  = present worth

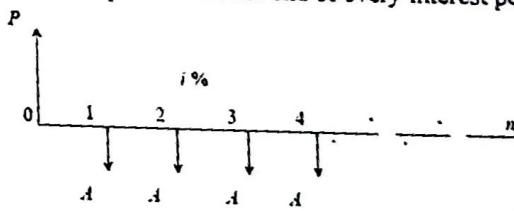
$A$  = annual equivalent payment

$i$  = interest rate

$n$  = No. of interest periods

Where  $(P/A, i, n)$  is called *equal-payment series present worth factor*

**Equal-Payment Series capital recovery** The objective of this mode of investment is to find the annual equivalent amount ( $A$ ) which is to be recovered at the end of every interest period for  $n$  interest periods for a loan ( $P$ ) which is sanctioned now at an interest rate of  $i$  compounded at the end of every interest period



Cash flow diagram of equal-payment series capital recovery amount.

The formula to compute  $P$  is  $A = \frac{i(1+i)^n}{(1+i)^n - 1} = P(A/P, i, n)$

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$P$  = present worth (loan amount)

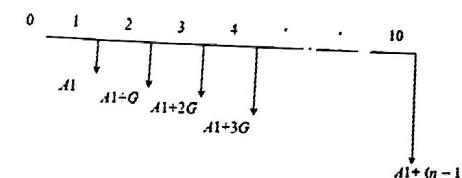
$A$  = annual equivalent payment (recovery amount)

$i$  = interest rate

$n$  = No. of interest periods

Where,  $(A/P, i, n)$  is called *equal-payment series capital recovery factor*.

**Uniform Gradient series annual equivalent** The objective of this mode of investment is to find the annual equivalent amount of a series with an amount  $A_1$  at the end of the first year and with an equal increment ( $G$ ) at the end of each of the following  $n - 1$  years with an interest rate  $i$  compounded annually.



Cash flow diagram of uniform gradient series annual equivalent amount.

$$A = A_1 + G \frac{(1+i)^n - 1}{i(1+i)^n - i} = A_1 + G (A/G, i, n)$$

Where  $(A/G, i, n)$  is called *uniform gradient series factor*.

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**Effective Interest rate** Let  $i$  be the nominal interest rate compounded annually. But, in practice, the compounding may occur less than a year. For example, compounding may be monthly, quarterly, or semi-annually. Compounding monthly means that the interest is computed at the end of every month. There are 12 interest periods in a year if the interest is compounded monthly. Under such situations, the formula to compute the effective interest rate, which is compounded annually, is

$$\text{Effective interest rate, } R = 1 + i/C^C - 1$$

where,  $i$  = the nominal interest rate

$C$  = the number of interest periods in a year.

## CASH FLOW

- **Introduction:** In this method of comparison, the cash flows of each alternative will be reduced to time zero by assuming an interest rate  $i$ . Then, depending on the type of decision, the best alternative will be selected by comparing the present worth amounts of the alternatives.
- In a cost dominated cash flow diagram, the costs (outflows) will be assigned with positive sign and the profit, revenue, salvage value (all inflows), etc. will be assigned with negative sign.
- In a revenue/profit-dominated cash flow diagram, the profit, revenue, salvage value (all inflows to an organization) will be assigned with positive sign. The costs (outflows) will be assigned with negative sign.
- In case the decision is to select the alternative with the minimum cost, then the alternative with the least present worth amount will be selected. On the other hand, if the decision is to select the alternative with the maximum profit, then the alternative with the maximum present worth will be selected.

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- **BASES FOR COMPARISON OF ALTERNATIVES**

In most of the practical decision environments, executives will be forced to select the best alternative from a set of competing alternatives.

- There are several bases for comparing the worthiness of the projects. These bases are:

1. Present worth method
2. Future worth method
3. Annual equivalent method
4. Rate of return method

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### PRESENT WORTH METHOD

- In this method of comparison, the cash flows of each alternative will be reduced to time zero by assuming an interest rate  $i$ .
- Then, depending on the type of decision, the best alternative will be selected by comparing the present worth amounts of the alternatives.
- In a cost dominated cash flow diagram, the costs (outflows) will be assigned with positive sign and the profit, revenue, salvage value (all inflows), etc. will be assigned with negative sign.
- In a revenue/profit-dominated cash flow diagram, the profit, revenue, salvage value (all inflows to an organization) will be assigned with positive sign. The costs (outflows) will be assigned with negative sign.

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- Example: Alpha Industry is planning to expand its production operation. It has identified three different technologies for meeting the goal. The initial outlay and annual revenues with respect to each of the technologies are summarized in Table 1. Suggest the best technology which is to be implemented based on the present worth method of comparison assuming 20% interest rate, compounded annually.

	Initial Outlay (N)	Annual Rev (N)	Life (year)
Technology 1	1,200,000	400,000	10
Technology 2	2,000,000	600,000	10
Technology 3	1,800,000	500,000	10

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**Solution:** In all the technologies, the initial outlay is assigned a negative sign and the annual revenues are assigned a positive sign.

- TECHNOLOGY 1

Initial outlay,  $P = N 1,200,000$

Annual revenue,  $A = N 400,000$

Interest rate,  $i = 20\%$ , compounded annually

Life of this technology,  $n = 10$  years

- Draw the cash flow diagram of this technology

- The present worth expression for this technology is

$$\begin{aligned}
 PW(20\%)_1 &= -1,200,000 + 400,000 (P/A, 20\%, 10) \\
 &= -1,200,000 + 400,000 (4.1925) = -1,200,000 + 1,677,000 \\
 &= N 477,000
 \end{aligned}$$

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