# AGNI COLLEGE OF TECHNOLOGY.

**MECHANICAL ENGINEERING**

## MG6863 ENGINEERING ECONOMICS

**Year: IV** **Semester: 7th**

## UNIT I - INTRODUCTION TO ECONOMICS

PART – A 2- Marks

***1. What are factors that affect supply curve? (May 2016).***

1. Price
2. Cost of Production.
3. Natural Conditions.
4. Technology.
5. Transport Conditions
6. Factor Prices and their Availability
7. Government's Policies
8. Prices of Related Goods.

***2. Define Economics (May 2015)***

A study of mankind in the ordinary business of life; it examines that part of individual and social action which is most closely connected with attainment and with the use of the material requisites of wellbeing.

***3. What is technical efficiency? (May 2016, Nov 2011)***

Technical efficiency = output/cost of all input

Technical efficiency is measured by the relationship between the physical quantities of output.

***4. How does Marshall explains the Law of Demand? (Nov 2014)***

There is an inverse relationship between quantity demanded and its price. The people know that when price of a commodity goes up its demand comes down. When there is decrease in price the demand for a commodity goes up. There is inverse relation between price and demand. The law refers to the direction in which quantity demanded changes due to change in price.

***5. What is equilibrium point? (May 2014)***

In economics, equilibrium means that a position has been reached in which there is no incentive to charges. We can illustrate the equilibrium concept by taking the example of a commodity market. In the market, equilibrium is achieved at the price at which the total amount demanded per unit of time is equal to the total amount supplied per unit of time.

***6. Differentiate technical efficiency and economic efficiency. (Nov 2013, May 2010)***

Technical efficiency = output/cost of all input

Technical efficiency is measured by the relationship between the physical quantities of output. Economic efficiency =Value of output/cost of all inputs

Economic efficiency is measured by the relationship between value of the output and the value of the relationship between the value of the output and the value of the input.

***7. Define break-event point. (Nov 2013, Nov 2012, May 2011, May 2014)***

The breakeven point is therefore the volume of output at which neither a profit is made nor a loss is incurred. Breakeven point is a point where the total sales are equal to total cost.

***8. Define opportunity cost. (May 2013, May 2008, Nov 2010, Nov 2008, May 2011)***

Opportunity cost may be defined as the potential benefit that is give up as you seek an alternative course of action. In other words, the expected return or benefit forgone in rejecting one course of action for another. When rejecting one course of action the rejected alternative becomes the opportunity cost for the alternative accepted.

Or

In practice, if an alternative ($X$) is selected from a set of competing alternatives ($X$,$Y$), then the corresponding investment in the selected alternative is not available for any other purpose. If the same money is invested in some other alternative ($Y$), it may fetch some return. Since the money is invested in the selected alternative

($X$), one has to forego the return from the other alternative ($Y$). The amount that is foregone by not investing in the other alternative ($Y$) is known as the opportunity cost of the selected alternative ($X$). So the opportunity cost of an alternative is the return that will be foregone by not investing the same money in another alternative.

***9. Define P/V ratio. (May 2013)***

Margin of safety = Actual sales –sales at B.E.P

= profit / (P/V)

= (profit /contribution) x sales.

### 10. *What are the way by which the economic efficiency can be improved? (Nov 2012)*

Economic efficiency is also called 'productivity'. There are several ways of improving productivity.

- Increased output for the same input
- Decreased input for the same output
- By a proportionate increase in the output which is more than the proportionate increase in the input.
- By a proportionate decrease in the input which is more than the proportionate decrease in the output
- Through simultaneous increase in the output with decrease in the input.

### 11. *State the law of demand. (Nov 2017, May 2012, Nov 2009, Nov 2011)*

The law of demand states that if all other factors remain equal the higher the price of good the less people will demand that good. In other words, the higher the price the lower the quantity demands.

### 12. *Write about the case flow in a simple economy (May 2010)*

The flow of goods, services, resources and money payments in a simple economy are shown in Figure. Households and businesses are the two major entities in a simple economy. Business organizations use various economic resources like land, Labour and capital which are provided by households to produce consumer goods and services which will be used by them.

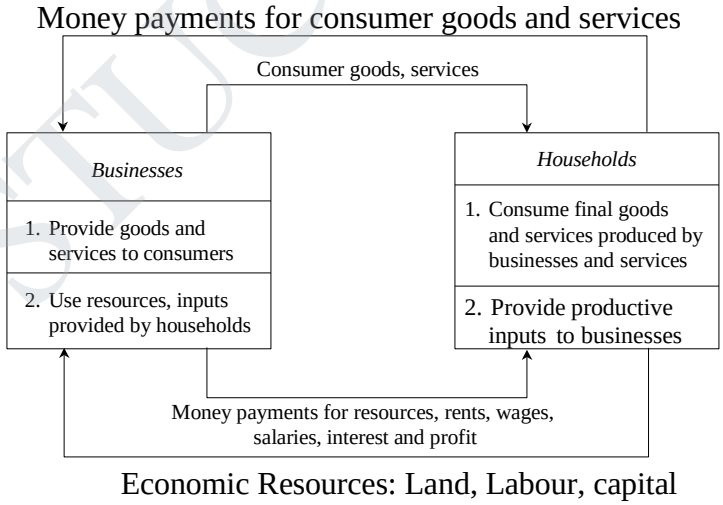


**Figure** -Flow of goods, services, resources and money payments in a simple economy.

***13. Define Marginal cost? (May 2015, May 2011)***

The amount at any given volume of output by which aggregate cost are the change, if the volume of output is increased or decreased by one unit.

a. Direct materials

b. Direct Labor.

c. Other direct expenses, and

d. Total variable overheads.

Marginal cost= Total cost – Fixed cost.

***14. What is technical efficiency? (Nov 2011, May 2016)***

Technical efficiency = output/cost of all input

Technical efficiency is measured by the relationship between the physical quantities of output.

***15. Define Engineering economics? (Nov 2011, May 2009)***

Engineering economics may be define as a set of principle, concepts, techniques and methods by which alternatives within a project can be compare and evaluated for the best monetary return.

***16. Write about factors influencing demand factor? (Nov 2010)***

Factors influencing demand, the shape of the demand curve is influenced by the following factors:

- Income of the people
- Prices of related goods
- Tastes of consumers

***17. What is break even analysis? (Nov 2009)***

Break even analysis is also known as cost volume profit analysis. The analysis is a tool of financial analysis whereby the impact on profit of the changes in volume, price, costs and mix can be estimated with reasonable accuracy.

***18. What is elasticity of demand? (May 2008)***

Elasticity of demand may be as ‘the degree of responsiveness of quantity demanded to a change in price.

***19. Define Economic efficiency? (Nov 2015, May 2009)***

Economic efficiency =Value of output/cost of all inputs

Economic efficiency is measured by the relationship between value of the output and the value of the relationship between the value of the output and the value of the input.

***20. What is the role of Micro "economical concept" in industrial engineering perspective? (Nov 2008)***

"Micro –economics is the study of particular firm's particular households, individual prices wages, income, individual industries, and particular commodities"

The fields covered by micro economics are as follows:

1. Theory of product pricing.
2. Theory of factor pricing.
3. Theory of economic welfare.

***21. What are the elements of cost? (May 2009)***

The elements of cost are:

1. Material cost.
2. Labour cost.
3. Expenses.

***22. What is equilibrium point? (May 2014)***

In economics, equilibrium means that a position has been reached in which there is no incentive to charges. We can illustrate the equilibrium concept by taking the example of a commodity market. In the market, equilibrium is achieved at the price at which the total amount demanded per unit of time is equal to the total amount supplied per unit of time.

***23.What is law of supply and Demand. (Nov 2017, May 2017)***

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. The interrelationships between them are shown in Figure.

From Figure 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. 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.

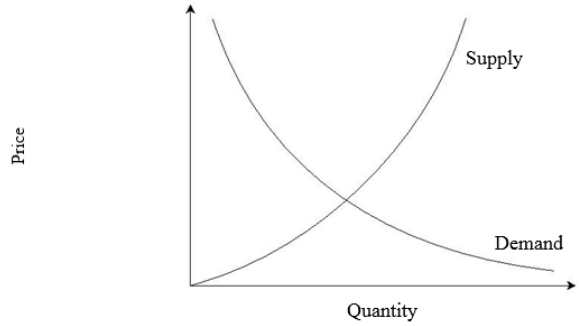


**Fig.** | **Demand** and supply curve.

### *24.What is process planning?*

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.

The steps in process planning are as follows:

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

Steps 3–5 aim to determine the most practical and economical sequence of operations to produce a component. This concept is demonstrated with a numerical problem.

### *25.What is Sunk cost?*

This is known as the past cost of an equipment/asset. Let us assume that an equipment has been purchased for Rs. 1,00,000 about three years back. If it is considered for replacement, then its present value is not Rs. 1,00,000. Instead, its present market value should be taken as the present value of the equipment for further analysis. So, the purchase value of the equipment in the past is known as its sunk cost. The sunk cost should not be considered for any analysis done from now onwards.

***PART –B*** ***16 Marks.***

***1. What is break-even Analysis? (May 2016).***
***From the following figure extracted from the books of Associates, find the following:***
***(a) Break-even sales quantity.***
***(b)The break-even sales.***
***(c) If the actual production quantity is 60,000.***
***Find (1) Contribution and margin of safety.***
***Data:***
***Fixed cost: Rs. 10,00, 000***
***Variable cost per unit= Rs.50***
***Selling price per unit=Rs.100***

Give:
Fixed cost: Rs 10,00,000
Variable cost per uint=Rs.50
Selling price per uint=Rs.100
Actual production quantity 60,000.

Sol.
(a) Break-Even sales quantity:

= {Fixed cost/ (selling price-Variable cost)}
= {10,00,000/ (100-50)}
= 20000 Units

(b) Break-Even sales:
= {Fixed cost/ (selling price-Variable cost)}* (selling price)
=20,00,000. Rs.

(c) If the actual production quantity is 60,000.
Contribution = Sales – Variable cost.
= {selling price x volume of production } –{Variable cost x Volume of Production}
= {100x60000}-{50x60000}
=30,00,000 Rs.

***2. (i).Mention about the Law of supply and demand. (May 2015)***
***(ii).Suguna associate has the following details:***
***Fixed cost =Rs 20,00,000***
***Variable cost unit=Rs 100.***
***Selling price per unit =Rs.200***
***Find out:***
***(1) The break-even point in quantity.***
***(2) The break-even point sales [Rupees].***

***Answer- Same as problem No.2***

Give:
Fixed cost: Rs 20,00,000
Variable cost per uint=Rs.100
Selling price per uint=Rs.200
Sol.
(a) Break-Even sales quantity:
cacal
= {Fixed cost/ (selling price-Variable cost)}
= {20,00,000/ (200-100)}
= 20000 Units
(b) Break-Even sales:
= {Fixed cost/ (selling price-Variable cost)}* (selling price)
=40,00,000. Rs.

 

***3. Write on; break even analysis engineering and economic efficiency cost that into Fixing of product cost (May 2013).***

***or***

***Describe the various concepts of Engineering Economics and Analysis its Efficiency (Nov 2017,May 2017)***

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:

$$S = s \times Q$$

The total cost of the firm for a given production volume is given as

$$TC = \text{Total variable cost} + \text{Fixed cost}$$
$$= v \times Q + FC$$

The linear plots of the above two equations are shown in Figure given below. The intersection point of the total sales revenue line and the total cost line is called

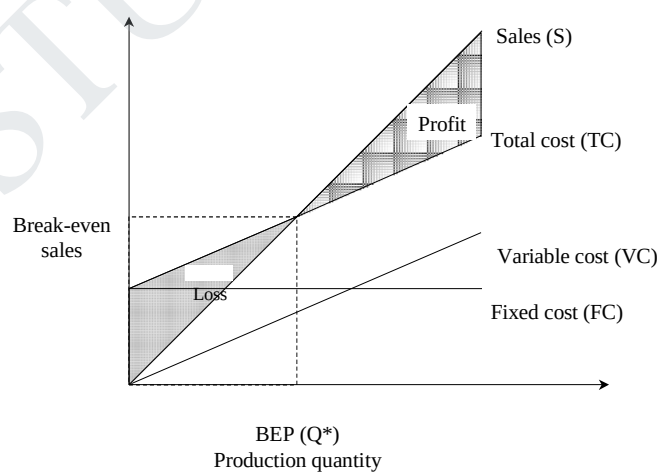


**Figure** -Break-even chart.

the break-even point. The corresponding volume of production on the $X$-axis is known as the break-even sales quantity. At the intersection point, the total cost is equal to the total revenue. This point is also called the no-loss or no-gain situation. For any production quantity which is less than the break-even quantity, the total cost is more than the total revenue. Hence, the firm will be making loss

 

For any production quantity which is more than the break-even quantity, the total revenue will be more than the total cost. Hence, the firm will be making profit.

$$\text{Profit} = \text{Sales} - (\text{Fixed cost} + \text{Variable costs})$$
$$= s \times Q - (FC + v \times Q)$$

The formulae to find the break-even quantity and break-even sales quantity

$$\text{Break-even quantity} = \frac{\text{Fixed cost}}{\text{Selling price/unit} - \text{Variable cost/unit}}$$

$$= \frac{FC}{s - v} \text{ (in units)}$$

$$\text{Break-even sales} = \frac{\text{Fixed cost}}{\text{Selling price/unit} - \text{Variable cost/unit}} \times \text{Selling price/unit}$$

$$= \frac{FC}{s - v} \times s \text{ (R.s.)}$$

The contribution is the difference between the sales and the variable costs. The margin of safety (M.S.) is the sales over and above the break-even sales. The formulae to compute these values are

$$Contribution = Sales - Variable\ costs$$

$$Contribution/unit = Selling\ price/unit - Variable\ cost/unit$$

$$M.S. = Actual\ sales - Break - even\ sales$$

$$= \left(\frac{\text{Profit}}{\text{Contribution}}\right) X \quad Sale$$

$$M.S\ as\ a\ percent\ of\ sales = \left(\frac{M.S}{sales}\right) X100$$

## CONCEPT OF ENGINEERING ECONOMICS

Science is a field of study where the basic principles of different physical systems are formulated and tested. Engineering is the application of science. It establishes varied application systems based on different scientific principles. From the discussions in the previous section, it is clear that price has a major role in deciding the demand and supply of a product. Hence, from the organization's point of view, efficient and effective functioning of the organization would certainly help it to provide goods/services at a lower cost.Which in turn will enable it to fix a lower price for its goods or services. The following section discusses the different types of efficiency and their impact on the operation of businesses and the definition and scope of engineering economics.

### Types of Efficiency

Efficiency of a system is generally defined as the ratio of its output to input. The efficiency can be classified into *technical efficiency* and *economic efficiency*.

#### *Technical efficiency*

It is the ratio of the output to input of a physical system. The physical system may be a diesel engine, a machine working in a shop floor, a furnace, etc.

$$\text{Technical efficiency (\%)} = \frac{\text{Output}}{\text{Input}} \times 100$$

The technical efficiency of a diesel engine is as follows:

$$\text{Technical efficiency (\%)} = \frac{\text{Heat equivalent of mechanical energy produced}}{\text{Heat equivalent of fuel used}} \times 100$$

In practice, technical efficiency can never be more than 100%. This is mainly due to frictional loss and incomplete combustion of fuel, which are considered to be unavoidable phenomena in the working of a diesel engine. Economic efficiency is the ratio of output to input of a business system

$$\text{Economic efficiency (\%)} = \frac{\text{Output}}{\text{Input}} \times 100 = \frac{\text{Worth}}{\text{Cost}} \times 100$$

'Worth' is the annual revenue generated by way of operating the business and 'cost' is the total annual expenses incurred in carrying out the business. For the survival and growth of any business, the economic efficiency should be more than 100%.

Economic efficiency is also called 'productivity'. There are several ways of improving productivity.

- Increased output for the same input
- Decreased input for the same output
- By a proportionate increase in the output which is more than the proportionate increase in the input
- By a proportionate decrease in the input which is more than the proportionate decrease in the output
- Through simultaneous increase in the output with decrease in the input.

*Increased output for the same input.* In this strategy, the output is increased while keeping the input constant. Let us assume that in a steel plant, the layout of the existing facilities is not proper. By slightly altering the location of the billet-making section, and bringing it closer to the furnace which produces hot metal, the scale formation at the top of ladles will be considerably reduced. The molten metal is usually carried in ladles to the billet-making section. In the long run, this would give more yield in terms of tones of billet produced. In this exercise, there is no extra cost involved. The only task is the relocation of the billet-making facility which involves an insignificant cost.

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

*Less proportionate increase in output is more than that of the input.* Consider the example of introducing a new product into the existing product mix of an organization. Let us assume that the existing facilities are not fully utilized and the R&D wing of the company has identified a new product which has a very good market and which can be manufactured with the surplus facilities of the organization. If the new product is taken up for production, it will lead to An increase in the revenue of the organization by way of selling the new product in addition to the existing product mix.

- An increase in the material cost and operation and maintenance cost of machineries because of producing the new product.

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

  *When proportionate decrease in input is more than that of the output.* Let us consider the converse of the previous example, i.e. dropping an uneconomical product from the existing product mix. This will result in the following:

- A decrease in the revenue of the organization

- A decrease in the material cost, and operation and maintenance cost of machinery.

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

  *Simultaneous increase in output and decrease in input.* Let us assume that there are advanced automated technologies like robots and automated guided vehicle system (AGVS), available in the market which can be employed in the organization we are interested in. If we employ these modern tools, then:

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

- These advanced facilities would help in producing more products because they do not experience fatigue. The increased production will yield more revenue. In this example, in the long run, there is an increase in the revenue and a decrease in the input. Hence, the productivity ratio will increase at a faster rate

***4. (i) Form the following information relating to Geetha Ltd. You are required to find out***

1. ***P/V ratio***
2. ***BEP.***
3. ***Profit.***
4. ***Margin of safety.***

***Total Fixed cost R.s 4500***
***Total Variable cost R.s 7500***
***Total sale R.s s15000***

***(ii) Also calculate the volume of sales to earn profit of R.s 6000 (May 2013)***

1. $$\left\langle \frac{p}{v} ratio \right| = \left\| \left[ \frac{contribution}{Sales} \right] x\ 100 \right\rangle$$

Contribution = sales –Variable coast

=15000-7500

=Rs 7500

$$P/V = \left[ \frac{7500}{15000} \right] x \quad 100$$

=50%

2. BEP

$$BEP = \left[ \frac{Fixed\ cost}{\frac{P}{V} ratio} \right]$$

$$= \left[ \frac{4500}{50\%} \right]$$

$$= \left[ \frac{4500}{50} \right] X \quad 500$$

=Rs 9000

3. Profit

Profit =Contribution-Fixed Cost

=7500-4500

=R.s 3000

4. Margin of Safety

$$\text{Margin of Safety} = \left[\frac{Profit}{Contribution}\right] X \quad 100$$

$$= \left[\frac{3000}{7500}\right] X \quad 100$$

=R.s 6000

(ii) Calculation Volume of sale to earn profit of R.s 6000

Profit=Sales-(Fixed cost+ Variable cost)

6000=Sales-(7500+4500)

Sales=6000+12000

=Rs.18000

 

***5. (i). Mention the factors influencing demand and supply***
***(ii). Explain the method of deriving the selling price of a product***
***(Nov 2012, Nov 2013, Nov 2016)*** ***Answer-page no: 19***

**i. Law of Supply and Demand**

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. The interrelationships between them are shown in Fig. 1.2.
From Fig. 1.2 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. 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*.
Factors influencing demand

The shape of the demand curve is influenced by the following factors:

- Income of the people
- Prices of related goods
- Tastes of consumers

If the income level of the people increases significantly, then their purchasing power will naturally improve. This would definitely shift the demand curve to the north-east direction of Fig. 1.2. A converse situation will shift the demand curve to the south-west direction. If, for instance, the price of television sets is lowered drastically its demand would naturally go up. As a result, the demand for its associated product,

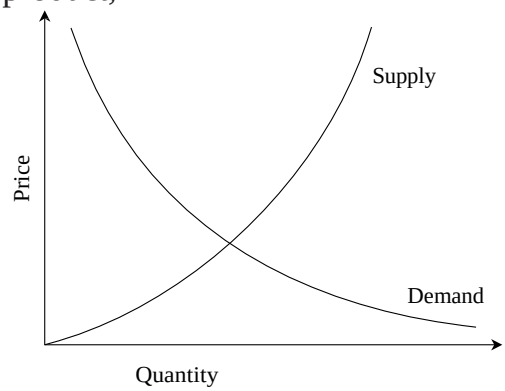


**Fig. 1.2** Demand and supply curve.

 

Namely VCDs would also increase. Hence, the prices of related goods influence the demand of a product.

Over a period of time, the preference of the people for a particular product may increase, which in turn, will affect its demand. For instance, diabetic people prefer to have sugar-free products. If the incidence of diabetes rises naturally there will be increased demand for sugar-free products.

Factors influencing supply

The shape of the supply curve is affected by the following factors:

- Cost of the inputs
- Technology
- Weather
- Prices of related goods

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. 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.

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.

Again, take the case of television sets. If the price of TV sets is lowered significantly, then its demand would naturally go up. As a result, the demand for associated products like VCDs would also go up. Over a period of time, this will lead to an increase in the price of VCDs, which would result in more supply of VCD.

***6. (i) Explain the method of deriving the selling price of a product.***

***Answer-page no: 19***

***In the design of a jet engine part, the designer has a choice of specifying either an aluminum alloy casting or a steel casting .Either material will provide equal service, but aluminum alloy casting will weight 1.2kg as compared with 1.35kg for the steel casting .The aluminum can be cast Rs.80kg and steel for Rs.35kg.The cost of machining per unit is Rs.150 for aluminum and Rs.170 for steel. Every kg of excess weight is associated with a penalty of Rs.1, 300 due to increase in fuel consumption. Which material should be specified and what is the economic advantage of the selection per unit? (Nov 2013).***

Cost of using aluminium metal for the jet engine Part
GIVEN
Weight of aluminium casting /unit =1.25
Cost of making aluminium casting=R.s 80 Kg
Cost of machining aluminium casting per unit =R.s 150
Find: Total cost of jet engine part of aluminium/unit

Total cost

$$=[(cost\ of\ making\ aluminium/unit) \quad + \quad (cost\ of\ machining\ aluminium/unit\ )]$$

$$= ((80x1.2) \quad + \quad 200)$$

$$= 296.R.s$$

Total cost

$$=[(cost\ of\ making\ aluminium/unit) \quad + \quad (cost\ of\ machining\ aluminium/unit\ )]$$

$$= ((80x1.2) \quad + \quad 200)$$

$$= 296.R.s$$

Cost of jet engine part made of steel / Unit
Weight of steel casting /unit=1.35 kg
Cost of making steel casting =R.s 85 per kg.
Cost machining steel casting= R.s 170 per unit.
Partly of exited weight of steel casting =1800
FIND: Total cost of jet engine part made of steel/unit.
Total

$$= [(cost\ of\ making\ steel\ cast/unit) \quad +(cast\ machining\ steel\ casting/unit) \quad +(penalty\ of\ excess\ weight\ )]$$

$$\text{Total} =[(35X1.35) \quad +(170) \quad +(1300X(1.35-1.2)\ )]$$

$$= 412.25$$

Economic advantage is $= R.s[412.5 - 296]$

=116.25 R.s

 

***7. Krishna Company Ltd have the following details (Nov 2012, Nov 2011, and May 2010)***
***Fixed cost =Rs.40, 00,000***
***Variable cost per unit =Rs.300***
***Selling price per unit =Rs.500***
***Find***
***(i) The break even sales quantity***
***(ii) The break even sales***
***(iii) If the actual production quantity is 1, 20,000, find the following: (Nov 2011)***

i. $$\left[Break\ even\ quantity = \left(\frac{FC}{(S - V)}\right)\right]$$

$$= \left(\frac{4000000}{(500 - 300)}\right)$$

= 20000 units

ii. $$Break-even\ sales = \left(\frac{FC}{(S - V)}\right) X\ S \quad Rs$$

$$= \left(\frac{4000000}{(500 - 300)}\right) X\ 500 \quad Rs$$

= 10,00,0000 R.s

iii. Contribution = Sales – Variable cost

= s **x** $Q$ – $v$ **x** $Q$

= (500 x 120000)-(300x120000)

=36000000 R.s

 

***8. (i) Define break –even point. Draw a break-even chart and explain its components. (Nov 2012 May 2010)***
***(ii)Discuss the factors which influence demand and supply.***

**i. 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:

$$S = s \times Q$$

The total cost of the firm for a given production volume is given as

$$TC = \text{Total variable cost} + \text{Fixed cost}$$
$$= v \times Q + FC$$

The linear plots of the above two equations are shown in Figure. The intersection point of the total sales revenue line and the total cost line is called

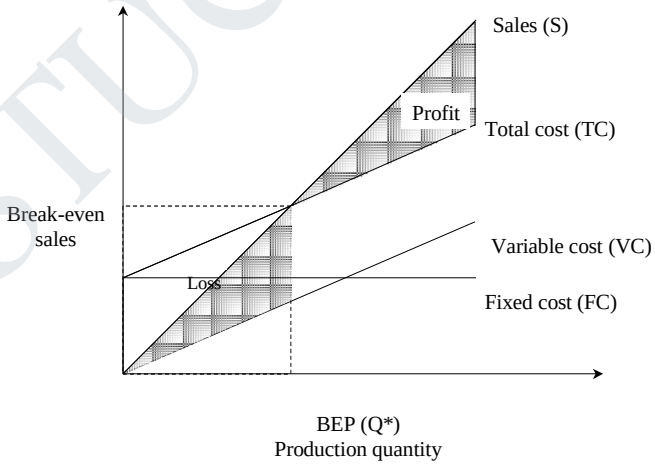


**Figure- B r e a k** -even chart.

The break-even point. The corresponding volume of production on the $X$-axis is known as the break-even sales quantity. At the intersection point, the total cost is equal to the total revenue. This point is also called the no-loss or no-gain situation. For any production quantity which is less than the break-even quantity, the total cost is more than the total revenue. Hence, the firm will be making los

For any production quantity which is more than the break-even quantity, the total revenue will be more than the total cost. Hence, the firm will be making profit.

$$\text{Profit} = \text{Sales} - (\text{Fixed cost} + \text{Variable costs})$$
$$= s \times Q - (FC + v \times Q)$$

The formulae to find the break-even quantity and break-even sales quantity

$$\text{Break-even quantity} = \frac{\text{Fixed cost}}{\text{Selling price/unit} - \text{Variable cost/unit}}$$

$$= \frac{FC}{s - v} \text{ (in units)}$$

$$\text{Break-even sales} = \frac{\text{Fixed cost}}{\text{Selling price/unit} - \text{Variable cost/unit}} \times \text{Selling price/unit}$$

$$= \frac{FC}{s - v} \times s \text{ (Rs.)}$$

The contribution is the difference between the sales and the variable costs. The margin of safety (M.S.) is the sales over and above the break-even sales. The formulae to compute these values are

$$Contribution = Sales - Variable\ costs$$

$$Contribution/unit = Selling\ price/unit - Variable\ cost/unit$$

$$M.S. = Actual\ sales - Break - even\ sales$$

$$= \left(\frac{\text{Profit}}{\text{Contribution}}\right) X \quad Sale$$

$$M.S\ as\ a\ percent\ of\ sales = \left(\frac{M.S}{sales}\right) X100$$

$$\text{Break-even quantity} = \frac{\text{Fixed cost}}{\text{Selling price/unit} - \text{Variable cost/unit}}$$

$$= \frac{FC}{s - v} \text{ (in units)}$$

$$\text{Break-even sales} = \frac{\text{Fixed cost}}{\text{Selling price/unit} - \text{Variable cost/unit}} \times \text{Selling price/unit}$$

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$$Contribution = Sales - Variable\ costs.$$
$$Contribution/unit = Selling\ price/unit - Variable\ cost/unit$$
$$M.S. = Actual\ sales - sales\ at\ B.E.P$$
$$= \left(\frac{\text{Profit}}{\text{Contribution}}\right) X \quad Sale$$
$$M.S\ as\ a\ percent\ of\ sales = \left(\frac{M.S}{sales}\right) X100$$

### *ii.* ***Factors influencing demand***

The shape of the demand curve is influenced by the following factors:

- Income of the people
- Prices of related goods
- Tastes of consumers

If the income level of the people increases significantly, then their purchasing power will naturally improve. This would definitely shift the demand curve to the north-east direction of Fig. 1.2. A converse situation will shift the demand curve to the south-west direction.

If, for instance, the price of television sets is lowered drastically its demand would naturally go up. As a result, the demand for its associated product

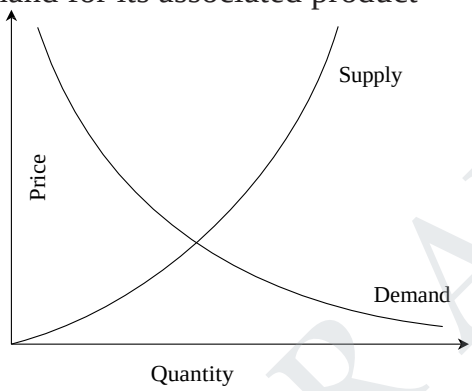


**Fig. 1.2** Demand and supply curve.

namely VCDs would also increase. Hence, the prices of related goods influences the demand of a product. Over a period of time, the preference of the people for a particular product may increase, which in turn, will affect its demand. For instance, diabetic people prefer to have sugar-free products. If the incidence of diabetes rises naturally there will be increased demand for sugar-free products.

***Factors influencing supply***

The shape of the supply curve is affected by the following factors:

- Cost of the inputs
- Technology
- Weather
- Prices of related goods

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.

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.

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

Again, take the case of television sets. If the price of TV sets is lowered significantly, then its demand would naturally go up. As a result, the demand for associated products like VCDs would also go up. Over a period of time, this will lead to an increase in the price of VCDs, which would result in more supply of VCDs.

***9. What is the process planning? What are its objectives? Explain the various steps in process planning. (May2015, Nov2013 May 2017) Process Planning /Process Modification***

***Answer - Page: 46***

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.

The steps in process planning are as follows:

1. Analyze the part drawing to get an overall picture of what is required.
2. Make recommendations to or consult with product engineers on product design changes.
3. List the basic operations required to produce the part to the drawing or specifications.

4. Determine the most practical and economical manufacturing method and the form or tooling required for each operation.
5. Devise the best way to combine the operations and put them in sequence.
6. Specify the gauging required for the process.

Steps 3–5 aim

To determine the most practical and economical sequence of operations to produce a component. This concept is demonstrated with a numerical problem.

***EXAMPLE*** The process planning engineer of a firm listed the sequences of operations as shown in Table 2.3 to produce a component.

**Table 2.3** Data for Example 2.6

| *Sequence* | *Process sequence* |
|---|---|
| 1 | Turning – Milling – Shaping – Drilling |
| 2 | Turning – Milling – Drilling |
| 3 | All operations are performed with CNC machine |

The details of processing times of the component for various operations and their machine hour rates are summarized in Table 2.4.

**Table 2.4** Machine Hour Rates and Processing Times (minutes) for Example 2.6

| *Operation* | *Machine hour rate* (Rs.) | *Process sequence* 1 | 2 | 3 |
|---|---|---|---|---|
| Turning | 200 | 5 | 5 | – |
| Milling | 400 | 8 | 14 | – |
| Shaping | 350 | 10 | – | – |
| Drilling | 300 | 3 | 3 | – |
| CNC operations | 1,000 | – | – | 8 |

Find the most economical sequence of operations to manufacture the component

***Solution*** *(a) Cost of component using process sequence 1.* The process sequence 1 of the component is as follows:

Turning – Milling – Shaping – Drilling

The calculations for the cost of the above process sequence are summarized in Table 2.5.

**Table 2.5** Workings for Process Sequence 1

| *Operation No.* | *Operation* | *Time* (min) | *Time* (hr) | *Machine hour rate* (Rs.) | *Cost* (Rs.) |
|---|---|---|---|---|---|
| 1 | Turning | 5 | 0.083 | 200 | 16.60 |
| 2 | Milling | 8 | 0.133 | 400 | 53.20 |
| 3 | Shaping | 10 | 0.167 | 350 | 58.45 |
| 4 | Drilling | 3 | 0.050 | 300 | 15.00 |
| | | | | Total: | 143.25 |

*(b) Cost of component using process sequence 2.* The process sequence 2 of the component is as follows:

Turning – Milling – Drilling

The calculations for the cost of the above process sequence are given in Table 2.6.

**Table 2.6** Workings for Process Sequence 2

| *Operation No.* | *Operation* | *Time* (min) | *Time* (hr) | *Machine hour rate* (Rs.) | *Cost* (Rs.) |
|---|---|---|---|---|---|
| 1 | Turning | 5 | 0.083 | 200 | 16.60 |
| 2 | Milling | 14 | 0.233 | 400 | 93.20 |
| 3 | Drilling | 3 | 0.050 | 300 | 15.00 |
| | | | | Total: | 124.80 |

*(b) Cost of component using process sequence 3.* The process sequence 3 of the component is as follows:

Only CNC operations

The calculations for the cost of the above process sequence are summarized in Table 2.7

**Table 2.7** Workings for Process Sequence 3

| *Operation No.* | *Operation* | *Time* (min) | *Time* (hr) | *Machine hour rate* (Rs.) | *Cost* (Rs.) |
|---|---|---|---|---|---|
| 1 | CNC operations | 8 | 0.133 | 1,000 | 133 |

The process sequence 2 has the least cost. Therefore, it should be selected for manufacturing the component.

***10. (i) Explain as to how the concept elasticity of demand is superior to concept of law of demand. (Nov2009) (ii) Analyses the various types of elasticity of demand and their usefulness.*** ***Answer-Page no: 18***

The law of demand tells us that a change in price of a commodity is followed by a changes is quantity demanded. But the rate at which demand changes is different for different commodities. The law of demand tells us the direction of changes, but not the rate at which the change takes places. The elasticity of demand changes in response to changes in price.

Elasticity of demand may be defined as the degree of responsiveness of quantity demanded to changes in price. Elasticity of demand may be defined as the degree of responsiveness of quantity demanded to a change in price.

Elastic and inelastic demand a demand for the good is elastic when the quantity demanded responds greatly to price changes the demand is inelastic when its quantity demanded responds greatly to price changes. The demand is inelastic when its quantity demanded responds very little to changes in its price.

***11. What is the cost volume 'profit analyses? State the assumptions and applications of breakeven analysis. (Nov 2009)***

Assumption in the breakeven analysis

The following assumption are made while plotting a breakeven chart

1. The total cost of production can be divided into two categories a. fixed b. variable cost.
2. Fixed cost remains constant i.e it is independent of quantity produced and includes executives' salaries rent of building depreciation of plant and equipment etc.
3. The variable cast varies directly and proportionately with the volume of production. It v=variable cost per unit and
   Q=is the quantity produced,
   Variable cost =VxQ.
4. The selling price does not changes in the volume of sales. If p is the selling price per unit. The total sales income =PxQ.
5. The firm deal with only one product, or the sales mix. Remains unchanged.
6. There is perfect synchronization between production and sales. This assumes everything produced is sold and there is no change in the inventory of finished goods.
7. Productivity per worker and efficiency of plant, etc. remains mostly unchanged.

Any change in any one the above factors will affect the breakeven point and the profits will be affected by factors other than volume. Hence the result of the break even analysis should be interpreted subject to the limitations of the above assumptions.

Application of Break –Even Analysis. The following are some of the signification area of application of break-even Analysis. The manager is confronted with make or buy decision the necessary components or arts. Where the consumption is large making may be economical.

***12. (i) Explain the process of material selection in new product development***

***(ii)From the following details, calculate the breakeven point. What will be the selling price per unit if breakeven point to be brought to 9,000 units:***

***Variable cost per unit Rs.750.***

***Fixed expenses Rs.27, 00,000.***

***Selling price per unit Rs.1, 000. (Nov 2017, April 2008, May2011, April 2011)***

**i. 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:

- Cheaper raw material price
- Reduced machining/process time
- Enhanced durability of the product

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 two numerical problems.

**ii. Building Material Selection**

As discussed in the introduction to this chapter, the sourcing of raw materials will have a significant effect on the cost of any product. Hence, it is assumed that the price of raw material is location dependent. While sourcing a raw material, the cost of transportation is to be considered in conjunction with the price of the raw material. This concept is demonstrated with a numerical example.

ii. Given

Variable cost per unit Rs.750.
Fixed expenses Rs.27, 00,000.
Selling price per unit Rs.1, 000

$$\left[i.\,Break\ even\ quantity\ =\ \left(\frac{FC}{(S\ -\ V)}\right)\right]$$

$$=\ \left(\frac{2700000}{(1000\ -\ 750)}\right)$$

= 10800 units

$$ii.\,Break-even\ sales\ =\ \left(\frac{FC}{(S\ -\ V)}\right) X\ S\ \ Rs$$

$$=\ \left(\frac{2700000}{(1000\ -\ 750)}\right) X\ 1000\ \ Rs$$

= 10800000. R.s

iii. Contribution = Sales – Variable cost

= s **x** $Q$ – $v$ **x** $Q$

= (1000x 9000)-(750x9000)

=2250000 R.s

***13. What are all the factors influencing supply? (April 2011, Nov 2011)***

**Factors influencing supply**

The shape of the supply curve is affected by the following factors:

- Cost of the inputs
- Technology
- Weather
- Prices of related goods

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. 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. Weather also has a direct bearing on the supply of products.

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Again, take the case of television sets. If the price of TV sets is lowered significantly, then its demand would naturally go up. As a result, the demand for associated products like VCDs would also go up. Over a period of time, this will lead to an increase in the price of VCDs, which would result in more supply of VCDs.

 

***14. Explain the concept of law of supply and demand with suitable example? (Nov 2008) (or)***
***15. Explain how demand and supply determine the equilibrium price. What happens if the supply curve shifts to the right? Illustrate. (May 2012) (Same Answer for both Questions.)***
***16. Explain why the demand curve slope downward. (Nov 2014) (or)***

## Law of Supply and Demand

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. The interrelationships between them are shown in Fig. 1.2..From Fig. 1.2 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. 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*.

Factors influencing demand;The shape of the demand curve is influenced by the following factors

- Income of the people
- Prices of related goods
- Tastes of consumers

If the income level of the people increases significantly, then their purchasing power will naturally improve. This would definitely shift the demand curve to the north-east direction of Fig. 1.2. A converse situation will shift the demand curve to the south-west direction. If, for instance, the price of television sets is lowered drastically its demand would naturally go up. As a result, the demand for its associated product,

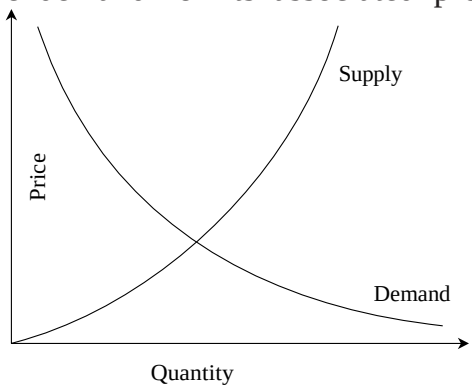


**Fig. 1.2** Demand and supply curve

 

namely VCDs would also increase. Hence, the prices of related goods influences the demand of a product. Over a period of time, the preference of the people for a particular product may increase, which in turn, will affect its demand. For instance, diabetic people prefer to have sugar-free products. If the incidence of diabetes rises naturally there will be increased demand for sugar-free products.

**Factors influencing supply**

The shape of the supply curve is affected by the following factors:

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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.

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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. Weather also has a direct bearing on the supply of products. For example, demand for woolen 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. Again, take the case of television sets. If the price of TV sets is lowered significantly, then its demand would naturally go up. As a result, the demand for associated products like VCDs would also go up. Over a period of time, this will lead to an increase in the price of VCDs, which would result in more supply of V

***17. List and explain the different situation deserving elementary economic analysis. (Nov 2010, May 2014, Nov 2015, Nov 2017)***

## EXAMPLES FOR SIMPLE ECONOMIC ANALYSIS:

In this section, the concept of simple economic analysis is illustrated using suitable examples in the following areas:

- Material selection for a product
- Design selection for a product
- Design selection for a process industry
- Building material selection for construction activities
- Process planning/Process modification.

### 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:

- Cheaper raw material price
- Reduced machining/process time
- Enhanced durability of the product

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 two numerical problems.

### Building Material Selection

As discussed in the introduction to this chapter, the sourcing of raw materials will have a significant effect on the cost of any product. Hence, it is assumed that the price of raw material is location dependent. While sourcing a raw material, the cost of transportation is to be considered in conjunction with the price of the raw material. This concept is demonstrated with a numerical example.

### Design Selection for a Product

The design modification of a product may result in reduced raw material requirements, increased machinability of the materials and reduced Labour. Design is an important factor which decides the cost of the product for a specified level of performance of that product. The elementary economic analysis applied to the selection of design for a product is illustrated with two example problems

## 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.

The steps in process planning are as follows:

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

Steps 3–5 aim to determine the most practical and economical sequence of operations to produce a component. This concept is demonstrated with a numerical problem.

***18. (i) Explain the scope and significance of economics.***
***(ii) Discuss the main area of application of engineering economics (May 2015, May 2009)***

1.19 SCOPE AND SIGNIFICANCE OF ENGINEERING ECONOMICS

1. **The problem of scarcity and choice**. It focuses on the problem of scarcity and choice. Resources are scarce. They are not available in abundance. Hence, goods and services Cannot be produced as much as we required. Thus, goods and services are also scarce. The
Problem of scarcity gives rise to the problem of choice. Because choice is so pervasive, a
Great deal of intellectual effort has gone into study. The process of choice is a part of culture Customs, habits, religion, historical and other factors in a society. Most of the personal decisions are made within the limits imposed by time, laws and customs. Economics tell us how best to Use the scarce resources to derive the greatest amount of satisfaction.

2. **Allocation of resources**: It explains how scarce resources can be allocated efficiently. It reconciles the conflice between matching unlimited wants with the scarce resources. Because Resources are scarce, individuals, films and nations have to make careful choices. Individuals have to carefully allocate their budgeted income to various goods and services in order to maximise their satisfaction. Firms have to allocate the limited resources with the utmost care to minimise costs and maximise profits. Any misallocation will lead to inefficiency and, consequently, looses. Nations have to allocate their limited resources efficiently in order to achieve the goals such as a satisfactory growth rate, low unemployment rates, a moderate rate of inflation and growth with equity. Nations also have to reconcile between conflicting goals. For example, economists opine that there is a trade-off between unemployment and inflation. If unemployment levels are to be reduces, the nation has to live with a higher rate of inflation. Likewise, if more resources are allocated to the defence sector, fewer resources will be available for education, health. And So on.

**3. A prerequisite for problem solving**: An understanding of Economics is a prerequisite to solve economic problems such as inflation, unemployment and so on.

**4. What to produce:** It explains how price determines the kind of goods and services that are to be produced in an economy. If a commodity fetches a higher price, the society needs more of such commodities and, according1 firms must produce more of such commodities. When there is a higher demand for a good or service, the price of the good or service rises and it is an indication for the firms that more of it is to be produced.

**5. How to produce:** Firms produce goo4and services choosing efficient methods of Production. Generally, two processes or methods of production are available to firms-capital intensive and labour intensive. The capital is available at a lower rate, firms adopt capital intensive methods of production. On the other hand, if labour is cheap, firms adopt

labour 1'intensive techniques, that is the same good or services are produced with more labour as labour is cheap. How to produce depends upon the prices of the factors of production.
Throughout there is a shift from using expensive inputs to less expensive inputs. For example in countries such as China and India, labour is relatively cheap and labour. Intensive techniques arc used. In countries such as the USA. Capital is cheap and labour expensive. Hence. They prefer automation.

6. **For whom to produce:** In a market economy this is decided by the markets. For example firms produce mere of those goods and services that fetch higher prices. The prices much-in-demand goods and services are higher. Members of the society who have a great purchasing power can influence the kinds of goods that are produced.

7. **Income distribution**: The distribution of income in a country tells how income is djj between different groups or individuals. If distribution of income is left completely to the market forces, inequalities of income and wealth in the society tend to increase.

**8. Economic systems**: There are two kinds of economic systems-a capitalist or free-mark Economy system and a socialist or centrally-planned economic system. Decisions such as
What to produce, how to produce and for whom to produce are decided by the markets
Through a price mechanism in capitalist or free-market economy nations and by a central Committee or the government in socialist or centrally planned economy countries. Economics throws light on the functioning of different economic systems and different theories of development.
**9. Policy issues**: Economics discusses the problems in measuring national income, interest
Rates and their impact on income and employment, balance of trade and balance payments,
Exchange rates, the theories of international trade and the significance of international trade and a nation's development.
Appropriate policies can be formulated for the development of economy. The kind of policies formulated will make or mar the progress of the economy.
Both economic theory and economic policies constitute the subject matter of Economics. Economic theories will be reduced to a useless intellectual exercise if they do not suggest Sound policy implications. Thus, the scope of Economics is not merely to satisfy intellectual curiosity by developing theories but to formulate sound economic policies.

**10. Thrust area:** Economics studies the problems of consumption, production, exchange and consumption, investment, income and employment development, banking, currency and at the macro level. It ah international trade

**The main area of1 application of engineering economics.**
Mac Economic study is indispensable for formulation of successful government economic policies whether capitalism, socialism or communism, the concept of welfare has gained momentum in all economics intervention in economic affairs is increasing day by day. The economic policies of the government are directed towards the masses and not towards few chosen groups. Therefore, the government must possess adequate knowledge of the aggregates like total national income, total consumption. Total savings and investment. Accurate and reliable statistics of 'aggregative variables' are essential for sound economic policies. In this context the importance of Macro-study can be well imagined.
The area covered by macro-economics are:
I. Theory of income, output and employment.
2. Theory of prices.
3. Theory of economic growth.
4. Macro theory of distribution.
1. Theory of income, output and employment consists of theory of consumption function and the theory investment and also business cycle.
2. The theories of prices consists of the theories of inflation, deflation and reflation.
3. Theory of economics growth deals with the long-run rowth of income, output and employment as applied to envelop and underdeveloped countries.
4. Macro theory of distribution deals with the relative are of wages and profits in the total national income and employment, macroeconomics is called 'income and employment theory'. And "Macro' denotes 'very big' and subject matter of Economics is analyzed either through micro analysis or macro analysis.

**SCOP' and significance" of Micro Economics**:
Micro economic deals with the analysis of small Units the economy such as Individual consumers. Producers Firms and small units like industries or markets.

"Micro Economics" is the study of particular firm's particular household, individual prices, wages, incomes, Individual industries, particular commodities''. Micro Economics relates to an inquiry as to how an individual maximizes his satisfaction, how a maximizes its profit and how the households adjust expenditure to income.

Micro-economics that tells us how a free-make economy with its millions of consumers and producers work to decide about the allocation of productive resources among the thousands of goods and services.

It is only through Micro-Economics we came to know. "How the goods and services produced arc distributed among the various people for consumption, through price or market mechanism".

Micro-Economic theory explains the conditions of efficiency in consumption and production and

Suggests suitable policies to promote economic efficiency and welfare of the people in the economy.

It has a normative role in maximizing the satisfaction of the people and the welfare of them.

Held covered by micro by micro economics are

1. Theory of Product pricing
2. Theory of factor pricing.
3. Theory of economics welfare.

The theory of product pricing constitutes the theory of consumer' behavior and the theory of production and cost, the theory of factor pricing constitutes the theory of wages, rent, interest and profits.

Micro-economics analysis is applied in many branches of economics such as international trade and public finance, incidence of tax on producers and consumers is determine only through micro-economics analysis.

The gain from international trade and the distribution of gain among the participant countries are found out through micro analysis.
The determination of foreign exchange rate depends on the study of demand and supply of that currency. Thus micro-economic analysis largely used in various branches of economics theory.

**Scope and Significance of Macro-Economics**

With the onset of the 'Great Depression' due to the Failure of free economy, macro-study gained importance as weakness of 'micro' was fully exposed.
Macro-economics is a study of overall conditions like total production, total income, total saving and total investment in the economy.

Macro-Economics deals not with individual quantities a, but with aggregate of these quantities; not with.

***19. Discuss the flow in an economy with a neat sketch. What are all the factors increasing supply? (Nov 2011)***

**Flow Economy**

The modem economy is a monetary economy. In the modem economy, money in the process of exchange. Money has facilitate the process of exchange and has removed the difficulties of the barter system. Thus acts as a medium of exchange. The households supply the economic resources or fact to the productive firms and receive in return the

payments in terms of money.
From this, it is clear that in the monetary economy, there will be flows of money corresponding to the flows of economic resources and the flows of goods and services. But each money flow is in opposite direction to in real flow. Real flows of resources, goods and services have been shown in

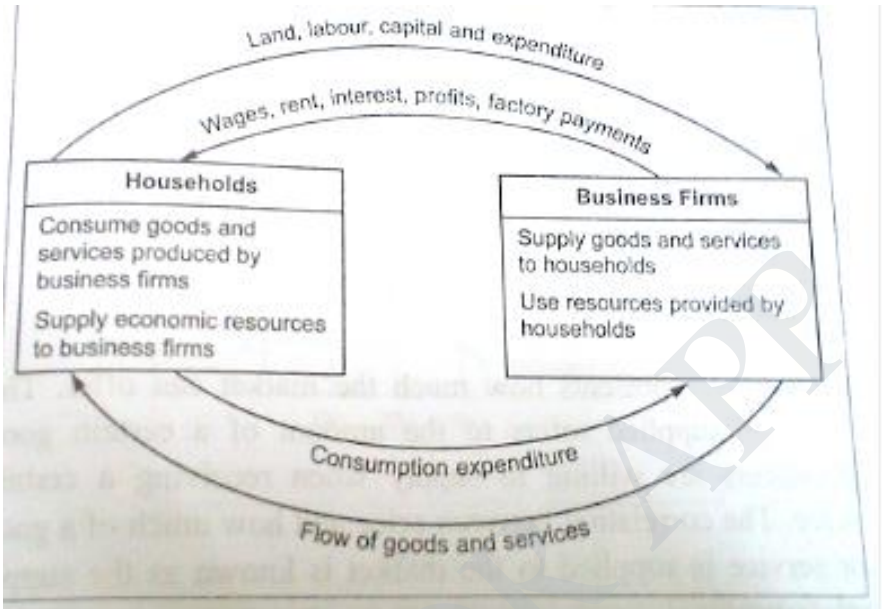



*Fig. 1.1. Flow of money, goods and services, and resources in a simple two sector economy*

Fig. I. 1. In the upper loop of this figure, the resources such as land, capital and entrepreneurial ability flow from households to business firms as indicated by the arrow marks. In opposite direction to this, money flows from business firms to the households as factor payments as wages, rent, interest and profits.In the lower part of the figure. Money flows from households to firms as Consumption expenditure made by households on the goods and services produced by firms, while the flow of goods and services is in opposite direction from to households.Thus we see that money flow from business firm to households as factor payments and then it flow from households to firms, Thus there is infact, a circular flow of money or income.

***20. What is break even analysis? What are all the assumptions of break-even analysis?***
***Beta associates has the following details:***
***Fixed costs = R.s, 1, 00,000***
***Variable cost per unit = R.s. 50***
***Selling price per unit = R.s. 100***
***Find (1) The break-even sales quantity.***

***(2) The break-even sales revenue.***
***(3) If the actual production quantity is 60,000.***
***Find (1) Contribution and (2) Margin of society. (Nov 2011).***

$$\left[i.\,Break\ even\ quantity\ =\ \left(\frac{FC}{(S\ -\ V)}\right)\right]$$

$$=\ \left(\frac{100000}{(100\ -\ 50)}\right)$$

= 2000 units

$$ii.\,Break-even\ sales\ =\ \left(\frac{FC}{(S\ -\ V)}\right) X\ S\ \ Rs$$

$$=\ \left(\frac{100000}{(100\ -\ 50)}\right) X\ 100\ \ Rs$$

= 200000. R.s

iii. Contribution = Sales – Variable cost

= s **x** $Q$ – $v$ **x** $Q$

= (100x 60000)-(50x60000)

=3000000 R.s

iv. Margin of safety = Sales-Break Even Sales

Profit = contribution-Fixed cost

=3000000-200000

=2800000 R.s.

***21. (a) (i) Draw a breakeven chart and explain its components.***

***(ii) From the following figures find out***

***(1) The break-even sales quantity.***

***(2) The break-even sales.***

***(3) If the production quantity is 30,000, find contribution and margin of safety.***

***Fixed cost = Rs.10, 00,000; Variable cost per unit = R.s 50; Selling price per unit = Rs.100. (May 2010).***

ii.Break Even Chart

A Break-Even chart is a Graphical representation of the relationship between costs and revenue at a given time.

It is a graphic device to determine the break-even point and profit potential under varying condition of output and costs

TC= total cost

FC=Fixed cost

VC=Variable cost

Q= Volume of production

B=The intersection of TC And sales

S=Selling price per unit.

v=Variable cost per unit.

Total cost = Fixed cost+ variable cost

TC= FC+VC

=FC+ v x Q

The linear plots of the above two equations are shows Fig... The intersection point of the total sales revenue and the total cost line is called as the break-even point. The

Corresponding volume of production on the X-axis is known as the break-even sales quantity. At the intersection point .The total cost is equal to the total revenue.

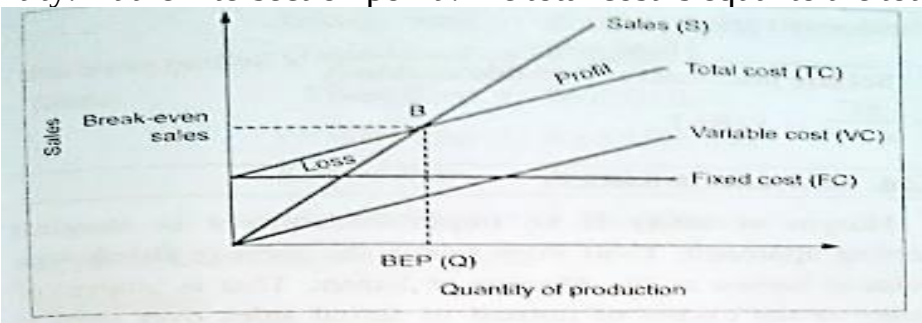



*Fig. 1.5. Break-even chart*

**ii.**

Given Data:

Fixed cost=100000

Variable cost per unit=R.s 50

Selling price per unit=R.s 1000

To find: 1. Break- even sales quantity

2. Break- even Sales.
3. Contribution and margin of safety if the production quantity is 30000.

Sol.

1. Break-Even Sales Quantity.

= (Fixed cost/ (Selling price-Variable cost)

=1000000/(100-50)

=1000000/50

=20000 units

2. Break-Even Sales

= Break-Even Sales Quantity x selling price

=20000 x 100

=2000000 R.s

3. Contribution

=Sales- variable cost.

=(selling) x (Volume of Production )-(variable cost ) x (Volume Production)

=100x30000-50x 30000

=3000000-1500000

=R.s 15000000

4.Margin of Safety

= Sales- Break –Even sales

=30000 x 100- 2000000

=R.s 1000000

Result

Break-even Quantityh= 20000units

Break-even sales=R.s 2000000

Contribution =R.s 1500000

Margin of Safety=R.s 1000000

***22. What is process planning? What are its objectives? Explain the various steps in process planning. (May 2010)***

**PROCESS PLAN**

A Process is defined as any group of actions instrumental to the achievement of the Output of an operations system in accordance with the specified measure of effectiveness. Process planning is the systematic determination of the methods by which a product is to be manufactured economically and competitively. Process planning has been defined as the subsystem responsible for the conversion of design data to work instruction.

Process planning is "that Junction within a manufacturing facility which establishes the process and process parameters to be used (as well as those machine capable of performing these processes) in order to convert a piece-point from its initial form to a final form that is pre-determined drawing.

**Process Planning Procedure.**

The various steps involved ¡n process planning are:

1. Preparation of working drawings
2. Deciding to make or buy
3. Selection 0fanufaCtLtriflg process
4. Machine capacity and machine equipment selection
5. Selection of material & bill of materials.
6. Selection of jigs. Fixtures and other attachments.

I. Is this operation necessary?

2. Can this operation be combined with another?
3. Are the operations performed in the best sequence?
4. Does this process give the right quantity?
5. Is the process definite, i.e. do the workers & management know-how to produce?
6. Can the operation be simplified?
7. Can a manual job be done by a machine?

S. Are the materials and parts up Lo the required standard of quality and accuracy?

9. Can the proportion of scrap be reduced?
10. Is best use made of unavoidable scrap?
11. Is it desirable to eliminate (or) separate the operations?

**Process Selection Process selection produced**. It involves

1 .Major technological choice
2. Minor technological choice
3. Specific Component choice
4. Process flow choice

1. Major Technology Choice.

-Does technology exist to make the product?

-Are there competing technology among which we should choose?

— should the technology be developed in the country itself
— Should innovations be licensed from foreign countries?

**Minor Technological Choice**

- Once the major technological choice is made, there may be a number of minor technological process.

Alternatives available. The operations manager should be involved in evaluating alternatives for costs and for consistency with the desired product and capacity plans.

— Should the process be continuous, which is carried out for 24 hours a day in order to avoid expensive start-ups and shutdowns as used by steel and chemical industries.

— An assembly line process on the other hand, follows the same series of steps as mass production but need not run for 24 hours a day e.g. automobile and readymade garment industries.

— Job shop process produce items in small lots, perhaps custom-made for a given customer made for a given customer/market.

— Suppose, we make a job shop choice. The alternatives do not end here. For example, in a factory the

Fabrication, joining together and finishing off to pieces of metal, may represent only a minuscule part.

Of creating a finished product. There may be numerous ways of casting md mouldings several ways of cutting, forming assembly and finishing.

Deciding on best combination of process in them of cost and total operation process can be difficult.

**Specific component choice**

What type of equipment (and degree of automation) should be used.

-Should the equipment be specific purpose or general purpose/

-Should the equipment be specific purpose (or) general purpose?

To what degree should machines be used to replace human labour in performing & automatically controlling the work?

— Computer Aided Manufacturing (CAM) and industrial robots are being used increasingly in many

Manufacturing systems.

**Process Flow Choice**

-How should the product flow through operation system?

-The final process-selection step determines how material and products will move through the system.

-Assembly may lead to Resequencing , Combining or Eliminating operation in order to reduce material handling and storage costs.

**Factors Influencing Process design**

The following factors should be considered while designing a manufacturing process.

**1. Volume of Output**
The quantity and rate of production affects the methods of production. Generally more advanced methods of manufacture can be used when output is large. The number of identical units to be produced exercises important influence on manufacturing design. In multi-product organisation. Standardisation of component parts and product are very important in process designing.

**2. Volume vs Variety**
It could be considered as continues. One extreme end of this continue shows very high variety (and hence very low volume). The other extreme is that of very low product variety but very high volumes. Variety requires skilled technicians, general purpose machines & complex production planning and control. High volume requires automation, mass production machines and simple production planning and control.

**3. Quality of the Product.**
Product quality determines the quality of components parts and materials which in turn determines the methods and equipment to be used. Therefore, drawing, specifications, bill of materials, Parts lists, etc. Should be read by the process engineer to determine process design.

**4. Type of Equipment's.**
The process engineer should attempt to design manufacturing processes that are adaptable to and will balance the productive load of existing equipment that may be used in the manufacture of the product.

**5. Environmental Effect**
Process selection responds to environmental changes. Especially changes in technology. A process may have replaced as it might have obsolete. Even the technology ¡involved in organising the operations function tells upon the process selected.

**6. Forms of Transformation Process**
Process selection also refers to the selection of sub processes. And the sub-process of these Sub-processes also. When the output consists of a product there are assemblies and sub-assemblies and this break-up continues till the elementary level of component become incapable of being.
Broken down further. These components and sub-components can either he made by the organisation or purchased from outside. We have to take "make or buy" decision here. For those components which arc to be made. The organisation has to select the process-technology to he employed, and also to decide on the sequence of operations, process storage and transport from one work-centre to another, plant and machinery for

transformation process. Manpower deployment layout of the work-place. Tooling jigs and fixtures necessary, etc.
For example. If an organisation assembles certain products like transistor, radios. etc., it has to outline in detail the assembly process. Here. The point to be noted in that there is no ideal process for an ideal product-there is room for improvement in both the process used and the output generated.

**7. Produce-to-Stock Vs Produce-to-Order**
One important consideration affecting selection of process is that of making production either for storage a selling or receiving an order first from the customers, then starting the production process. Standardisation and variety reduction lead to batch production which forms the inventory from which stock to sell are drawn inventory from which stock to sell are drawn, is replenished by further batch production once it reaches a minimum pre-determined level. The system employed here is anticipated of demand. There is no waiting time involved for the customer. Such products arc inventory able.
The risk is much more in the case of perishables and short shelf-life products. Produce-to-order is customaries producing where the manufacturing process follows the respect of customer's order. Yes, there is a waiting time for the customer (delivery date) in this process. The time ¡s proportional to the head time of the operational process. Non-inventory services are always produced to order, ensuring that the waiting time for the customer is as short as possible.
There could be combination of both of these process-components and spares are produced to stock and the assembly is carried out to order. In a restaurant dishes are in the semi-cooked form (procedure to stock) and ar3e converted to dishes to be served on customers demand (produce to order).

**8. Output characteristic Vs Process Selection.**
The selection of process form- Project types. Intermittent- types. Continuous-types or process type depends upon the characteristics of the output. For Example, unique non-repetitive output like ship-building requires project-from. Assembly of ceiling fans may require intermittent-form Intermittent -form may be used if the batch-size is small. There are products with no Variety at all and they are genet commodities-fertilizers, Sugar, cement and others. The require a Continuous process-form.

***23. (ii) A firm has a fixed cost of R.s. 50,000. Selling prices per unit is R.s. 50 and variable cost per unit is Rs.25. Present level of production of is 3,500 units. (May 2009)***

***(1) Determine the break-even points in terms of volume and sales value.***

***(2) Calculate margin of safety.***

***1. Break-even point in terms of volume***

$$= \frac{\text{Fixed cost}}{\text{Selling price} - \text{Variable cost}}$$

$$= \frac{50000}{50 - 25}$$

$$= \frac{50000}{25}$$

$$= 2000 \text{ units}$$

***2. Break-even sales***

$$= \frac{\text{Fixed cost}}{\text{Selling price} - \text{Variable cost}} \times \text{Selling price}$$

$$= \frac{50000}{50 - 25} \times 50$$

$$= \frac{50000}{25} \times 100$$

$$= \text{Rs } 1,00,000$$

***3. Margin of safety***

$$= \text{Sales} - \text{Break-even sales}$$

$$= (3500 \times 50) - 100,000$$

$$= 1,75,000 - 1,00,000$$

$$= 75,000$$

***Result***

1. Break-even point in terms of volume = 2000 units
2. Break-even sales value = Rs 1,00,000
3. Margin of safety = Rs 75,000

***24. Explain the detail the different element of cost. (May 2014)***

**ELEMENT OF COST.**

Simple ascertainment of total Cost cannot satisfy the various requirements of decision making. For effective control and managerial decision making, data is to be provided on the basis of analysed and classified Costs. In order to satisfy this objective Cost is analysed by element of cost i.e., by nature of expenditure.

The elements of cost are:

1. Materials
2. Labour cost
3. Expenses

The above elements of cost are analysed in the chart given below.

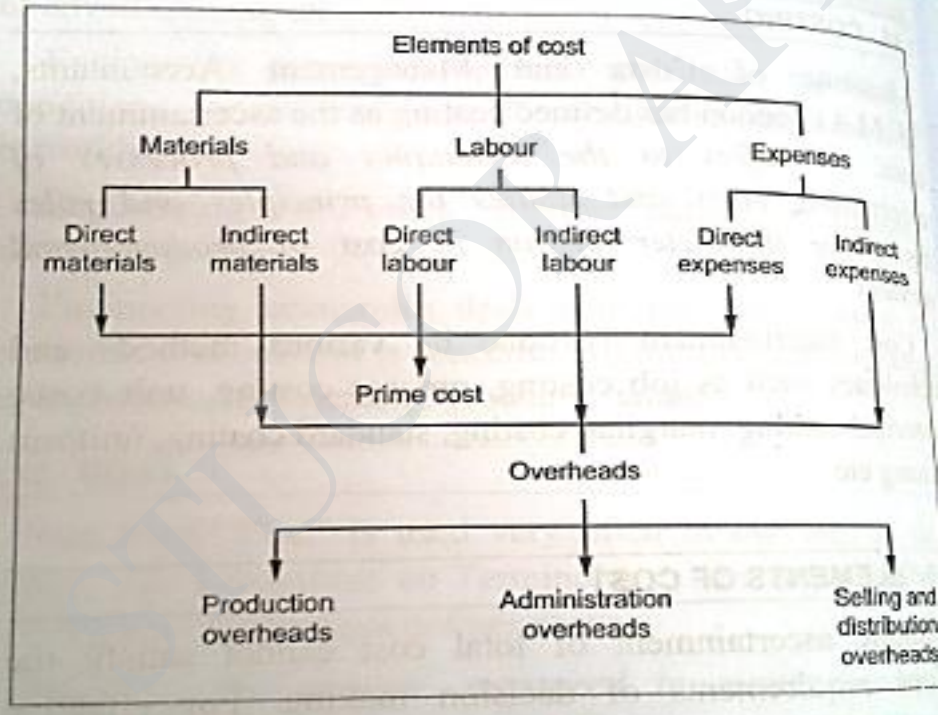



*Fig. 1.4.*

The above elements of cost are explained below:

**1. Materials**

***"The material cost is the cost of commodities supplied to an undertaking"- I.C.M.A.***

Material cost tis two types (i) Direct material cost and (ii) Indirect material cost. Direct material is material that can be directly identified with each unit of the finished product.

Raw materials, semi-finished material Component etc. Which become part and parcel of the product are known as direct material. For example, cotton used in production of cloth leather used in for a specific job are materials

**2. Indirect Materials**

Materials used for the product other titan the direct materials are called indirect materials. In oilier words, materials cost which cannot be identified with a product, job, process is known Process is known as indirect material cost.

Small tools, stationery used in works, office stationery. Advertising posters and materials used in maintenance of plant and machinery arc a few examples of indirect materials.

**3. Labour**

Labour is the remuneration paid for physical or mental effort expended in production and distribution. " The labour cost is the cost of remuneration (wages, salaries, commissions, banus, etc). Of the employers of an undertaking" Labour cost is also divided into direct and indirect portions.

**(i) Direct Labour Cost**

It is also called 'Direct wages'. Direct labour cost is the cost of labour directly engaged in production operations. For example workmen engaged in assembling parts, carpenters engaged ¡n furniture making etc.

**(ii) Indirect Labour Cost**

Indirect labour cost is the re paid for engaged to help the production operations. For example inspectors, watchmen, sweepers, storekeepers, etc. Remuneration paid to these persons cannot be traced to a process or production order. The labour costs of idle time, overtime, holidays etc. also taken as indirect costs. Similarly, clerical and managerial staff, salesman, distribution employees are also included in the orbit of 'Indirect labour'

**(iii). Expenses**

It is defined by I.C.M.A as the cost of service provides to an undertaking and the national cost the used of owned assets"

Assets ".

Expenses arc of two types:

(I) Direct expenses and

(ii) Indirect expenses

(I) Direct Expenses

These are the expenses which can be directly identified with a unit of output, job, process or operation. They are specifically incurred for a job, or unit or process and in no way the connected with other jobs or process. The direct expenses are also known as chargeable expenses. For example, hire charges of special plant used for a job royalty

**(iii) Selling and Distribution overhead**

This includes indirect selling and distribution expenses, Examples are salaries of salesman, selling

Advertising, warehousing rent, maintenance of delivery vans warehouse staff expenses, warehouse lighting, etc.

***25. State and explain the factors influencing Process design. (Nov 2014)***

***26. Explain why the demand curve slope downward. (Nov 2014)***

***27. Discuss about the simple economics analysis. (May 2014)***

***28.(i) Trace out flow of Goods, services, resources and money payment in an Economy with a suitable sketch. (May 2016).***

***(ii) Different between law of demand and law of supply.***

***29 Analyze the various types of elasticity of demand and their usefulness. (Nov 2015).***

***Answers: Refer above Questions***

# UNIT II - VALUE ENGINEERING

***PART – A*** ***2 Marks***

***1. Mention the criteria for make decision. (Nov 2013, May 2015)***

1. Opportitative costs.
2. Incremental cost
3. Idle facilities.

***2. What is BEP? (May 2014).***

Break-Even Point is the volume of output at which neither a profit is, where the total revenue equals total cost.
B.E.P = (F.C/(S.P-V.C))

***3. Mention any two applications of various interest formulas. (Nov 2013)***

Interest is the cost of using capital. Interest is the premium paid by a borrower to compensate a lender for the administrative cost of making a loan the risk of nonpayment and the loss of earning of the loaned money. The cost of money is established and measured by an interest rate. It is more appropriate for engineering economics to view interest as the productive gain from the efficient use of the money resource.

***4. State any two uses of Value Engineering. (May 2013)***

Value analysis identifies and reduces- the product cost.
It modifies and improves the product design.
It increases the performance/utility of the product economical means.
It helps to generate new ideas.
It creates quality consciousness and cost consciousness among the employer.

***5. What is time value of Money? (May 2013, Nov 2011, May 2011, May 2010, Nov 2008, Nov2012, May 2010, Nov2016, Nov 2014, May 2017)***

An owner of money can lend it at the prevailing rate of interest and wait to be repaid the original amount plus an extra increment. Equivalently the borrower could convert the money into productive good that would be expected to earn more than the amount needed to repay the loan. In both cases the prevailing interest rate sets minimum level of expected productivity and both cases involve time between receipt and return of the to secure the earning the time value of money.

***6. Define value analysis (V/A)/Value Engineering. (Nov 2012, May 2011, May 2009, Nov 2009, Nov 2011, Nov 2016, Nov 2014, Nov 2015,Nov 2017).***

An owner of money can lend it at the prevailing rate of interest and wait to be repaid the original amount plus an extra increment. Equivalently the borrower could convert the money into productive good that would be expected to earn more than the amount needed to repay the loan. In both cases the prevailing interest rate sets minimum level of expected productivity and both cases involve time between receipt and return of the to secure the earning the time value of money.

***7.What is time engineering? (Nov 2011)***

We may define the principle of time value money as follows. The economic value of a sum depends on when it is received. Because money has earning power over time a rupee received today has a greater value than a rupee received at some future time.

***8. What would be the future value of R.s 100 invested in a fixed deposit of 5 year with an interest rate of 15% compounded annually? (May 2010)***

F=P(1i)^N
=P(F/P,i, N)
=100(F/P, 15%,5)
=R.s 201.1

***9. What is meant by discounting? (May 2012, Nov 2010, Nov 2009, Nov 2015)***

Finding the present worth of a future sum is simply the reverse of compounding and is known as discounting process.

The formula to obtain present worth is

P= F/(1+i)^N
=F(P/F,i,N)

(P/F,I,N) is the factor notation for single payment present worth factor. The interest rate i and the P/F factor are also referred to as the discount rate and discounting factor, respectively.

***10.What is annual equivalent method of comparing alternatives? (May 2008).***
***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. The corresponding cash flow diagram is shown in Fig. 3.8. Here,***

$P$ = present worth, $A$ = annual equivalent payment
$i$ = interest rate, $n$ = No. of interest periods The formula to compute $P$ is

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

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

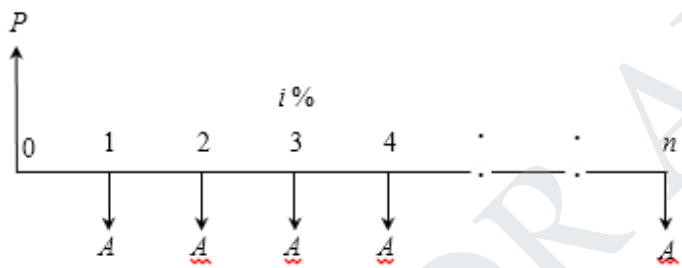



**Fig. 3.8** Cash flow diagram of equal-payment series present worth amount.

***11. Give the expression for single payment present worth factor. (May 2012). Write down the formula to obtain single-payment compound amount. (Nov 2010).***

**Single-Payment compound Amount**

Given a present sum, P invested for N interest periods at interest rate,I what sum will have accumulate at the end of periods? Here the aim is to find the single future sum (F) of the intinal payment(P)
The cash flow transaction of this situtation is illustrated in Fig 2.3

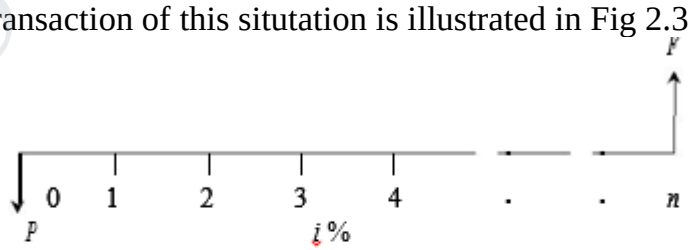



**Fig. 3.3 Cash** flow diagram of single-payment present worth amount.

The formula to obtain the present worth is

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

***12.List few factors that need to be considered in making a "make or buy" decision (May 2012).***

Quantitative Factors

1. Opportunity costs
2. Increment costs
3. Idle facilities

Qualitative Factors

1. Product Quality
2. Patents
3. Skills and Materials
4. Long term considerations.

***13. How much will a piece of property have to increase in value over the next 5 years, if it is to ear 10% per year on the purchase price? (May 2011, May 2008).***

N=5
I=10%
P/F=1/ (1+0.1) ^5
P/F=0.628

***14. Calculate the present worth of the following payments Rs 5,000 in year 3 in 10000 in year 5. (May 2011, May 2008)***

P= F/ (1+i) ^N

***15. What are the approaches available for make or buy decision? (Nov 2011)***

The following are the approaches /analysis followed in make or buy decisions.

1. Simple cost analysis
2. Economic analysis
3. Break-even analysis.

***16. What is the different between Accounting cost and economic cost? (May 2009)***

Accounting cost is the total amount of money or good s expended in an endeavor. It is money paid out at some time in the past and recorded in journal entries and ledgers. It reflects what a firm actually pays for capital equipment and any other cost incurred to provide service during that accounting period. The economic cost is the actual forward cost is the actual forward looking cost, forward looking. Cost are the cost of present and future uses of a firm resources. Only forward looking cost are relevant for making pricing production and investment decisions in the present or the future.

### *17. Define single payment present worth factor? (May 2009, May 2012)*

## 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.

The corresponding cash flow diagram is shown in Fig. 3.3.

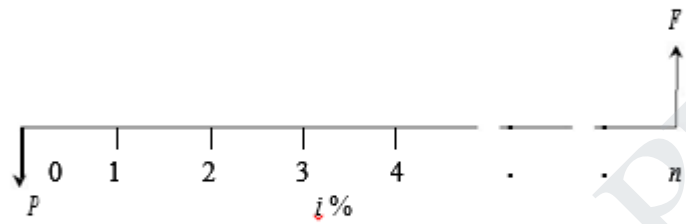



**Fig. 3.3 Cash** flow diagram of single-payment present worth amount.

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.*

### *18. What is sinking Fund Factor? (Nov 2009, Nov 2008)*

## 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 $i$.

The corresponding cash flow diagram is shown in Fig. 3.6.

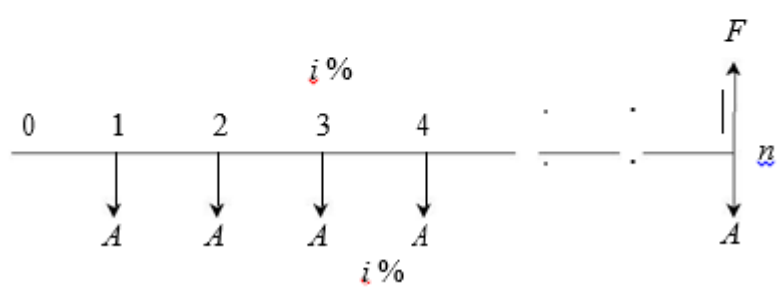



**Fig. 3.6 Cash** flow diagram of equal-payment series sinking fund.

### *19. What is simple interest rate? (May 2014)*

Under simple interest scheme, the interest earned in each period is the calculated based on the principle amount. In this scheme, calculation of interest is not applicable.

### *20. What is Make or Buy decision? (May 2014)*

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. So, in a given situation, the organization should evaluate each of the above make or buy alternatives and then select the alternative which results in the lowest cost. This is an important decision since it affects the productivity of the organization. In the long run, the make or buy decision is not static. The make option of a component/product may be economical today; but after some time, it may turn out to be uneconomical to make the same. Thus, the make or buy decision should be reviewed periodically, say, every 1 to 3 years. This is mainly to cope with the changes in the level of competition and various other environmental factors.

### *21. What is effective interest rate? (May 2014)*

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

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

where,

$i$ = the nominal interest rate

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

**PART –B**

***1.A company has extra capacity that can be used to produce a sophisticated fixture which it has been buying for Rs 900 each. If the company makes the fixture, it will incur material cost of Rs 300 per unit, Labour costs of Rs 250 per unit and Variable overhead cost Rs.100 per unit. The annual fixed cost associated with the in used capacity is Rs.10, 00,00. Demand. Over the next year is estimated at, 5,000 units. Would it be profitable for the company to make the fixture? (Nov 2016)***

Given:

Fixed cost: Rs 10,00,00.
Material cost: Rs 300/Unit.
Labour cost: Rs 250/Unit.
Variable overhead cost =Rs.100 /Unit.
Purchase price=Rs.900
Future Demand=5000units

Sol.

**Cost to make**

Variable cost/unit = Material Cost+ Labour cost + Overhead cost.
=300+250+100
=650 Rs.
Total variable cost =5000 X 650
=3250000 Rs.
Add fixed cost cost associated with unused capacity= 100000
**Total = 3350000.=best**

**Cost to Buy.**

Purchase cost= Rs. 5000 X 900
=4500000
Add fixed cost cost associated with unused capacity=100000
Total=4600000

***2. A person wishes to have a future sum of Rs 1,00,000 fir his son's education after 10 years from now. What is the single payment that he should deposit now so that he gets the desired amount after 10 years? The bank gives 15% interest rate compounded annually. (May 2015).***

**Given**

F=10,00,000
I=15% compounded annually.
N=12 Years

**To find: P**

Sol: The formula to obtain the present worth is

$P=F/(1+i)^N$

$=10,00,000/(1+15/100)^{12}$

=5350250.1054. Rs

***3.(i) Write briefly about the time value of money.***

***(ii) A person is planning for his retired life. He has 10 more years of service. He would like to deposit Rs. 8,500 at the end of the first year and thereafter he wishes to deposit the amount with an annual decreases of Rs.500 for the next 90 years with an interest rate of 15%. Find the total amount at the end of the 10th year of the above series. (May 2015).***

**Given:**

$A_1$=Rs. 8500
G= -500.
i=15%
N=10 Years.

**To find:**

A and F

**Solution: The formula to obtain A is**

$$A = A1 + G\frac{(1+i)^n - in - 1}{i(1+i)^n - i}$$

=A1-G (A/G,I,N)
=8500-500(A/G, 15%, 10)
=Rs. 6808.40

The formula to obtain F is

F=A (F/A,i,N)
=6808.40 (F/A,15%, 10)
=6808.40 (20.304)
=Rs. 1, 38,237.75

At the end of the 10th Year, the total amount of his payment is Rs. 1, 38,237.75

***4. Sri Nethra Industries Ltd, Offer 12% Interest on fixed depodite . What is the effective rate of interest rate of compounding is done.***
***(i) Half yearly.***
***(ii) Quarterly.***
***(iii) Monthly. (Nov 2014).***

**Sol.**

**N=6 F/P=$(1+i)^N$**
**=$(1+12/100)^6$**
**= 1.97**
**N=3 F/P=$(1+i)^N$**
**=$(1+12/100)^3$**
**=1.47**
**N=3 F/P=$(1+i)^N$**
***=$(1+12/100)^{12}$***
***= 3.84***

***5. Mr. Nimish Expects to receive Rs. 10,000 at beginning of each year for 5 years. Calculate the present value of annuity due, assuming an interest rate 8%.(Nov 2014).***

**Given**

**F=10000**
**i=8% per year.**
**N=5 Years**

**Sol**

**P=F/$(1+i)^N$**
**=10000(P/F, 8%, 5)**
**=6806 Rs.**

***6. (i)Mention the basic steps of value Engineering. 16 Marks***
***(ii)A person deposits a sum of Rs.20, 000 at the interest rate of 18% compounded annually for 10 years. Find the maturity value after 10years.use single payment compound amount formula.(Nov 2013)***

THE BASIC STEPS OF VALUE ENGINEERING

**1. Identify and select the production**

In this stage, the product for the study is identified Selected Value engineering can be applied to a Product Whole. But it is advisable to apply value analysis on a problem which is manageable. Example: The fuel injection system or clutch system of car.

2. **Constitute a team**

In this stage, a team consisting persons from different disciplines should be constituted. When we speak of a team the emphasis is on team work which signifies the subordination of personal preferences to group consensus.

3**. Gather Information**

In this stage, all the relevant information should be collected. These may relate to technical specifications with drawings. Production processes, parts, names of suppliers. Methods of purchase, annual requirements of materials, time study details, manufacturing capacity, cost data, marketing details and latest developments.

**4. Analyse functions**

In this stage, the primary, secondary and tertiary functions of the product/component should be determined through a detailed analysis. Also identify the value content and cost of various functions.

**5. Generate ideas**

In this stage, the aim is generating new ideas and create different alternatives so as to increase the value of the product. A brain storming session will help generate ideas. Here members are encouraged to express their ideas freely. All feasible or non-feasible ideas are recorded without any immediate evaluation.

**6. Evaluate the ideas.**

The generation of a quantity of ideas does not accomplish anything until ideas are put to use. Before these can be utilized an evaluation process must be applied. Different ideas are compared, Evaluated and critically assessed for their virtue, validity and feasibility as regards their financial and technical requirement.

**7. Develop the best idea**

In this stage. The selection of ideas which are to be carried through further development is made. Detailed development plans are made for those ideas which appear most suitable and promising. These development plans comprise drawing the

sketches, building of models, conducting discussions with the purchase department, finance department and marketing department etc.

**8. Recommendation and implementation**
In this stage, the selected best idea along with benefits and limitations ¡s presented Lo the management. After the carefully accepted, the best idea Manufacturing model which
Ultimately goes into operation and its results are recorded.

ii

***Solution***

$P$ = Rs. 20,000
$i$ = 18% compounded annually
$n$ = 10 years
$F = P(1 + i)^n = P(F/P, i, n)$
$= 20{,}000\ (F/P, 18\%, 10)$
$= 20{,}000 \times 5.234$ = Rs. 1, 04,680

The maturity value of R.s. 20,000 invested now at 18% compounded yearly is equal to R.s. 1, 04,680 after 10 years.

***7. (i) Write short notes on the time value of money.***

***(ii)A company has to replace a present facility after 15 years at an outlay of Rs.5,00,000. It plans to depot an equal amount at the end of every year for the next 15 years at an interest rate of 18% compounded annually. Find the equivalent amount that must be deposited at the end of every year for the next 15 years. Use equal payment series sinking fund formula. (Nov 2013, Nov 2011, May2017)***

ii.

***Solution***

$F$ = Rs. 5, 00,000
$n$ = 15 years
$i$ = 18%
$A$ =?

The corresponding cash flow diagram is shown in Fig. 3.7.

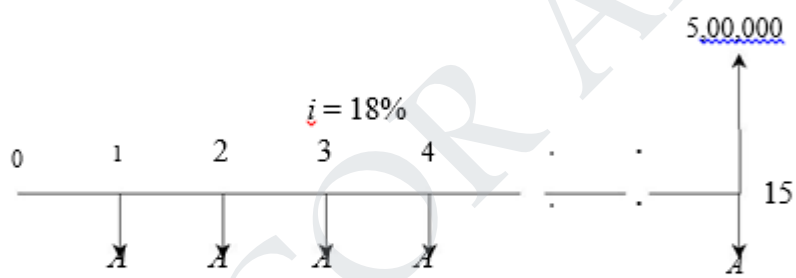



**Fig. 3.7 Cash** flow diagram of equal-payment series sinking fund.

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

$$= 5{,}00{,}000(A/F, 18\%, 15)$$

$$= 5{,}00{,}000 \times 0.0164$$

$$= \text{Rs. } 8{,}200$$

The annual equal amount which must be deposited for 15 years is Rs. 8,200.

i. Interest rate is the rental 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 rupees invested now, an amount of Rs. 15 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 Rs. 115. At the end of the second year, again 15% of Rs. 115, i.e. Rs. 17.25 will be added to the account. Hence the total amount at the end of the second year will be Rs. 132.25. The process will continue thus till the specified number of years.

# TIME VALUE OF MONEY

If an investor invests a sum of Rs. 100 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 Table 3.1.

**Table 3.1** Compound Amounts

(amount of deposit = Rs. 100.00)

| *Year end* | *Interest* (Rs.) | *Compound amount* (Rs.) |
|---|---|---|
| 0 | | 100.00 |
| 1 | 15.00 | 115.00 |
| 2 | 17.25 | 132.25 |
| 3 | 19.84 | 152.09 |
| 4 | 22.81 | 174.90 |
| 5 | 26.24 | 201.14 |

The formula to find the future worth in the third column is

$$F = P \times (1 + i)^n$$

where

$P$ = principal amount invested at time 0,
$F$ = future amount,

$i$ = interest rate compounded annually,
$n$ = period of deposit.

The maturity value at the end of the fifth year is Rs. 201.14. This means that the amount Rs. 201.14 at the end of the fifth year is equivalent to Rs. 100.00 at time 0 (i.e. at present). This is diagrammatically shown in Fig. 3.1. This explanation assumes that the inflation is at zero percentage.

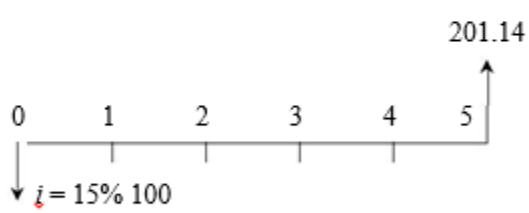



**Fig. 3.1 Time** value of money.

Alternatively, the above concept may be discussed as follows: If we want Rs. 100.00 at the end of the $n$th year, what is the amount that we should deposit now

**Table 3.2 Present** worth Amounts

(Rate of interest = 15%)

**Table 3.2 Present** worth Amounts

(rate of interest = 15%)

| *End of year* (*n*) | *Present worth* | *Compound amount after n year(s)* |
|---|---|---|
| 0 | | 100 |
| 1 | 86.96 | 100 |
| 2 | 75.61 | 100 |
| 3 | 65.75 | 100 |
| 4 | 57.18 | 100 |
| 5 | 49.72 | 100 |
| 6 | 43.29 | 100 |
| 7 | 37.59 | 100 |
| 8 | 32.69 | 100 |
| 9 | 28.43 | 100 |
| 10 | 24.72 | 100 |

The formula to find the present worth in the second column is

$$P = \frac{F}{(1+i)^n}$$

From Table 3.2, it is clear that if we want Rs. 100 at the end of the fifth year, we should now deposit an amount of Rs. 49.72. Similarly, if we want Rs. 100.00 at the end of the 10th year, we should now deposit an amount of Rs. 24.72. Also, this concept can be stated as follows:

A person has received a prize from a finance company during the recent festival contest. But the prize will be given in either of the following two modes:

1. Spot payment of Rs. 24.72 or
2. Rs. 100 after 10 years from now (this is based on 15% interest rate compounded annually). If the prize winner has no better choice that can yield more than 15% interest rate compounded annually, and if 15% compounded annually is the common interest rate paid in all the finance companies, then it makes no difference whether he receives Rs. 24.72 now or Rs. 100 after 10 years.On the other hand, let us assume that the prize winner has his own business wherein he can get a yield of 24% interest rate (more than 15%) compounded annually, it is better for him to receive the prize money of Rs. 24.72 at present and utilize it in his business. If this option is followed, the equivalent amount for Rs. 24.72 at the end of the 10th year is Rs. 212.45. This example clearly demonstrates the time value of money

***8. (i) Explain the criteria for make or buy decision and its approach.***
***(ii)Write the equation for interest compounding of a capital (yearly, half yearly and quarterly compounding. (May 2013, May 2017)***

***Or***

***1.Discuss opportunity cost.4 mark (May 2017)***
***2.Describe process planning.12 mark***

(i)

**Quantitative Factors**

1. Opportunity costs: h may be defined as the monetary value sacrificed in rejecting an alternative. Facilities utilized in manufacturing a part or components are in effect. Sacrificed for any other use. The decision to make or buy often boils down to an attempt to optimize the utilization of facilities.

**2. Incremental costs**: Only those costs that vary with the decision to make or buy are generally considered relevant. Incremental cost refers to the additional cost incurred due to change in the activity such as addition of a product, change in distribution channel, expansion of market etc.

**3. Idle Facilities**: Availability of idle facilities bears directly on the make or buy decisions, particularly with regard to determining the incremental costs involved. If sufficient facilities are available, only variable costs i.e. those costs that vary with volume, must be considered.

(ii).

**Equation for Yearly interest compounding of a capital.**

F= P(1+i)N
F= The total accumulated value or the future worth of investment
P= The Principal.
I = Interest rate
N=year/Period.

**Equation for half yearly and quarterly compounding:**

Generally nominal interest rates are compounded annually. But in practice, the interest rate may Compounded for Less than a year i.e monthly, quarterly or half yearly. Under such situations. We need an effective interest rate. Effective interest rate is a percentage which periodically applied to measure the cost of money when the interest rates compounded for less than a year i.e monthly. Quarterly and half yearly.
The formula to compute the effective interest rate is

$$R = \left(1 + \frac{i}{c}\right)^c - 1$$

where R = Effective interest rate

$i$ = The nominal interest rate

$c$ = The number of interest periods

The formula to find half yearly and quarterly interest compounding is

$$F = P(1 + R)^N$$

where F = The total accumulated value or the maturity value

P = The principal

R = The effective interest rate

N = Number of interest period (Number of quarters or number of half years)

***9. The Management of a company finds that while the cost of making a component part is Rs.10, the same is available in the market at Rs.9 with an assurance of continuous supply. Give a suggestion whether to make or buy this part. Give also your views in case the supplier reduces the price from Rs.9 to Rs.8. The cost information is as follows:***

| *Particulars* | *R.s.* |
|---|---|
| *Material* | *3.50* |
| *Direct Labour* | *4.00* |
| *Other variable expenses* | *1.00* |
| *Fixed expenses* | *1.50* |
| *Total* | *10.00* |

***(May 2013)***

**Given**
Material Cost = R.s 3.50.
Direct Labour =R.s 4.00.
Other Variable= R.s 1.00.
Fixed Expenses =R.s 1.50

**Solution:**
Cost to make:
Total variable cost= Material Cost +Labour cost + other variable
=3.50+4.00+1.00
=R.s 8.50.
Total Variable Cost=R.s 8.50
Add fixed expenses =R.s 1.50
Total =10.20
Cost to buy:
Purchase cost=R.s 9.00
Add fixed Expenses=R.s 1.50
Total=10.50
In case the supplier reduces the price from R.s 9 to R.s 8
Purchase cost= R.s 8.00
Fixed Expense=R.s 1.50
Total cost=R.s 9.50
The cost the making the component part is less than the cost of buying, so the company should make the part…

***10. (i) Discuss the symptoms favoring that application of VA/VE.***
***(ii) A person is planning for his retired life. He has 10 more years of service. He would like to depot 20% of his salary, which is Rs.4, 000 at the end of the first year, and thereafter he wishes to deposit the amount with an annual increase of Rs.500 for the next 9years with an interest rate of 15%. Find the total amount at the above series, at the of the 10th year at which time he retires. (Nov 2012)***

ii.

***Solution Here,***

$A1 = \text{Rs. } 4{,}000$
$G = \text{Rs. } 500$
$i = 15\%$
$n = 10 \text{ years}$
$A = ?\ \&\ F = ?$

The cash flow diagram is shown in Fig. 3.13.

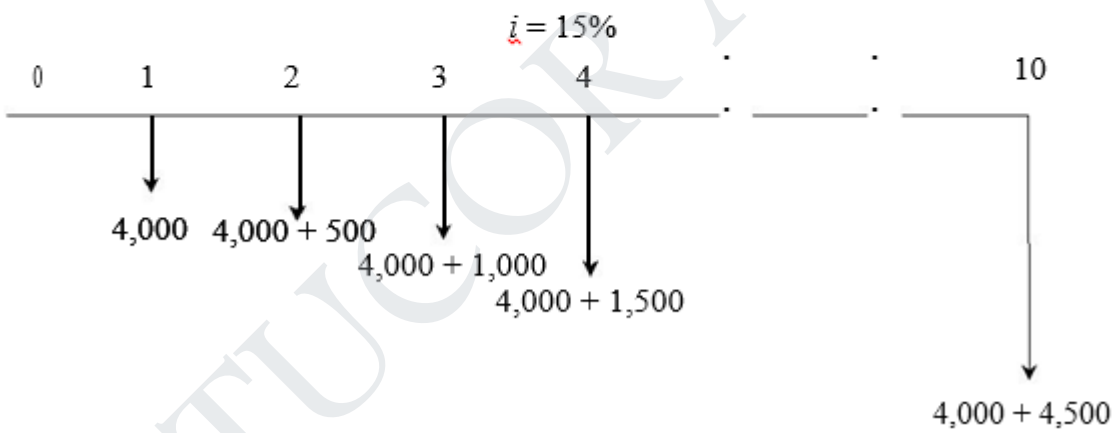



**Fig. 3.13 Cash** flow diagram of uniform gradient series annual equivalent amount.

$$A = A1 + G\,\frac{(1+i)^n - in - 1}{i(1+i)^n - i}$$

$$= A1 + G(A/G, i, n)$$

$$= 4{,}000 + 500(A/G, 15\%, 10)$$

$$= 4{,}000 + 500 \times 3.3832$$

$$= \text{Rs. } 5{,}691.60$$

This is equivalent to paying an equivalent amount of Rs. 5,691.60 at the end of every year for the next 10 years. The future worth sum of this revised series at the end of the 10th year is obtained as follows:

$$F = A(F/A, i, n)$$
$$= A(F/A, 15\%, 10)$$
$$= 5{,}691.60(20.304)$$
$$= \text{Rs. } 1{,}15{,}562.25$$

At the end of the 10th year, the compound amount of all his payments will be Rs. 1, 15,562.25.

***11. (i) A company has to replace a present facility after 15 years at an outlay of Rs.5,00,000. It plans to deposit an equal amount at the end of every year for the next 15 years at interest rate of 18% compounded annually. Find the equivalent amount that must be deposited at the end of every year for the next 15 years.***
***(Nov 2011).***
***(ii)Discuss the advantages and application areas of values engineering***
***(Nov 2012)***
**(i.)**
***Solution***

$F$ = Rs. 5, 00,000
$n$ = 15 years
$i$ = 18%
$A$ =?

The corresponding cash flow diagram is shown in Fig. 3.7.

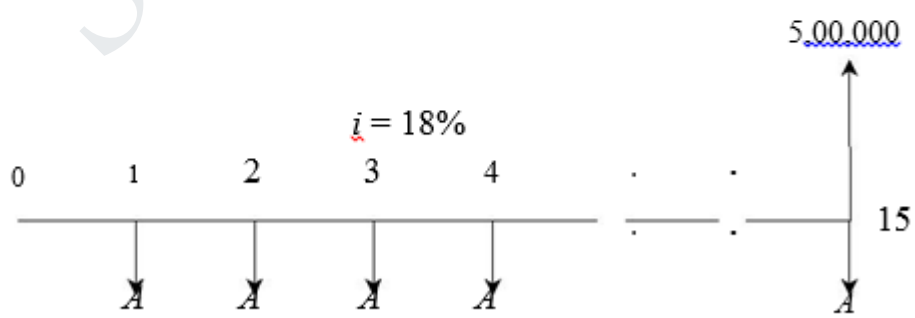



**Fig. 3.7 Cash** flow diagram of equal-payment series sinking fund.

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

$$= 5{,}00{,}000(A/F, 18\%, 15)$$

$$= 5{,}00{,}000 \times 0.0164$$

$$= \text{Rs. } 8{,}200$$

The annual equal amount which must be deposited for 15 years is Rs. 8,200.

ii.

**Advantages of Value Analysis/ Value**

Value analysis identifies and reduces the product cost
It modifies and improves the product design increases the performance / utility of the product by economical means. It helps to generate new ideas
It creates quality Consciousness and cost Consciousness among the employer
It helps to save money and increase the profits
Value engineering improve your ability to manage project, solve problems, innovate and communicate.

***12. What are the functions of value engineering?***
***Discuss the value engineering procedure. (May 2012, Nov 2009, Nov 2011, May 2009, Nov 2008, Nov 2016, Nov 2015, May 2017) (or)***
***13. Write about the aims of value engineering and briefly explain the steps of value engineering? (April 2010, Nov 2009)***

i. ***The aims of value engineering (same answer for both question).***

**AIMS / OBJECTIVES**

The aims/objectives of value analysis is to
(1) Simplify the product
(ii) Reduce cost of the product
(iii) Use (new) cheaper and better materials
(iv) Modify and improve product design so as to make it acceptable to consumer.
(y) Use efficient processes
(vi) Increase the utility of the product by economics means.
(vii) Ensure greater return on investment
(viii) Improve organization efficiency

### *ii The value engineering procedure (***) (May 2017)*

**1. Identify and select the product**
In this stage the product for the study is identified and selected. Value engineering can be applied to a product a whole. But it is advisable to apply value analysis on a Specific problem which is manageable. Example: The fuel injection system or clutch system of car.

**2. Constitute a team**
In this stage, a team consisting persons different disciplines should be constituted. When we speak of a team, the emphasis is n team work which signifies the subordination of personal preferences to group consensus.

**3. Gather Information**
In this stage, all the relevant information should be collected. These may relate lo technical specifications with drawings. Production processes, parts, names of supplier's methods of purchase, annual requirements of materials, time study details, manufacturing capacity cost data, marketing details and latest developments.

**4. Analyse function**
In this stage, the primary, secondary and tertiary functions of the product/component should be determined through a detailed analysis. Also identify the value Content and cost of various functions.

**5. Generate ideas**
In this stage, the aim is generating new ideas and create different alternatives so as to increase the value of the product. A brain storming session will help generate ideas. Here members are encouraged to express their ideas freely. All feasible or non-feasible ideas arc recorded without an immediate evaluation.

**6. Evaluate the ideas**
The generation of a quantity of ideas does not accomplish anything until these ideas are put to use. Before these can be utilized an evaluation process must be applied. Different ideas are compared, evaluated and critically assessed for their virtues, validity and feasibility as regards their financial and technical requirements

**7. Develop the best idea**
In this stage the selection of ideas which are to be carried through further development is made. Detailed development plans are made for those ideas which appear most suitable and promising. These development plans comprise drawing the sketches, building of models, conducting discussions with the purchase department, finance department and marketing department etc.

**8. Recommendation and implementation**

In this stage, the selected best idea along with benefits and limitations is presented to the management. After the Recommendations have been carefully accepted, the best idea is converted in to proto type manufacturing model which ultimately goes into operation and its results are recorded.

***14. A manufacturing company has extra capacity which can be used to produce gears that the company has been buying for Rs.300 each. If the company makes the gears, it will have incurred material cost of Rs.90 per unit, Labour cost of Rs.120 per unit and variable overhead cost of Rs.30 per unit. The annual fixed cost associated with the unused capacity is Rs.2, 40,000. Demand over the next year is estimated as 4,000 units.***

***(i) Should company make the gears or continue to buy?***

***(ii) Suppose the capacity could be used by another department for the production of the same pump components that would cover its fixed and variable cost and contribute Rs.90, 000 to profit. What would be the more advantageous, gear production or pump components production?***

***(May 2012, April 2008, May 2011, May 2008)***

Sol..

Variable Cost/unit=Material + Labour + Overheads

= R.s 90+R.s120+ R.s.30.

=R.s 240

Total Variable cost =4000 units x R.s 240/ Units

= R.s 9, 60000

Add fixed cost associated with unused capacity=+R.s 240000

=R.s 1200000

**(i) Cost to buy:**

Purchase cost=4000 units x R.s 300/unit

=R.s 1200000

Add fixed cost associated with unused capacity = + R.s240000

Total cost = R.s 1440000

Result: The cost of making gears is less than the cost buying gears. Therefore, the company should make the gears.

**(ii) Cost to buy and unused capacity to produce pump components:**

Purchase cost =4000 units x R.s 300/unit.

=R.s 12000000.

Contribution from making pump components using the unused capacity =-R.s90000

Net relevant cost = R.s 11,10000

Cost to make =Rs 1200000

Cost to buy and leave unused capacity idle= R.s 1440000

***15. (i)What is time value of money? How is it useful in taking investment related decision?***
***(ii)Compute the present value of Rs.1, 000 receivable 6 years hence if the rate of discount is 10 percent? (Nov 2009, Nov 2015, May 2015)***

**(i) Time value of money**

Owner of money can lend it at the prevailing rate of interest and wait to be repaid the original amount plus an extra increment. Equivalently, the borrower could convert the money into productive goods that would be expected to earn more than the amount needed to repay the loan. In both cases the prevailing interest rate sets the minimums level of expected productivity, and both cases involve time between receipt and return of the Loan to secure the earnings-the time value of money.

We may define the principle of time value of money follows. The Economics value of a sum depends on when it received. Because money has earning power over time ( it can be put to work, Earning more money for its owner), A rupee received today has a greater value than a rupee received a some future time

**(ii)**
**Given:**

**P=1000**

**i=10% per year**

**N=5 year**

Sol.

$$p = \frac{f}{(1+i)\text{^}5}$$

$$p = \frac{1000}{(1+10\%)\text{^}5}$$

P=909.090 R.s

***16. (i) What is uniform gradient conversion? Illustrate with an example.***
***(ii) What is value engineering? With a suitable example, explain the various phases of value engineering job plan. (April 2008)***

## Uniform Gradient Series Annual Equivalent Amount

The objective of this mode of investment is to find the annual equivalent amount of a series with an amount $A1$ 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.

The corresponding cash flow diagram is shown in Fig. 3.12.

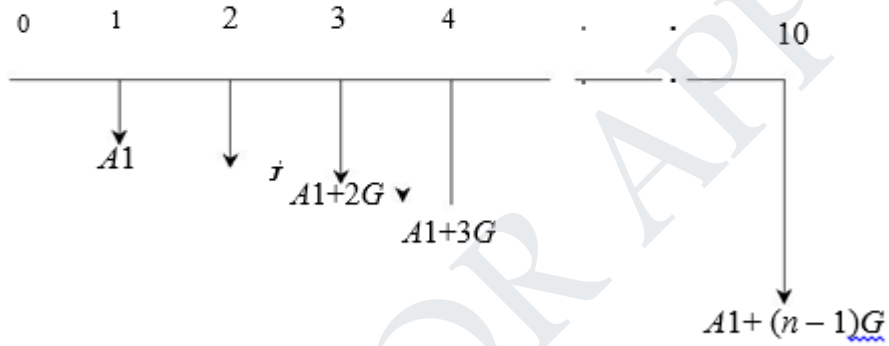



**Fig. 3.12** **Cash** flow diagram of uniform gradient series annual equivalent amount.

The formula to compute $A$ under this situation is

$$A = A1 + G\frac{(1+i)^n - in - 1}{i(1+i)^n - i}$$
$$= A1 + G\,(A/G, i, n)$$

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

***17. Different between value analysis and value Engineering. Explain value Engineering Procedure (May 2011)***

***The two values analysis and value engineering are used interchangeably. The philosophy underlying the two.***

Terms is one and the same. i.e. identification of unnecessary cost associated with any product yet they are different. The techniques are applied. The following table represent the major different between the two terms.

| Value Analysis | Value Engineering |
|---|---|
| 1. Value analysis is the application of a set of techniques to an existing product with a view to improve its value | Value engineering is the application of exactly the same set of techniques to a new product at design stage |
| 2. It is a remedial process | It is a preventive process |

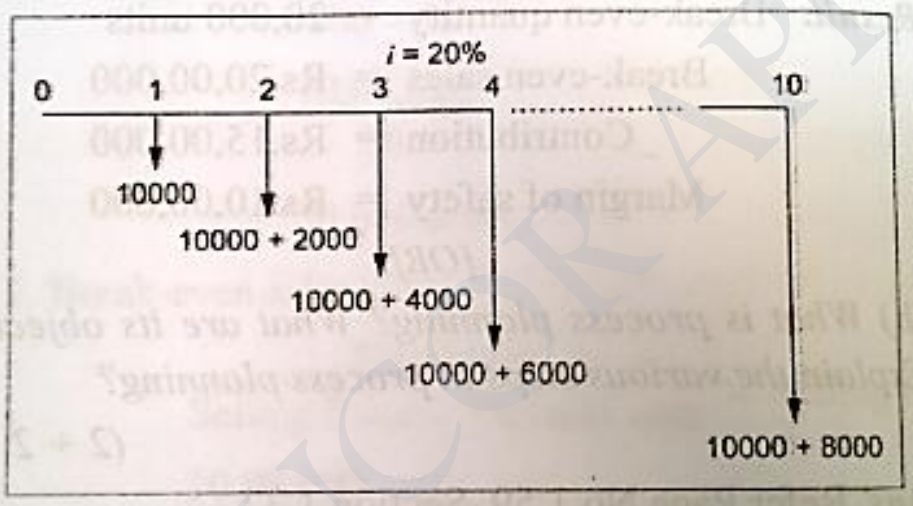
Continuations are present------- (***)

***18. Mr. Ganesh is planning for his retired life. He has 10 more years of service. He would like to deposit 20% of his salary, which is R.s. 10,000 at the end of first year and thereafter he wishes to deposit every year with an annual increase of R.s. 2,000 for the next 9 years. At an interest rate of 20%. Find the total amount at the end of the 10th year at which time he retires. (May 2010)***

***To find:*** A and F (Annual equivalent amount and future sum of annual equivalent amount)

***Cash flow diagram of uniform gradient series annual equivalent amount:***




☺ ***Solution:*** The formula to compute A is

$$A = A_1 + G\left[\frac{(1+i)^N - i\,N - 1}{i\,[(1+i)^N - 1]}\right]$$

$$= A_1 + G\,(A/G, i, N)$$

$$= 10{,}000 + 2{,}000\,(A/G, 20\%, 10)$$

$$= 10{,}000 + 2{,}000\,(3.0739)$$

$$= 10{,}000 + 6147.8$$

$$= 16147.8$$

The future sum of this annual equal payment (A) at the end of every year for the next 10 years is equal to the total amount of gradient series at the end of $10^{th}$ year. The future sum of this revised series at the end of the $10^{th}$ year is obtained as follows:

The formula to compute F is

$$F = A\,(F/A, i, N)$$

$$= A\,(F/A, 20\%, 10)$$

$$= 16147.8\,(25.959)$$

$$= \text{Rs.}4{,}19{,}180.74$$

***Result:*** At the end of the $10^{th}$ year the total amount of all his payments will be Rs.4,19,180.74.

***19. (i)Write in detail about value engineering procedure.***
***(ii) Discuss about the single payment compound amount factor. (May 2009, Nov 2016) Value engineering answer is present in Question Number: 8***

### 3.3.1 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. The cash flow diagram of this situation is shown in Fig. 3.2.

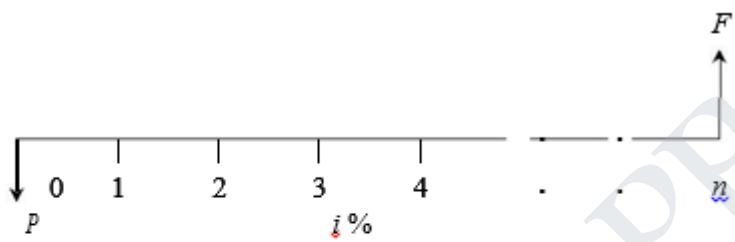



**Fig. 3.2** Cash flow diagram of single-payment compound amount.

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.

### 3.3.2 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.

The corresponding cash flow diagram is shown in Fig. 3.3.

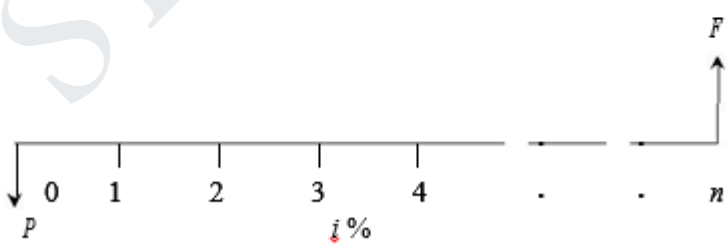



**Fig. 3.3** Cash flow diagram of single-payment present worth amount.

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

where

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

***20. Explain in detail.***
***(1) Equal payment series sinking fund factor.***
***(2) Equal payment series capital recovery factor. (May 2009)***

## 3.3.4 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 $i$.

The corresponding cash flow diagram is shown in Fig. 3.6.

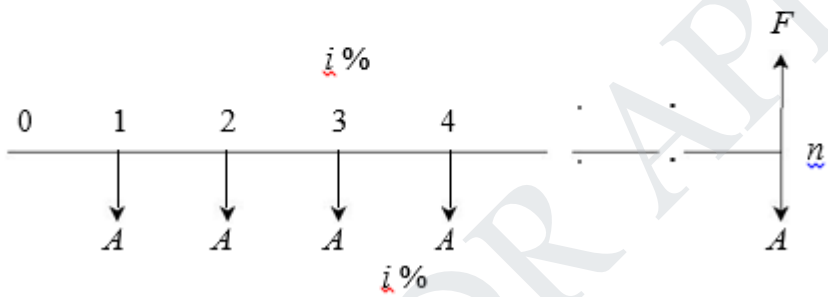



**Fig. 3.6** Cash flow diagram of equal-payment series sinking fund.

In Fig. 3.6,

$A$ = 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

The formula to get $F$ is

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

Where

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



### 3.3.6 Equal-Payment Series Capital Recovery Amount

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 (see Fig. 3.10).

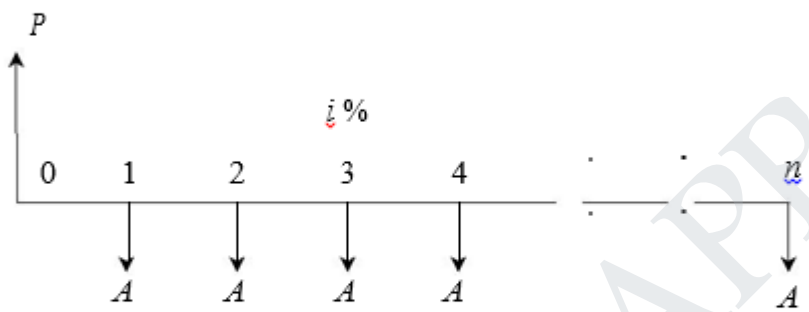



**Fig. 3.10** Cash flow diagram of equal-payment series capital recovery amount.

In Fig. 3.10,

$P$ = present worth (loan amount)
$A$ = annual equivalent payment (recovery amount)
$i$ = interest rate
$n$ = No. of interest periods

The formula to compute $P$ is as follows:

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

where,

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

***21. What is make or buy decision? Discuss the operational issues associated with the business proposals related with make or buy decision with respect to profitability. (Nov 2008, Nov 2016)***

APPROACHES FOR MAKE OR BUY DECISION

Types of analysis followed in make or buy decision are as follows:

Simple cost analysis

Economic analysis

Break-even analysis

Simple Cost Analysis

The concept is illustrated using an example problem.

A company has extra capacity that can be used to produce a sophisticated fixture which it has been buying for Rs. 900 each. If the company makes the fixtures, it will incur materials cost of Rs. 300 per unit, labour costs of Rs. 250 per unit, and variable overhead costs of Rs. 100 per unit. The annual fixed cost associated with the unused capacity is Rs. 10,00,000. Demand over the next year is estimated at 5,000 units. Would it be profitable for the company to make the fixtures?

***Solution We*** assume that the unused capacity has alternative use.

**Cost to make**

Variable cost/unit = Material + labour + overheads

= Rs. 300 + Rs. 250 + Rs. 100

= Rs. 650

Total variable cost = (5,000 units) (Rs. 650/unit)

= Rs. 32,50,000

| | |
|---|---|
| Add fixed cost associated with unused capacity | + Rs. 10,00,000 |
| Total cost | = Rs. 42,50,000 |

**Cost to buy**

| | |
|---|---|
| Purchase cost | = (5,000 units) (Rs. 900/unit) |
| | = Rs. 45,00,000 |
| Add fixed cost associated with unused capacity | + Rs. 10,00,000 |
| Total cost | = Rs. 55,00,000 |

The cost of making fixtures is less than the cost of buying fixtures from outside. Therefore, the organization should make the fixtures.

### 13.3.2 Economic Analysis

The following inventory models are considered to illustrate this concept:

- Purchase model
- Manufacturing model

The formulae for EOQ and total cost (TC) for each model are given in the following table:

| *Purchase model* | *Manufacturing model* |
|---|---|
| $Q1 = \sqrt{\frac{2C_oD}{C_c}}$ | $Q2 = \sqrt{\frac{2C_oD}{C_c(1 - r/k)}}$ |
| $TC = D' P + \frac{DC_o}{Q1} + \frac{Q1 \cdot C_c}{2}$ | $TC = D' P + \frac{DC_o}{Q2} + C_c (k - r) \frac{Q2}{2 * k}$ |

where

$D$ = demand/year

$P$ = purchase price/unit

$C_c$ = carrying cost/unit/year

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

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

$r$ = demand/year

$Q1$ = economic order size

$Q2$ = economic production size

$TC$ = total cost per year

***EXAMPLE 13.2*** 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 | Rs. 8.00 | Rs. 5.00 |
| Procurement cost/order | Rs. 120.00 | |
| Set-up cost/set-up | | Rs. 60.00 |
| Annual carrying cost/ item/year | Rs. 1.60 | Rs. 1.00 |
| Production rate/year | | 8,000units |

***Solution***

**Buy option**

$D$ = 2,000 units/year

$C_o$ = Rs. 120/order

$C_c$ = Rs. 1.60/unit/year

$$Q1 = \sqrt{\frac{2C_oD}{C_c}} = \sqrt{\frac{2 \cdot 2{,}000 \cdot 120}{1.60}}$$

= 548 units (approx.)

$$TC = DP + \frac{DC_o}{Q1} + \frac{Q1C}{2}$$

$$= 2{,}000 \text{ ´ } 8 + \frac{2000, \cdot 120}{548} + \frac{548 \cdot 1.60}{2}$$

= Rs. 16,876.36

**Make option**

$C_o$ = Rs. 60/set-up

$r$ = 2,000 units/year

$C_c$ = Re 1/unit/year

$k$ = 8,000 units/year

$$Q2 = \sqrt{\frac{2C_or}{C_c[1 - (r/k)]}}$$

$$= \sqrt{\frac{2 \cdot 60 \cdot 2{,}000}{1.0(1 - 2{,}000/8{,}000)}}$$

= 566 units (approx.)

$$TC = DP + \frac{D \cdot C_o}{Q2} + C_c\,(k - r)\ \frac{Q2}{2 \cdot k}$$

$$= 2{,}000 \times 5.00 + \frac{2000, \cdot 60}{566} + 1.0\,(8{,}000 - 2{,}000)\ \frac{566}{2 \cdot 8{,}000}$$

$$= \text{Rs. } 10{,}424.26$$

**Result:** The cost of making is less than the cost of buying. Therefore, the firm should go in for the making option.

### 13.3.3 Break-even Analysis

The break-even analysis chart is shown in Fig. 13.1. In the figure

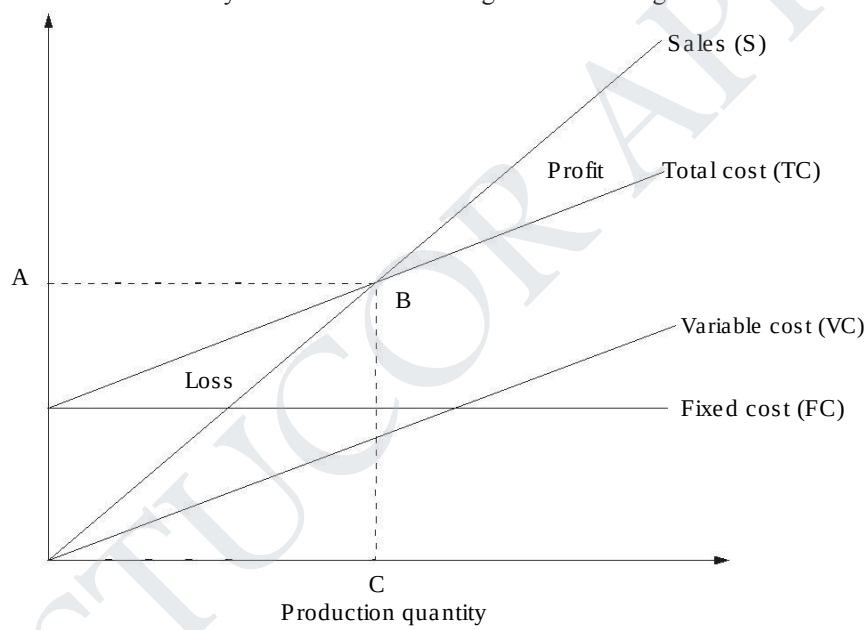



**Fig. 13.1** Break-even chart.

$TC$ = total cost

$FC$ = fixed cost

$TC = FC$ + 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)

The formula for the break-even point (BEP) is

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

***EXAMPLE 13.3*** A manufacturer of TV buys TV cabinet at Rs. 500 each. In case the company makes it within the factory, the fixed and variable costs would be Rs. 4,00,000 and Rs. 300 per cabinet respectively. Should the manufacturer make or buy the cabinet if the demand is 1,500 TV cabinets?.

***Solution***

Selling price/unit (SP) = Rs. 500
Variable cost/unit (VC) = Rs. 300
Fixed cost (FC) = Rs. 4,00,000

$$\text{BEP} = \frac{4,00,000}{500 - 300} = 2,000 \text{ units}$$

Since the demand (1,500 units) is less than the break-even quantity, the company should buy the cabinets for its TV production.

***EXAMPLE 13.4*** There are three alternatives available to meet the demand of a particular product. They are as follows:

(a) Manufacturing the product by using process A
(b) Manufacturing the product by using process B
(c) Buying the product

The details are as given in the following table:

| *Cost elements* | *Manufacturing the product by process A* | *Manufacturing the product by process B* | *Buy* |
|---|---|---|---|
| Fixed cost/year (Rs.) | 5,00,000 | 6,00,000 | |
| Variable/unit (Rs.) | 175 | 150 | |
| Purchase price/unit (Rs.) | | | 125 |

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?

***Solution***

Annual cost of process A = FC + VC ´ Volume
= 5,00,000 + 175 ´ 8,000
= Rs. 19,00,000

Annual cost of process B = FC + VC ´ Volume
= 6,00,000 + 150 ´ 8,000
= Rs. 18,00,000

Annual cost of buy = Purchase price/unit ´ Volume
= 125 ´ 8,000
= Rs. 10,00,000

***22. Discuss about the different interest formula and their applications. (May 2014)***

***or***

***Discuss the equal payment series, capital recovery factor, uniform gradient series and annual equivalent factor with suitable example (Nov 2017)***

### 3.3.1 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. The cash flow diagram of this situation is shown in Fig. 3.2.

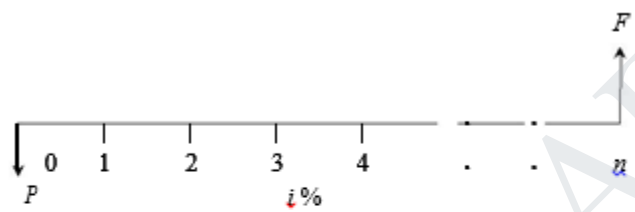



**Fig. 3.2** Cash flow diagram of single-payment compound amount.

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.

### 3.3.2 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.

The corresponding cash flow diagram is shown in Fig. 3.3.

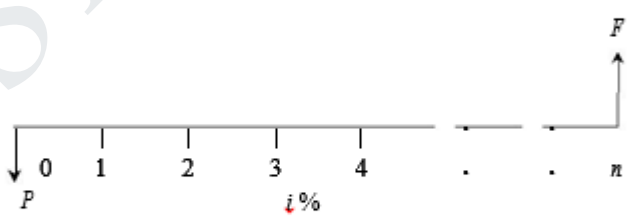



**Fig. 3.3** Cash flow diagram of single-payment present worth amount.

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.*

### 3.3.3 Equal-Payment Series Compound Amount

In this type of investment mode, the objective is to find the future worth of $n$ equal payments which are made at the end of every interest period till the end of the $n$th interest period at an interest rate of $i$ compounded at the end of each interest period. The corresponding cash flow diagram is shown in Fig. 3.4.

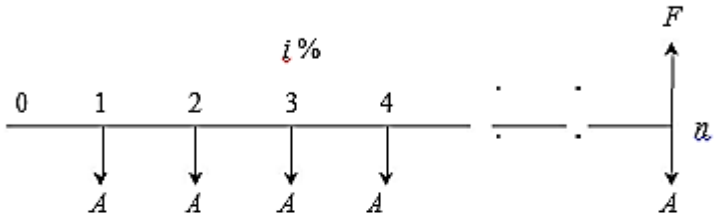



**Fig. 3.4** Cash flow diagram of equal-payment series compound amount.

In Fig. 3.4,

$A$ = equal amount deposited at the end of each interest period
$n$ = No. of interest periods
$i$ = rate of interest
$F$ = single future amount

The formula to get $F$ is

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

where

$(F/A, i, n)$ is termed as *equal-payment series compound amount factor*.

### 3.3.4 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 $i$.

The corresponding cash flow diagram is shown in Fig. 3.6.

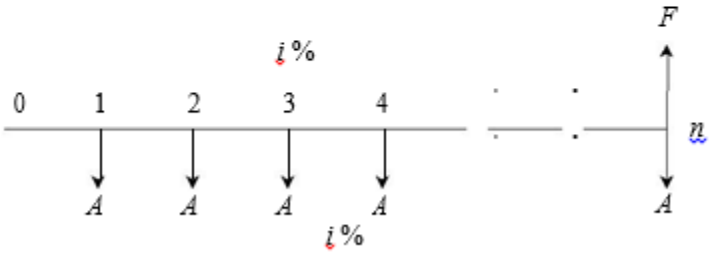



**Fig. 3.6** Cash flow diagram of equal-payment series sinking fund.

In Fig. 3.6,

$A$ = 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

The formula to get $F$ is

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

where

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

### 3.3.5 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.

The corresponding cash flow diagram is shown in Fig. 3.8. Here,

$P$ = present worth

$A$ = annual equivalent payment

$i$ = interest rate

$n$ = No. of interest periods

The formula to compute $P$ is

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

where

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

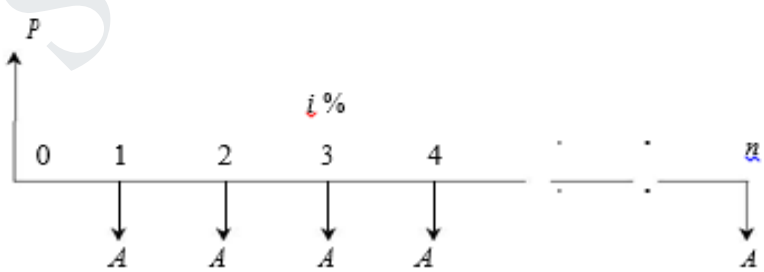



**Fig. 3.8 Cash** flow diagram of equal-payment series present worth amount.

### 3.3.6 Equal-Payment Series Capital Recovery Amount

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 (see Fig. 3.10).

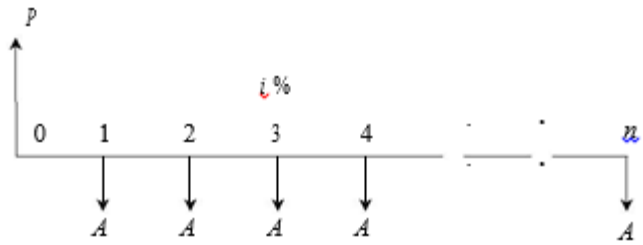



**Fig. 3.10** Cash flow diagram of equal-payment series capital recovery amount.

In Fig. 3.10,

$P$ = present worth (loan amount)
$A$ = annual equivalent payment (recovery amount)
$i$ = interest rate
$n$ = No. of interest periods

The formula to compute $P$ is as follows:

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

### 3.3.7 Uniform Gradient Series Annual Equivalent Amount

The objective of this mode of investment is to find the annual equivalent amount of a series with an amount $A1$ 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.

The corresponding cash flow diagram is shown in Fig. 3.12.

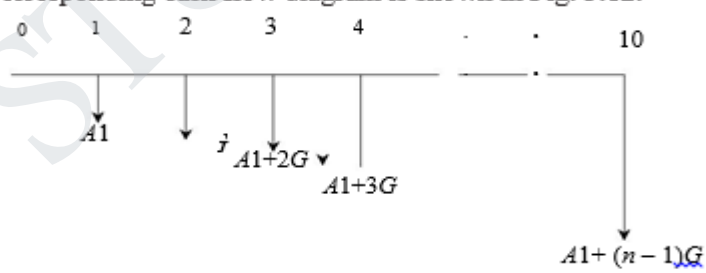



**Fig. 3.12** Cash flow diagram of uniform gradient series annual equivalent amount.

The formula to compute $A$ under this situation is

$$A = A1 + G\frac{(1+i)^n - in - 1}{i(1+i)^n - i}$$
$$= A1 + G\,(A/G, i, n)$$

where

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

*23. What are the different approach for the make or by decisions? (May 2014)*

## 13.3 APPROACHES FOR MAKE OR BUY DECISION

Types of analysis followed in make or buy decision are as follows:

1. Simple cost analysis
2. Economic analysis
3. Break-even analysis

### 13.3.1 Simple Cost Analysis

The concept is illustrated using an example problem.

***EXAMPLE 13.1*** A company has extra capacity that can be used to produce a sophisticated fixture which it has been buying for Rs. 900 each. If the company makes the fixtures, it will incur materials cost of Rs. 300 per unit, labour costs of Rs. 250 per unit, and variable overhead costs of Rs. 100 per unit. The annual fixed cost associated with the unused capacity is Rs. 10,00,000. Demand over the next year is estimated at 5,000 units. Would it be profitable for the company to make the fixtures?

***Solution*** /We assume that the unused capacity has alternative use.

**Cost to make**

Variable cost/unit = Material + labour + overheads

= Rs. 300 + Rs. 250 + Rs. 100

= Rs. 650

Total variable cost = (5,000 units) (Rs. 650/unit)

= Rs. 32,50,000

| | |
|---|---|
| Add fixed cost associated with unused capacity | + Rs. 10,00,000 |
| Total cost | = Rs. 42,50,000 |

**Cost to buy**

| | |
|---|---|
| Purchase cost | = (5,000 units) (Rs. 900/unit) |
| | = Rs. 45,00,000 |
| Add fixed cost associated with unused capacity | + Rs. 10,00,000 |
| Total cost | = Rs. 55,00,000 |

The cost of making fixtures is less than the cost of buying fixtures from outside. Therefore, the organization should make the fixtures.

| *Purchase model* | *Manufacturing model* |
|---|---|
| $Q1 = \sqrt{\frac{2C_oD}{C_c}}$ | $Q2 = \sqrt{\frac{2C_oD}{C_c(1 - r/k)}}$ |
| $TC = D \cdot P + \frac{DC_o}{Q1} + \frac{Q1 \cdot C_c}{2}$ | $TC = D \cdot P + \frac{DC_o}{Q2} + C_c(k - r)\frac{Q2}{2 * k}$ |

Where

$D$ = demand/year

$P$ = purchase price/unit

$C_c$ = carrying cost/unit/year

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

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

$r$ = demand/year

$Q1$ = economic order size
$Q2$ = economic production size
$TC$ = total cost per year

***EXAMPLE 13.2*** 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 | Rs. 8.00 | Rs. 5.00 |
| Procurement cost/order | Rs. 120.00 | |
| Set-up cost/set-up | | Rs. 60.00 |
| Annual carrying cost/ item/year | Rs. 1.60 | Rs. 1.00 |
| Production rate/year | | 8,000units |

***Solution***

**Buy option**

$D$ = 2,000 units/year
$C_o$ = Rs. 120/order
$C_c$ = Rs. 1.60/unit/year

$$Q1 = \sqrt{\frac{2C_oD}{C_c}} = \sqrt{\frac{2 \cdot 2{,}000 \cdot 120}{1.60}}$$

= 548 units (approx.)

$$TC = DP + \frac{DC_o}{Q1} + \frac{Q1C}{2}$$

$$= 2{,}000 \times 8 + \frac{2000, \cdot 120}{548} + \frac{548 \cdot 1.60}{2}$$

= Rs. 16,876.36

**Make option**

$C_O$ = Rs. 60/set-up

$r$ = 2,000 units/year

$C_C$ = Re 1/unit/year

$k$ = 8,000 units/year

$$Q2 = \sqrt{\frac{2C_Or}{C_c[1 - (r/k)]}}$$

$$= = \sqrt{\frac{2 \cdot 60 \cdot 2{,}000}{1.0(1 - 2{,}000/8{,}000)}}$$

566 units (approx.)

$$TC = DP + \frac{D \cdot C_o}{Q2} + C_c\,(k - r)\ \frac{Q2}{2 \cdot k}$$

$$= 2{,}000 \times 5.00 + \frac{2000, \cdot 60}{566} + 1.0\,(8{,}000 - 2{,}000)\ \frac{566}{2 \cdot 8{,}000}$$

$$= \text{Rs. } 10{,}424.26$$

**Result:** The cost of making is less than the cost of buying. Therefore, the firm should go in for the making option.

### 13.3.3 Break-even Analysis

The break-even analysis chart is shown in Fig. 13.1. In the figure

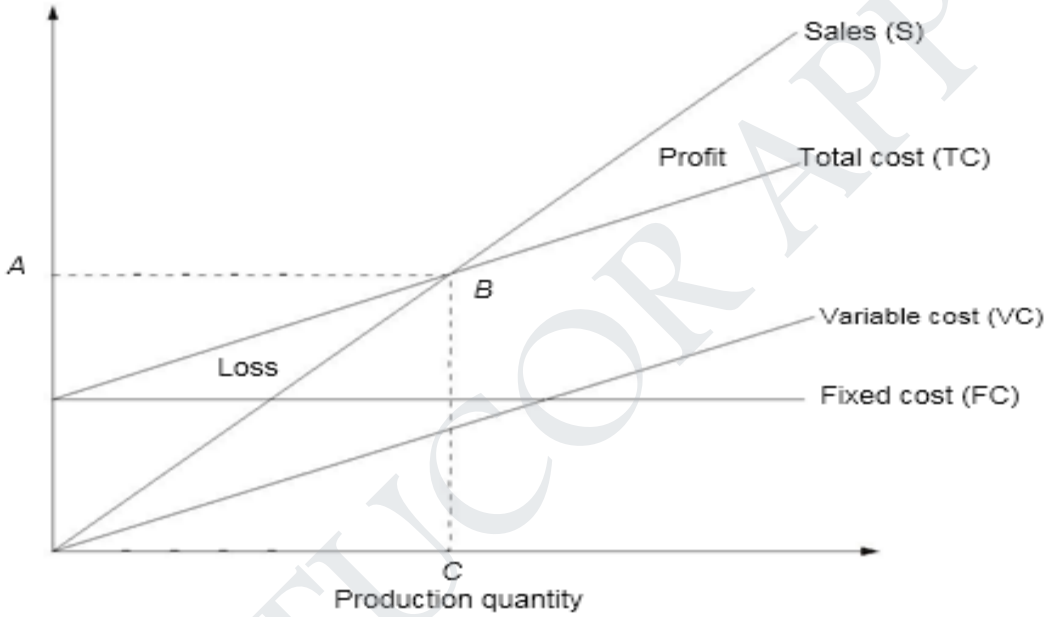



**Fig. 13.1 Break-even chart.**

$TC$ = total cost

$FC$ = fixed cost

$TC = FC$ + 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)

The formula for the break-even point (BEP) is

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

# UNIT-III CASH FLOW.

**PART – A** **2 Marks.**

***1. Write down the formula to obtain single payment compound amount. (May 2016).***

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.

***2. What is the concept of future worth method of comparison? (May 2015, May2017)***

The future worth of various alternatives will be computed. Then, the alternative with the maximum future worth of net revenue or with the minimum future worth of net cost will be selected as the best alternative for implementation.

***3. What is the idea of rate of return method of comparison? (May 2015, May 2017)***

The rate of return of a cash flow pattern is the in-interest rate which the present worth of the cash flow pattern to zero. In this method of comparison, the rate of return for each alternative is computed. Then the alternative which has the highest rate of return is selected as the best alternative.

***4. List out quantitative and qualitative factors to be considered in 'Make or Buy Decision. (Nov 2014).***

When a company is making a make or buy decision, the qualitative factors it must consider include the lives of the employees who would be let go if the product was outsourced, the time constraints involved in getting outsourced products delivered and whether or not an outsourced product would be up to the company's standards. Almost all manufacturing companies have to deal with make or buy decisions for products.

***5. What is statement of changes in financial position base on net working capital known as? (Nov 2014).***

He use of this statement is to provide relevant and focused on a period, so that users of financial statements with sufficient information to:

- Evaluate the company's ability to generate resources.
- Assess the reasons for the differences between net income and funds generated or used by the operation.
- To assess the ability of the company to meet its obligations to pay dividends, and if necessary, to anticipate the need for funding.

- To assess the changes in the company's financial situation arising from investing and financing transactions that occurred during the period.

***6. What is the basic the concept of present worth method of comparison? (Nov 2013).***

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.

***7. What is the basic an annual equivalent method of comparison? (Nov 2013, May 2008, May 2011).***

In the annual equivalent method of comparison, first the annual equivalent cost or the revenue of each alternative will be computed. Then the alternative with the maximum annual equivalent revenue in the case of revenue-based comparison or with the minimum annual equivalent cost in the case of cost- based comparison will be selected as the best alternative.

***8. What is cost dominated cash flow Diagram? (May 2013)***

## COST-DOMINATED CASH FLOW DIAGRAM

A generalized cost-dominated cash flow diagram to demonstrate the annual equivalent method of comparison is illustrated in Fig. 6.2.

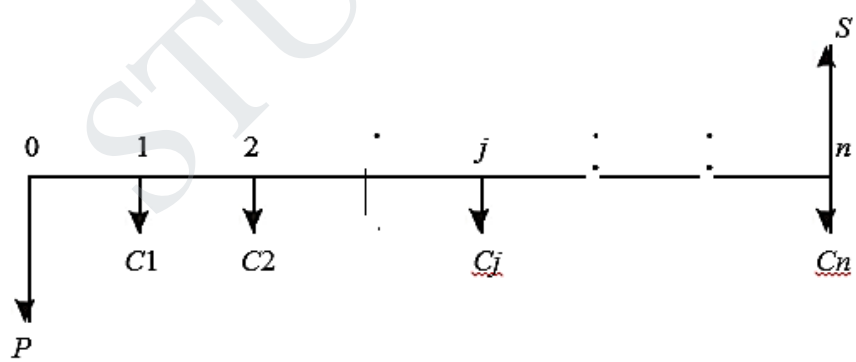



**Fig. 6.2** Cost-dominated cash flow diagram.

In Fig. 6.2, $P$ represents an initial investment, $C_j$ the net cost of operation and maintenance at the end of the $j$th year, and $S$ the salvage value at the end of the $n$th year.

$$PW(i) = P + C1/(1+i)^1 + C2/(1+i)^2 + \ldots$$
$$+ Cj/(1+i)^j + \ldots + Cn/(1+i)^n - S/(1+i)^n$$

In the above formula, each expenditure is assigned with positive sign and the salvage value with negative sign. Then, in the second step, the annual equivalent cost is computed using the following equation:

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

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

***9. Define rate of return method. (May 2013, Nov 2011, May 2014, Nov 2012, Nov 2008)***

The rate of return of a cash flow pattern is the interest rate at which the present worth of that cash flow pattern reduces to zero. In this method of comparison, the rate of return for each alternative is computed. Then the alternative which has the highest rate of return is selected as the best alternative. In this type of analysis, the expenditures are always assigned with a negative sign and the revenues/inflows are assigned with a positive sign. A generalized cash flow diagram to demonstrate the rate of return method of comparison is presented in Fig. 7.1.

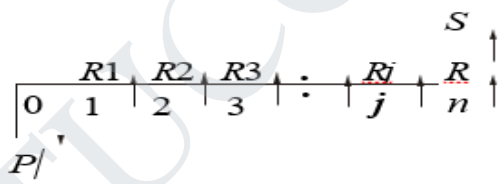



**Fig. 7.1** Generalized cash flow diagram.

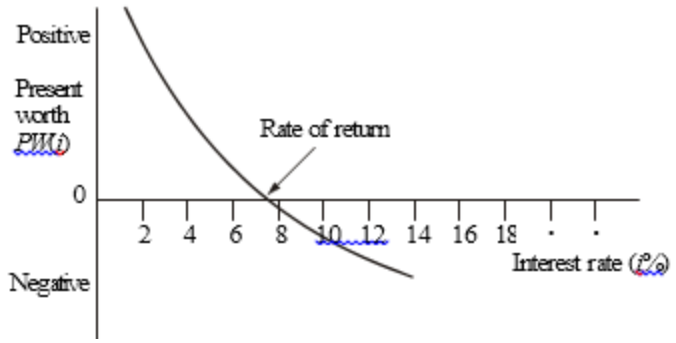
In the above cash flow diagram, P represents an initial investment, Rj the net revenue at the end of the jth year, and S the salvage value at the end of the nth year.

The first step is to find the net present worth of the cash flow diagram using the following expression at a given interest rate,

$$PW(i) = -P + R1/(1+i)^1 + R2/(1+i)^2 + \ldots$$
$$+ Rj/(1+i)^j + \ldots + Rn/(1+i)^n + S/(1+i)^n$$

Now, the above function is to be evaluated for different values of i until the present worth function reduces to zero, as shown in Fig. 7.2.In the figure, the present worth goes on decreasing when the interest rate is increased. The value of i at which the present worth curve cuts the X-axis is the rate of return of the given proposal/project. It will be very difficult to find the exact value of i at which the present worth function reduces to zero.

***10. Draw a neat sketch of present worth function of graph. (Nov 2012)***




***11. What is mean by discounting? (May 2012).***

Finding the present worth of a future sum is simply the reverse of compounding and is known as discounting process.

The formula to obtain present worth is

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

(P/F,i,N) is the factor natation for single payment present worth factor. The interest i and the P/F factor are also referred. The interest rate i and the P/F factor are also referred as the discount rate the and discount and discounting factor, respectively.

***12. Write down the techniques for comparing the worthiness of a Project (May 2012).***

1. Net present value methods.
2. Rate of return methods.
3. Ratio methods.
4. Pay back methods.
5. Annual equivalent methods.
6. Future worth method.

***13. Define IRR and MARR. (May 2010)***

IRR(Internal rate of the return)is the rate of return at which total present value of future cash inflow is equal to initial investment. The rate of return is generally found by trial and error method.

MARR (Minimum Attractive Rate of Return) represents the required or minimum interval rate of return for a project. The MARR is a minimum return the company will accept on the money it invests.

***14. How does present worth method help in comparing alternatives? (May 2010)***

***Or***

***15. What are present worth method of comparing alternatives? (Nov2009, Nov 2011, May 2011, Nov 2010)***

In developing the present worth method, we will use the concept of cash flows. As we observed, the most convenient point at which to calculate the equivalent values is often at time under the present worth method, the present worth of all cash inflows is compared against the present worth of all cash outflows associated with an investment project. The difference between the present worth of these cash flows, referred to as the net present worth determines whether or not the project is an acceptable investment. When two or more projects are under consideration, net present worth analysis further allows us to select the best project by comparing their net present worth figures.

***16. What is annual equivalent method of comparing alternatives? (May 2008, May 2011)***

In the annual equivalent method of comparison, first the annual equivalent cost or the revenue of each alternative will be computed. Then the alternative with the maximum annual equivalent revenue in the case of revenue-based comparison or with the minimum annual equivalent cost in the case of cost- based comparison will be selected as the best alternative.

***17. What is the decision criterion when applying the future worth method of alternative? (Nov 2010)***

In the future worth method of comparison of alternatives, the future worth of various alternatives will be computed. Then, the alternative with the maximum future worth of net revenue or with the minimum future worth of net cost will be selected as the best alternative for implementation.

***18. What is revenue dominated cash flow? (May 2008, May 2011).***

***Or***

***19. Define present worth method (Revenue dominated cash flow diagram) (Nov2009, Nov 2011, May 2011, Nov 2010, May 2010, Nov 08, May 2014)***

A generalized revenue-dominated cash flow diagram to demonstrate the annual equivalent method of comparison is presented in Fig. 6.1.

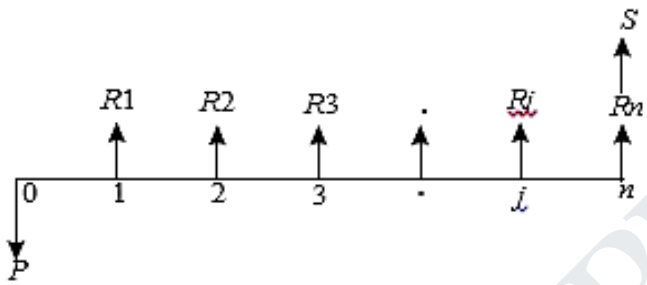



**Fig. 6.1** Revenue-dominated cash flow diagram.

In Fig. 6.1, $P$ represents an initial investment, $Rj$ the net revenue at the end of the $j$th year, and $S$ the salvage value at the end of the $n$th year.

The first step is to find the net present worth of the cash flow diagram using the following expression for a given interest rate, $i$:

$$PW(i) = -P + R1/(1+i)^1 + R2/(1+i)^2 + \ldots + Rj/(1+i)^j + \ldots + Rn/(1+i)^n + S/(1+i)^n$$

In the above formula, the expenditure is assigned with a negative sign and the revenues are assigned with a positive sign.

In the second step, the annual equivalent revenue is computed using the following formula:

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

$$= PW(i)\,(A/P, i, n)$$

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

If we have some more alternatives which are to be compared with this alternative, then the corresponding annual equivalent revenues are to be computed and compared. Finally, the alternative with the maximum annual equivalent revenue should be selected as the best alternative.

***20. What is the decision criterion when applying the future worth method of alternative? (Nov 2010, May2017)***

In the future worth method of comparison of alternatives, the future worth of various alternatives will be computed. Then, the alternative with the maximum future worth of net revenue or with the minimum future worth of net cost will be selected as the best alternative for implementation.

***21. What is the advantage of rate of Return method? (May 2009).***

1. It is easy to understand and operate.
2. It uses the entire earnings of an investment proposal, unlike the payback period method.
3. It gives a clear picture of the profitability of a project.

***22. What is the time value of money? (May 2009, Nov Dec 2017)***

The economic value of a sum depends on when it is received. Because money has earning power over time, (it can be put to work, earning more money for its owner), a rupee received has a greater value than a rupee received at some future some time.

***23. Mention the various rate of return method. (Nov 2008)***

The various rate of return methods are

1. Internal rate of return (IRR)
2. Average rate of return (ARR)
3. Net present value method (NPV)
4. Pay-back period (PBP)

***24.what is Capital Recovery (Nov Dec2017)?***

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.

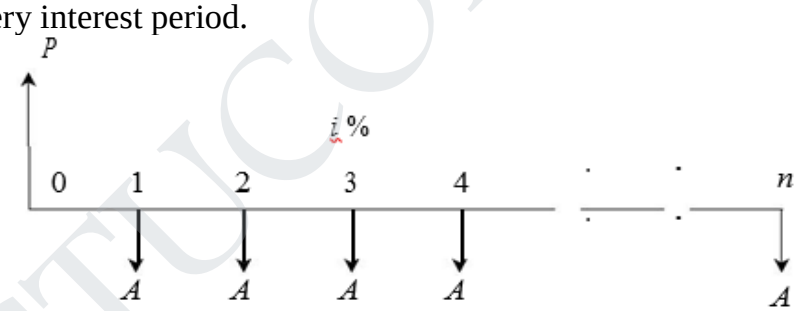



**Fig. 3.10** Cash flow diagram of equal-payment series capital recovery amount.

In Fig. 3.10,

$P$ = present worth (loan amount)
$A$ = annual equivalent payment (recovery amount)
$i$ = interest rate
$n$ = No. of interest periods

The formula to compute $P$ is as follows:

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

where,

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

**PART – B** **16 Marks**

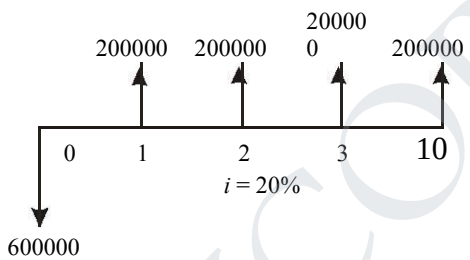
1. ***Arova Industry is planning to expand its production operation. It has identified two different technology for meeting the goal. The initial outlay and annual revenues with respect to each of the technology are summarized in the blew given table. Suggest the best technology is to be implemented based on the present worth of comparison assuming 20% interest rate compound annually.(May 2016).***

| | Initial outlay (Rs) | Annual Revenue (Rs) | Life (Years) |
|---|---|---|---|
| Technology 1 | 600000 | 200000 | 10 |
| Technology 2 | 1000000 | 300000 | 10. |

**Sol,**

**Technology 1**

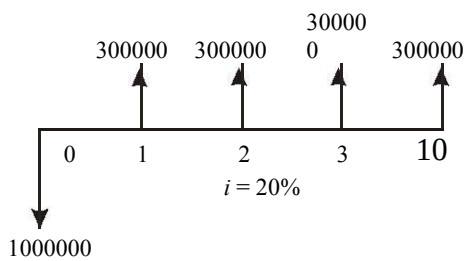
Initial outlay P=600000
Annual revenue A=200000
Interest rate i=20%
Life =10 years.




PW (20%) = -600000+200000 x (P/A, 20%, 10)
Using interest table
=-600000+200000 x 4.1925
=238500.R.s

**Technology 2**

Initial outlay P=1000000
Annual revenue A=300000
Interest rate i=20%
Life =10 years.




PW (20%) = -1000000+300000x4.19525 = 257750. R.s **Technology 2 Best**

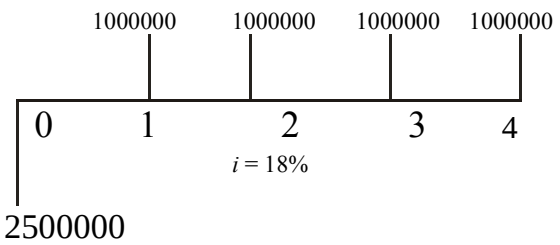
 

***2. Consider the following two mutually exclusive alternatives: (May 2016)***

| Alternative | End of year 0 | 1 | 2 | 3 |
|---|---|---|---|---|
| A(Rs) | 2500000 | 1000000 | 1000000 | 1000000 |
| B(Rs) | 2250000 | 900000 | 900000 | 900000 |

***At i=18% select the best alternative based on future worth method of comparison.***

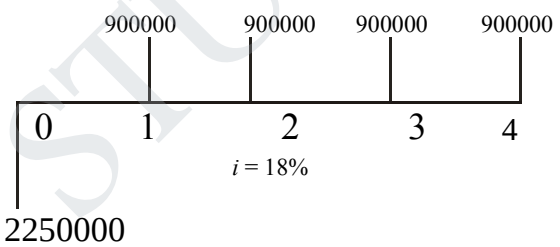
***Solution Alternative A***




Initial investment, $P$ = Rs. 2500000
Annual equivalent revenue, $A$ = Rs. 1000000
Interest rate, $i$ = 18%, compounded annually
Life of alternative A = 4 years

The future worth amount of alternative B is computed as
FWA(18%) = 2500000(F/P, 18%, 4) + 1000000 (F/A, 18%, 4)
=2500000(1.939) + 1000000 (5.215)
= 10062500 R.s

***Solution Alternative B***




Initial investment, $P$ = Rs. 2250000
Annual equivalent revenue, $A$ = Rs. 900000
Interest rate, $i$ = 18%, compounded annually
Life of alternative A = 4 years

The future worth amount of alternative B is computed as
FWA (18%) = 2250000 (F/P, 18%, 4) + 900000 (F/A, 18%, 4)
=2250000 (1.939) + 900000 (5.215)
= 4693500 R.s

**Ans: Select A best** 10062500 R.s

***3. An engineer has two bids for an elevator to be installed in a new building. The details of the bids for the elevators are as follows:***

| ***Bid*** | ***Engineer's estimates*** | | |
|---|---|---|---|
| | ***Initial cost (Rs.)*** | ***Service life (years)*** | ***Annual operations & maintenance cost (Rs.)*** |
| ***Alpha Elevator Inc.*** | ***4,50,000*** | ***15*** | ***27,000*** |
| ***Beta Elevator Inc.*** | ***5,40,000*** | ***15*** | ***28,500*** |

***Determine which bid should be accepted, based on the present worth method of comparison assuming 15% interest rate, compounded annually.(May 2015)***

Solution
Bid 1: Alpha Elevator Inc.
Initial cost, P = Rs. 4,50,000
Annual operation and maintenance cost, A = Rs. 27,000 Life = 15 years
Interest rate, i = 15%, compounded annually.
The cash flow diagram of bid 1 is shown in Fig. 4.6.

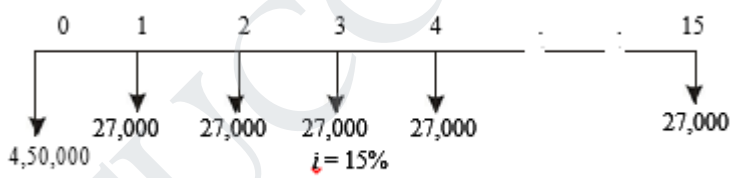



Fig. 4.6 Cash flow diagram for bid 1.

The present worth of the above cash flow diagram is computed as follows:
PW(15%) = 4,50,000 + 27,000(P/A, 15%, 15)
= 4,50,000 + 27,000 ´ 5.8474
= 4,50,000 + 1,57,879.80
= Rs. 6,07,879.80

**<u>Bid 2: Beta Elevator Inc.</u>**
Initial cost, P = Rs. 5,40,000
Annual operation and maintenance cost, A = Rs. 28,500
Life = 15 years.
Interest rate, i = 15%, compounded annually.

The cash flow diagram of bid 2 is shown in Fig. 4.7.

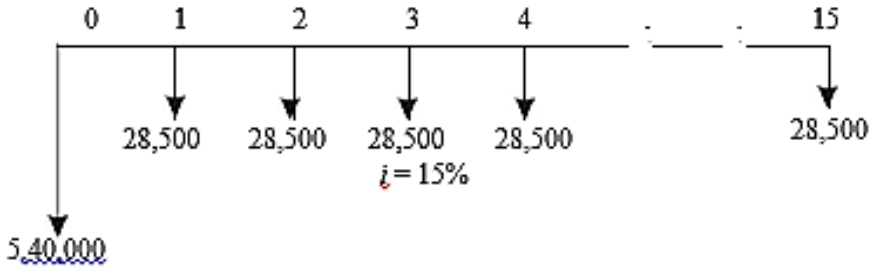



Fig. 4.7 Cash flow diagram for bid 2.

The present worth of the above cash flow diagram is computed as follows:
PW(15%) = 5,40,000 + 28,500(P/A, 15%, 15)
=5,40,000 + 28,500 ´ 5.8474
=5,40,000 + 1,66,650.90
=Rs. 7,06,650.90
The total present worth cost of bid 1 is less than that of bid 2. Hence, bid 1 is to be selected for implementation. That is, the elevator from Alpha Elevator Inc. is to be purchased and installed in the new building.

***4. Discuss the concept of make or buy decision and Explain the functions of value Engineering. (May 2015).***

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. So, in a given situation, the organization should evaluate each of the above make or buy alternatives and then select the alternative which results in the lowest cost. This is an important decision since it affects the productivity of the organization. In the long run, the make or buy decision is not static. The make option of a component/product may be economical today; but after some time, it may turn out to be uneconomical to make the same.

Thus, the make or buy decision should be reviewed periodically, say, every 1 to 3 years. This is mainly to cope with the changes in the level of competition and various other environmental factors.

13.2 CRITERIA FOR MAKE OR BUY
In this section the criteria for make or buy are discussed.
Criteria for make.

The following are the criteria for make:
1. The finished product can be made cheaper by the firm than by outside suppliers.
2. The finished product is being manufactured only by a limited number of

outside firms which are unable to meet the demand.
3. The part has an importance for the firm and requires extremely close quality control.
4. The part can be manufactured with the firm's existing facilities and similar to other items in which the company has manufacturing experience.
Criteria for buy
The following are the criteria for buy:
1. Requires high investments on facilities which are already available at suppliers plant.
2. The company does not have facilities to make it and there are more profitable opportunities for investing company's capital.
3. Existing facilities of the company can be used more economically to make other parts.
4. The skill of personnel employed by the company is not readily adaptable to make the part.
5. Patent or other legal barriers prevent the company for making the part.
6. Demand for the part is either temporary or seasonal.

13.3 APPROACHES FOR MAKE OR BUY DECISION
Types of analysis followed in make or buy decision are as follows:
1. Simple cost analysis
2. Economic analysis
3. Break-even analysis

**13.3.1 Simple Cost Analysis**

The concept is illustrated using an example problem.

EXAMPLE 13.1 A company has extra capacity that can be used to produce a sophisticated fixture which it has been buying for Rs. 900 each. If the company makes the fixtures, it will incur materials cost of Rs. 300 per unit, labour costs of Rs. 250 per unit, and variable overhead costs of Rs. 100 per unit. The annual fixed cost associated with the unused capacity is Rs. 10,00,000. Demand over the next year is estimated at 5,000 units. Would it be profitable for the company to make the fixtures?
Solution We assume that the unused capacity has alternative use.
Cost to make
Variable cost/unit = Material + labour + overheads
= Rs. 300 + Rs. 250 + Rs. 100
= Rs. 650
Total variable cost = (5,000 units) (Rs. 650/unit)
= Rs. 32,50,000
Add fixed cost associated

with unused capacity + Rs. 10,00,000
Total cost = Rs. 42,50,000

Cost to buy

Purchase cost = (5,000 units) (Rs. 900/unit)
= Rs. 45,00,000

Add fixed cost associated
with unused capacity+ Rs. 10,00,000

Total cost = Rs. 55,00,000

The cost of making fixtures is less than the cost of buying fixtures from outside. Therefore, the organization should make the fixtures.

### *13.3.2 Economic Analysis*

The following inventory models are considered to illustrate this concept:

- Purchase model
- Manufacturing model

The formulae for EOQ and total cost (TC) for each model are given in the following table:

| *Purchase model* | *Manufacturing model* |
|---|---|
| $Q1 = \sqrt{\frac{2C_oD}{C_c}}$ | $Q2 = \sqrt{\frac{2C_oD}{C_c(1 - r/k)}}$ |
| $TC = D \cdot P + \frac{DC_o}{Q1} + \frac{Q1 \cdot C_c}{2}$ | $TC = D \cdot P + \frac{DC_o}{Q2} + C_c(k - r)\frac{Q2}{2 * k}$ |

where

$D$ = demand/year

$P$ = purchase price/unit

$C_c$ = carrying cost/unit/year

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

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

$r$ = demand/year

$Q1$ = economic order size

$Q2$ = economic production size

$TC$ = total cost per year

*EXAMPLE 13.2* 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 | Rs. 8.00 | Rs. 5.00 |
| Procurement cost/order | Rs. 120.00 | |
| Set-up cost/set-up | | Rs. 60.00 |
| Annual carrying cost/ item/year | Rs. 1.60 | Rs. 1.00 |
| Production rate/year | | 8,000units |

***Solution***

**Buy option**

$D = 2{,}000$ units/year

$C_o$ = Rs. 120/order

$C_c$ = Rs. 1.60/unit/year

$$Q1 = \sqrt{\frac{2C_oD}{C_c}} = \sqrt{\frac{2 \cdot 2{,}000 \cdot 120}{1.60}}$$

= 548 units (approx.)

$$TC = DP + \frac{DC_o}{Q1} + \frac{Q1C}{2}$$

$$= 2{,}000 \times 8 + \frac{2000, \cdot 120}{548} + \frac{548 \cdot 1.60}{2}$$

= Rs. 16,876.36

**Make option**

$C_o$ = Rs. 60/set-up

$r = 2{,}000$ units/year

$C_c$ = Re 1/unit/year

$k = 8{,}000$ units/year

$$Q2 = \sqrt{\frac{2C_or}{C_c[1-(r/k)]}}$$

$$= = \sqrt{\frac{2 \cdot 60 \cdot 2{,}000}{1.0(1 - 2{,}000/8{,}000)}}$$

566 units (approx.)

$$TC = DP + \frac{D \cdot C_o}{Q2} + C_c(k-r)\frac{Q2}{2 \cdot k}$$

$$= 2{,}000 \times 5.00 + \frac{2000, \cdot 60}{566} + 1.0\,(8{,}000 - 2{,}000)\frac{566}{2 \cdot 8{,}000}$$

= Rs. 10,424.26

**Result:** The cost of making is less than the cost of buying. Therefore, the firm should go in for the making option.

### 13.3.3 Break-even Analysis

The break-even analysis chart is shown in Fig. 13.1. In the figure

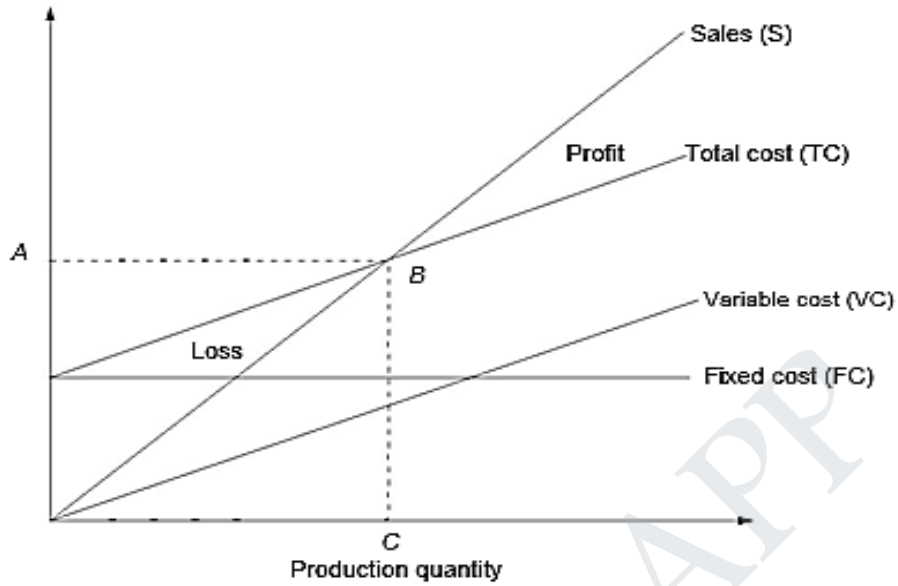



Fig. 13.1 Break-even chart.

$TC$ = total cost

$FC$ = fixed cost

$TC = FC +$ 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)

The formula for the break-even point (BEP) is

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

***5. Discuss the present worth method (Revenue Dominated Cash Flow Diagram). (Nov 2014, Nov 2009, Nov 2017)***

**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.

The sign of various amounts at different points in time in a cash flow diagram is to be decided based on the type of the decision problem.

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.

## 4.2 REVENUE-DOMINATED CASH FLOW DIAGRAM

A generalized revenue-dominated cash flow diagram to demonstrate the present worth method of comparison is presented in Fig. 4.1.

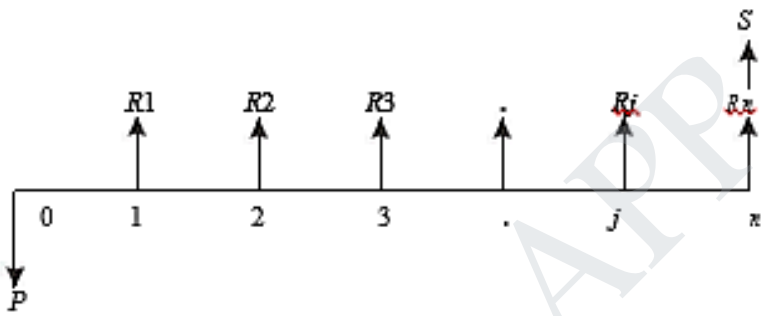



Fig. 4.1 Revenue-dominated cash flow diagram.

In Fig. 4.1, P represents an initial investment and Rj the net revenue at the end of the jth year. The interest rate is i, compounded annually. S is the salvage value at the end of the nth year. To find the present worth of the above cash flow diagram for a given interest rate, the formula is

$$PW(i) = -P + R1[1/(1+i)^1] + R2[1/(1+i)^2] + \ldots$$
$$+ Rj[1/(1+i)^j] + Rn[1/(1+i)^n] + S[1/(1+i)^n]$$

In this formula, expenditure is assigned a negative sign and revenues are assigned a positive sign.

If we have some more alternatives which are to be compared with this alternative, then the corresponding present worth amounts are to be computed and compared. Finally, the alternative with the maximum present worth amount should be selected as the best alternative.

## COST-DOMINATED CASH FLOW DIAGRAM

A generalized cost-dominated cash flow diagram to demonstrate the present Worth method of comparison is presented in Fig. 4.2.

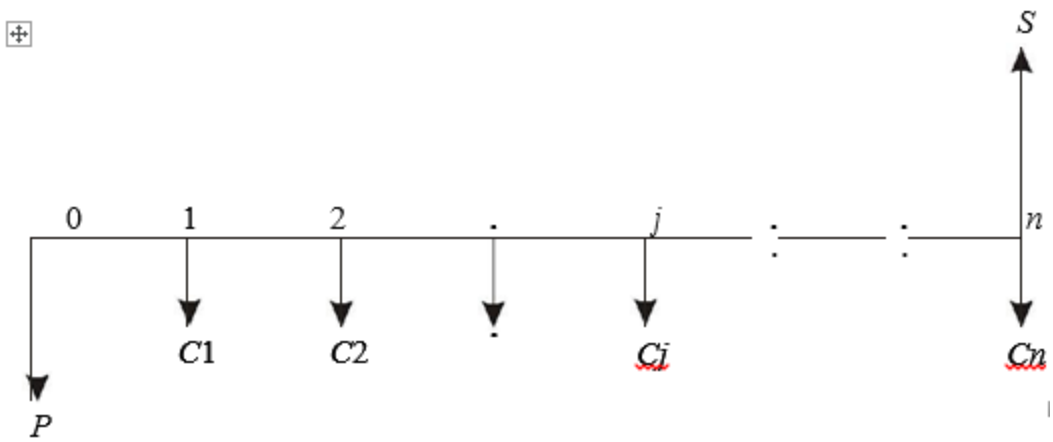



**Fig. 4.2** Cost-dominated cash flow diagram.

In Fig. 4.2, P represents an initial investment, Cj the net cost of operation and maintenance at the end of the jth year, and S the salvage value at the end of the nth year.

To compute the present worth amount of the above cash flow diagram for a given interest rate i, we have the formula.

$$PW(i) = P + C1[1/(1+i)^1] + C2[1/(1+i)^2] + \ldots + Cj[1/(1+i)^j] + Cn[1/(1+i)^n] - S[1/(1+i)^n]$$

In the above formula, the expenditure is assigned a positive sign and the revenue a negative sign. If we have some more alternatives which are to be compared with this alternative, then the corresponding present worth amounts are to be computed and compared. Finally, the alternative with the minimum present worth amount should be selected as the best alternative.

EXAMPLES

In this section, the concept of present worth method of comparison applied to the selection of the best alternative is demonstrated with several illustrations.

EXAMPLE 4.1 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 4.1. Suggest the best technology which is to be implemented based on the present worth method of comparison assuming 20% interest rate, compounded annually.

**Table 4.1**

| | *Initial outlay* (Rs.) | *Annual revenue* (Rs.) | *Life* (years) |
|---|---|---|---|
| Technology 1 | 12,00,000 | 4,00,000 | 10 |
| Technology 2 | 20,00,000 | 6,00,000 | 10 |
| Technology 3 | 18,00,000 | 5,00,000 | 10 |

***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, $P$ = Rs. 12,00,000
Annual revenue, $A$ = Rs. 4,00,000
Interest rate, $i$ = 20%, compounded annually
Life of this technology, $n$ = 10 years

The cash flow diagram of this technology is as shown in Fig. 4.3.

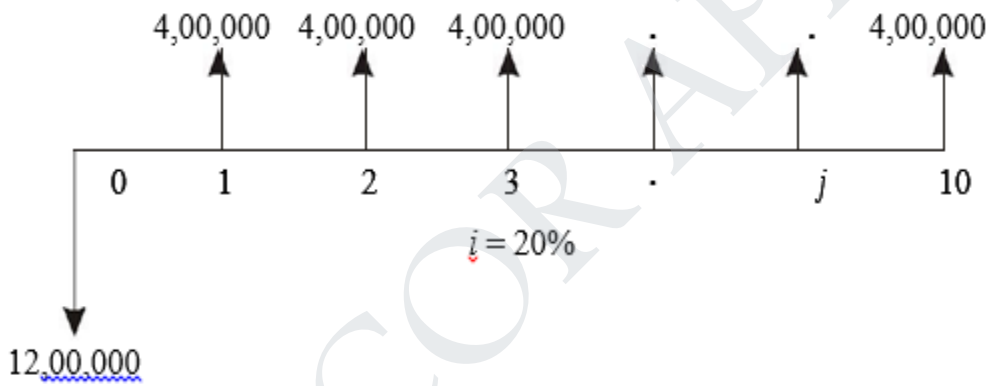



**Fig. 4.3** Cash flow diagram for technology 1.

The present worth expression for this technology is

$$
\begin{aligned}
PW(20\%)_1 &= -12,00,000 + 4,00,000 \times (P/A, 20\%, 10) \\
&= -12,00,000 + 4,00,000 \times (4.1925) \\
&= -12,00,000 + 16,77,000 \\
&= \text{Rs. } 4,77,000
\end{aligned}
$$

TECHNOLOGY 2

Initial outlay, $P$ = Rs. 20,00,000
Annual revenue, $A$ = Rs. 6,00,000
Interest rate, $i$ = 20%, compounded annually
Life of this technology, $n$ = 10 years

The cash flow diagram of this technology is shown in Fig. 4.4.

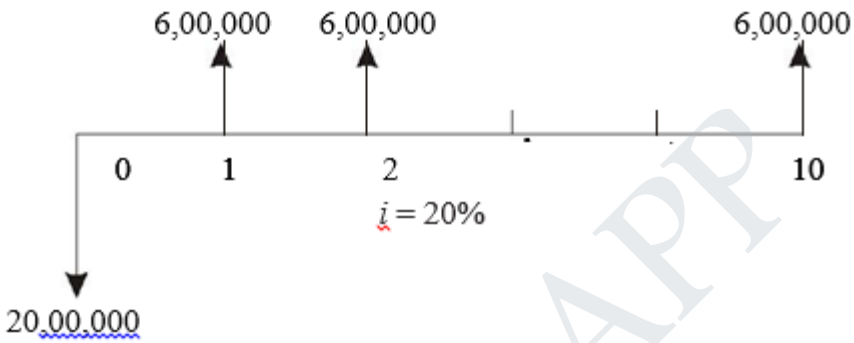



**Fig. 4.4** Cash flow diagram for technology 2.

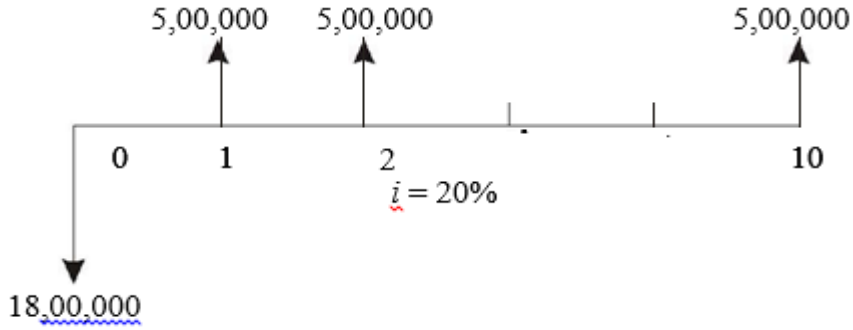
The present worth expression for this technology is

$$PW(20\%)_2 = -20,00,000 + 6,00,000 \times (P/A, 20\%, 10) =$$
$$-20,00,000 + 6,00,000 \times (4.1925)$$
$$= -20,00,000 + 25,15,500$$
$$= \text{Rs. } 5,15,500$$

TECHNOLOGY 3

Initial outlay, $P$ = Rs. 18,00,000
Annual revenue, $A$ = Rs. 5,00,000
Interest rate, $i$ = 20%, compounded annually
Life of this technology, $n$ = 10 years

The cash flow diagram of this technology is shown in Fig. 4.5.



From the above calculations, it is clear that the present worth of technology 2 is the highest among all the technologies. Therefore, technology 2 is suggested for implementation to expand the production.

***6. Discuss the Annual Equivalent method (revenue Dominated Cash Flow Diagram) (Nov 2014, Nov2009, May2009,Nov 2017)***

6.1 INTRODUCTION

In the annual equivalent method of comparison, first the annual equivalent cost or the revenue of each alternative will be computed. Then the alternative with the maximum annual equivalent revenue in the case of revenue-based comparison or with the minimum annual equivalent cost in the case of cost-based comparison will be selected as the best alternative.

6.2 REVENUE-DOMINATED CASH FLOW DIAGRAM

A generalized revenue-dominated cash flow diagram to demonstrate the annual equivalent method of comparison is presented in Fig. 6.1.

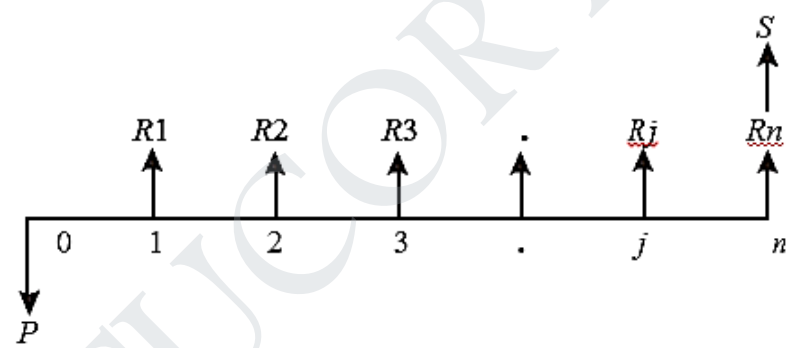



**Fig. 6.1** Revenue-dominated cash flow diagram.

In Fig. 6.1, $P$ represents an initial investment, $Rj$ the net revenue at the end of the $j$th year, and $S$ the salvage value at the end of the $n$th year.

The first step is to find the net present worth of the cash flow diagram using the following expression for a given interest rate, $i$:

$$PW(i) = -P + R1/(1+i)^1 + R2/(1+i)^2 + \ldots + Rj/(1+i)^j + \ldots + Rn/(1+i)^n + S/(1+i)^n$$

In the above formula, the expenditure is assigned with a negative sign and the revenues are assigned with a positive sign.

In the second step, the annual equivalent revenue is computed using the following formula:

$$A = PW(i) \frac{i(1+i)^n}{(1+i)^n - 1}$$

$$= PW(i)\,(A/P, i, n)$$

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

If we have some more alternatives which are to be compared with this alternative, then the corresponding annual equivalent revenues are to be computed and compared. Finally, the alternative with the maximum annual equivalent revenue should be selected as the best alternative.

## 6.3 COST-DOMINATED CASH FLOW DIAGRAM

A generalized cost-dominated cash flow diagram to demonstrate the annual equivalent method of comparison is illustrated in Fig. 6.2.

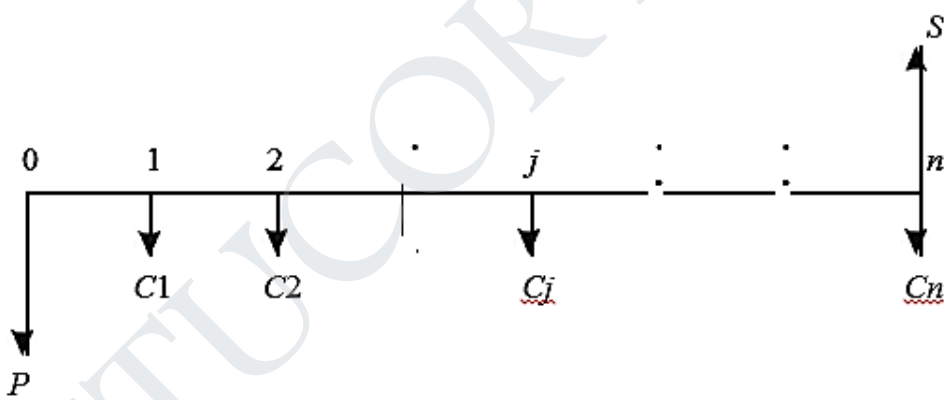



**Fig. 6.2** Cost-dominated cash flow diagram.

In Fig. 6.2, $P$ represents an initial investment, $C_j$ the net cost of operation and maintenance at the end of the $j$th year, and $S$ the salvage value at the end of the $n$th year.

The first step is to find the net present worth of the cash flow diagram using the following relation for a given interest rate, $i$.

As in the previous case, if we have some more alternatives which are to be compared with this alternative, then the corresponding annual equivalent costs are to be computed and compared.

Finally, the alternative with the minimum annual equivalent cost should be selected as the best alternative.

If we have some non-standard cash flow diagram, then we will have to

follow the general procedure for converting each and every transaction to time zero and then convert the net present worth into an annual equivalent cost/ revenue depending on the type of the cash flow diagram. Such procedure is to be applied to all the alternatives and finally, the best alternative is to be selected.

## 6.4 ALTERNATE APPROACH

Instead of first finding the present worth and then figuring out the annual equivalent cost/revenue, an alternate method which is as explained below can be used. In each of the cases presented in Sections 6.2 and 6.3, in the first step, one can find the future worth of the cash flow diagram of each of the alternatives. Then, in the second step, the annual equivalent cost/revenue can be obtained by using the equation:

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

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

***7. Write about the revenue dominated cash flow diagram and cost dominated cash flow diagram. (May 2014)***

## 5.2 REVENUE-DOMINATED CASH FLOW DIAGRAM

A generalized revenue-dominated cash flow diagram to demonstrate the future worth method of comparison is presented in Fig. 5.1.

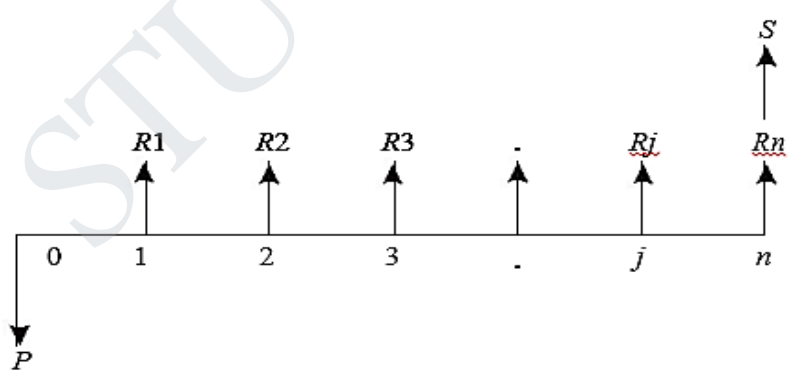



**Fig. 5.1** *Revenue*-dominated cash flow diagram.

In Fig. 5.1, $P$ represents an initial investment, $R_j$ the net-revenue at the end of the $j$th year, and $S$ the salvage value at the end of the $n$th year.

The formula for the future worth of the above cash flow diagram for a given interest rate, $i$ is

$$FW(i) = -P(1+i)^n + R1(1+i)^{n-1} + R2(1+i)^{n-2} + \ldots + R_j(1+i)^{n-j} + \ldots + R_n + S$$

In the above formula, the expenditure is assigned with negative sign and the revenues are assigned with positive sign. If we have some more alternatives which are to be compared with this alternative, then the corresponding future worth amounts are to be computed and compared. Finally, the alternative with the maximum future worth amount should be selected as the best alternative.

## 5.3 COST-DOMINATED CASH FLOW DIAGRAM

A generalized cost-dominated cash flow diagram to demonstrate the future worth method of comparison is given in Fig. 5.2.

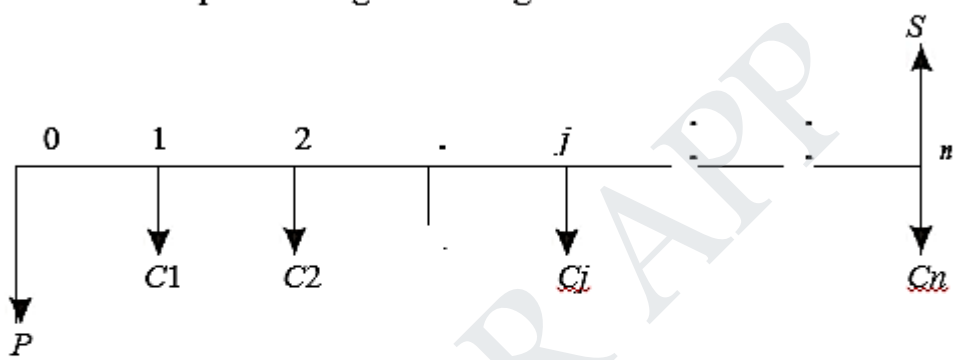



**Fig. 5.2** Cost-dominated cash flow diagram.

In Fig. 5.2, $P$ represents an initial investment, $Cj$ the net cost of operation and maintenance at the end of the $j$th year, and $S$ the salvage value at the end of the $n$th year.

The formula for the future worth of the above cash flow diagram for a given interest rate, $i$ is

$$FW(i) = P(1+i)^n + C1(1+i)^{n-1} + C2(1+i)^{n-2} + \ldots + Cj(1+i)^{n-j} + \ldots + Cn - S$$

In this formula, the expenditures are assigned with positive sign and revenues with negative sign.

If we have some more alternatives which are to be compared with this alternative, then the corresponding future worth amounts are to be computed and compared.

Finally, the alternative with the minimum future worth amount should be selected as the best alternative.

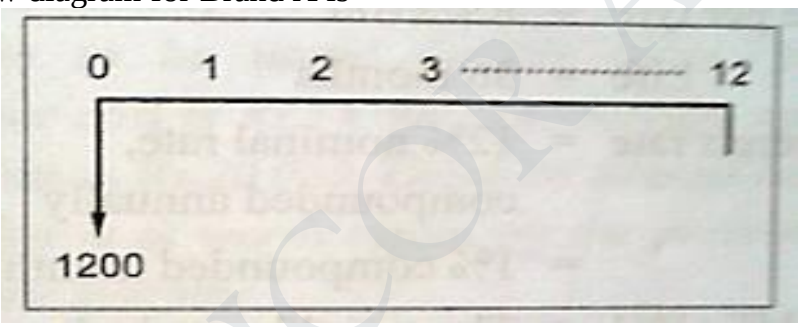
 

***8. A tyre company decided for new tyre for its vehicles and finalized on the following alternatives.***

| *Brands* | *types of warranty (Months)* | *price per tyre(Rs.)* |
|---|---|---|
| *A* | *12* | *1200* |
| *B* | *24* | *1800* |
| *C* | *36* | *2100* |

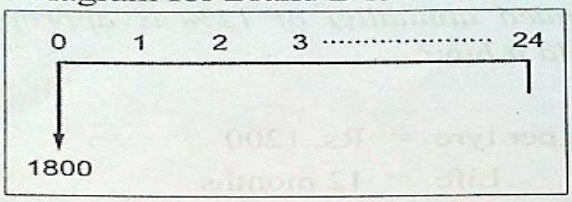
***If the company feels that warranty period is a good estimated of the tyres life and that a nominal interest rate (Compound annually) of 12% appropriate, Which tyre should it buy?***

Given: Price per tyre=R.s 1200
Life= 12months
Interest rate=12% (normal rate, compounded annually)
=1% compounded monthly.
To find: ME (1%)= The monthly equivalent cost
The cash flow diagram for Brand A is




<u>Brand:-B</u>
Given: Price per tyre = Rs. 1800
Life = 24 months
Interest rate =12 %( nominal rate compounded annually)
=1 % compounded monthly

***To find:*** ME (1%) = The monthly equivalent cost
The cash flow diagram for Brand B is




☺ ***Solution:***

ME (1%) = 1800 (A/P, 1%, 24)
= 1800 (0.0471)
= Rs. 84.78

***Brand C:***

***Given:*** Price per tyre = Rs. 2100

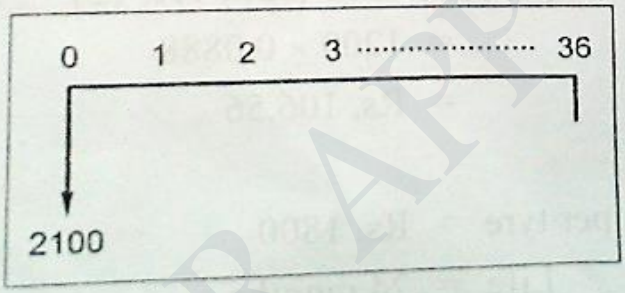
Life = 36 months

Interest rate = 12% nominal rate, compounded annually

= 1% compounded monthly

***To find:*** ME (1%) = The monthly equivalent cost

The cash flow diagram for Brand C is




☺ ***Solution:***

$$ME(1\%) = 2100\,(A/P, 1\%, 36)$$
$$= 2100 \times 0.0332$$
$$= \text{Rs. } 69.72$$

***9. Alpha industry is planning to expand its production operation. It has identified three different Technology for meeting the goal. The initial outlay and annual revenues with respect to each of the technologies are summarized in table. Suggest the best technology which is to be implemented based on the present worth method of comparison assuming 20% interest rate, compound annually.***

| | *Initial outlay(Rs.)* | *Annual revenue(Rs.)* | *Life(years)* |
|---|---|---|---|
| *Technology1* | *12,00,000* | *4,00,000* | *10* |
| *Technology2* | *20,00,000* | *6,00,000* | *10* |
| *Technology3* | *18,00,000* | *5,00,000* | *10* |

***(Nov 2013)***

***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, $P$ = Rs. 12, 00, 000
Annual revenue, $A$ = Rs. 4,00,000
Interest rate, $i$ = 20%, compounded annually
Life of this technology, $n$ = 10 years

The cash flow diagram of this technology is as shown in Fig. 4.3.

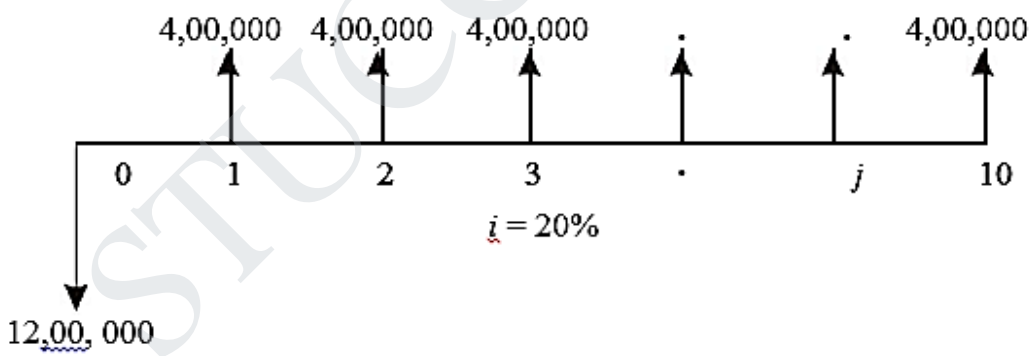



**Fig. 4.3** Cash flow diagram for technology 1.

The present worth expression for this technology is

$$PW(20\%)_1 = -12,00,000 + 4,00,000 \times (P/A, 20\%, 10)$$
$$= -12,00,000 + 4,00,000 \times (4.1925)$$
$$= -12,00,000 + 16,77,000$$
$$= \text{Rs. } 4,77,000$$

TECHNOLOGY 2

Initial outlay, $P$ = Rs. 20,00,000
Annual revenue, $A$ = Rs. 6,00,000
Interest rate, $i$ = 20%, compounded annually
Life of this technology, $n$ = 10 years

The cash flow diagram of this technology is shown in Fig. 4.4.

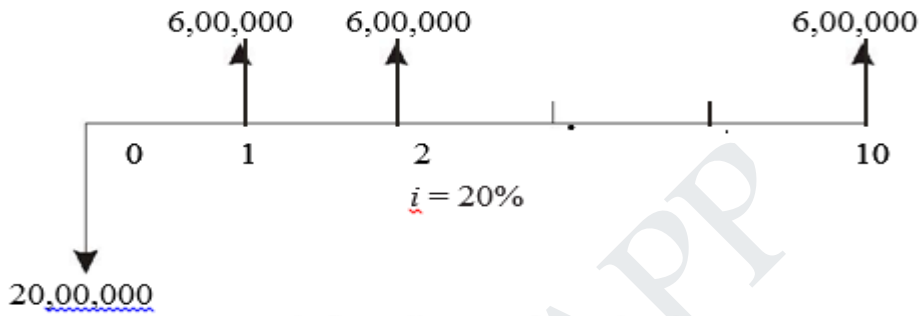



**Fig. 4.4** Cash flow diagram for technology 2.

The present worth expression for this technology is

$$PW(20\%)_2 = -20,00,000 + 6,00,000 \times (P/A, 20\%, 10) =$$
$$-20,00,000 + 6,00,000 \times (4.1925)$$
$$= -20,00,000 + 25,15,500$$
$$= \text{Rs. } 5,15,500$$

TECHNOLOGY 3

Initial outlay, $P$ = Rs. 18,00,000
Annual revenue, $A$ = Rs. 5,00,000
Interest rate, $i$ = 20%, compounded annually
Life of this technology, $n$ = 10 years

The cash flow diagram of this technology is shown in Fig. 4.5.

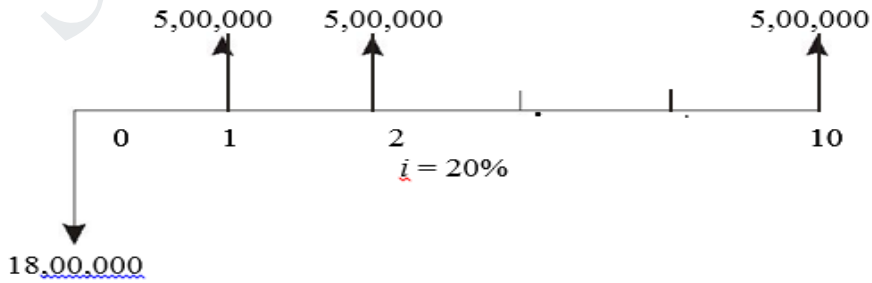



**Fig. 4.5** Cash flow diagram for technology 3.

The present worth expression for this technology is

$$\begin{aligned} PW(20\%)_3 &= -18{,}00{,}000 + 5{,}00{,}000 \times (P/A, 20\%, 10) \\ &= -18{,}00{,}000 + 5{,}00{,}000 \times (4.1925) \\ &= -18{,}00{,}000 + 20{,}96{,}250 \\ &= \text{Rs. } 2{,}96{,}250 \end{aligned}$$

From the above calculations, it is clear that the present worth of technology 2 is the highest among all the technologies. Therefore, technology 2 is suggested for implementation to expand the production

***10. Explain the concept cash flow and different methods of comparison of alternatives. List the merits and Limitation of each method if any. (May 2013, Nov 2010)***

## 4.2 REVENUE-DOMINATED CASH FLOW DIAGRAM

A generalized revenue-dominated cash flow diagram to demonstrate the present worth method of comparison is presented in Fig. 4.1.

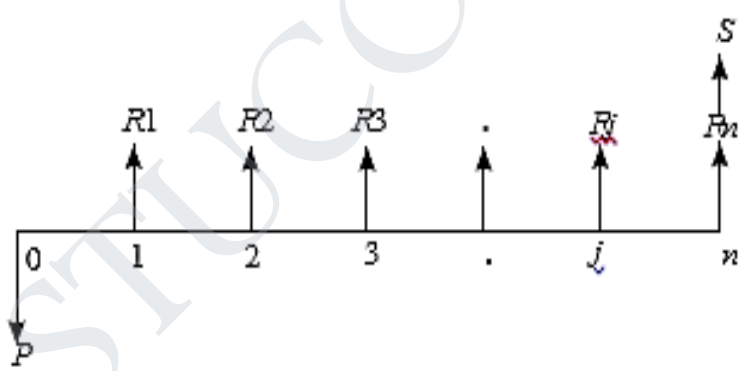



**Fig. 4.1** Revenue-dominated cash flow diagram.

In Fig. 4.1, $P$ represents an initial investment and $Rj$ the net revenue at the end of the $j$th year. The interest rate is $i$, compounded annually. $S$ is the salvage value at the end of the $n$th year.

To find the present worth of the above cash flow diagram for a given interest rate, the formula is

$$\begin{aligned} PW(i) = &-P + R1[1/(1+i)^1] + R2[1/(1+i)^2] + \ldots \\ &+ Rj[1/(1+i)^j] + Rn[1/(1+i)^n] + S[1/(1+i)^n] \end{aligned}$$

In this formula, expenditure is assigned a negative sign and revenues are assigned a positive sign.

If we have some more alternatives which are to be compared with this alternative, then the corresponding present worth amounts are to be computed and compared. Finally, the alternative with the maximum present worth amount should be selected as the best alternative.

## 4.3 COST-DOMINATED CASH FLOW DIAGRAM

A generalized cost-dominated cash flow diagram to demonstrate the present Worth method of comparison is presented in Fig. 4.2.

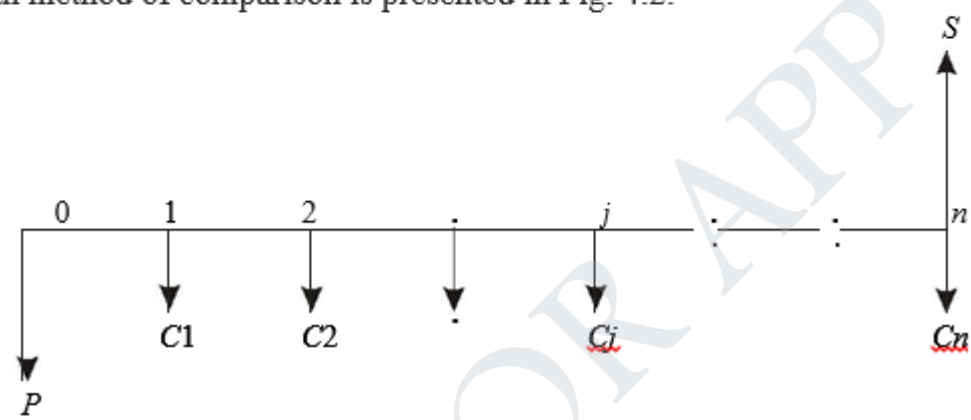



**Fig. 4.2 Cost**-dominated cash flow diagram.

In Fig. 4.2, $P$ represents an initial investment, $Cj$ the net cost of operation and maintenance at the end of the $j$th year, and $S$ the salvage value at the end of the $n$th year.

To compute the present worth amount of the above cash flow diagram for a given interest rate $i$, we have the formula

$$PW(i) = P + C1[1/(1+i)^1] + C2[1/(1+i)^2] + \ldots + Cj[1/(1+i)^j] + Cn[1/(1+i)^n] - S[1/(1+i)^n]$$

In the above formula, the expenditure is assigned a positive sign and the revenue a negative sign. If we have some more alternatives which are to be compared with this alternative, then the corresponding present worth amounts are to be computed and compared. Finally, the alternative with the minimum present worth amount should be selected as the best alternative.

## 5.2 REVENUE-DOMINATED CASH FLOW DIAGRAM

A generalized revenue-dominated cash flow diagram to demonstrate the future worth method of comparison is presented in Fig. 5.1.

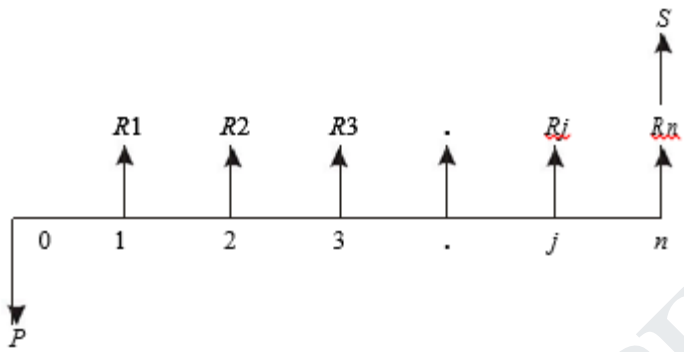



**Fig. 5.1 Revenue**-dominated cash flow diagram.

In Fig. 5.1, $P$ represents an initial investment, $Rj$ the net-revenue at the end of the $j$th year, and $S$ the salvage value at the end of the $n$th year.

The formula for the future worth of the above cash flow diagram for a given interest rate, $i$ is

$$FW(i) = -P(1+i)^n + R1(1+i)^{n-1} + R2(1+i)^{n-2} + \ldots$$
$$+ Rj(1+i)^{n-j} + \ldots + Rn + S$$

In the above formula, the expenditure is assigned with negative sign and the revenues are assigned with positive sign.

If we have some more alternatives which are to be compared with this Alternative, then the corresponding future worth amounts are to be computed and compared. Finally, the alternative with the maximum future worth amount should be selected as the best alternative.

## 5.3 COST-DOMINATED CASH FLOW DIAGRAM

A generalized cost-dominated cash flow diagram to demonstrate the future worth method of comparison is given in Fig. 5.2.

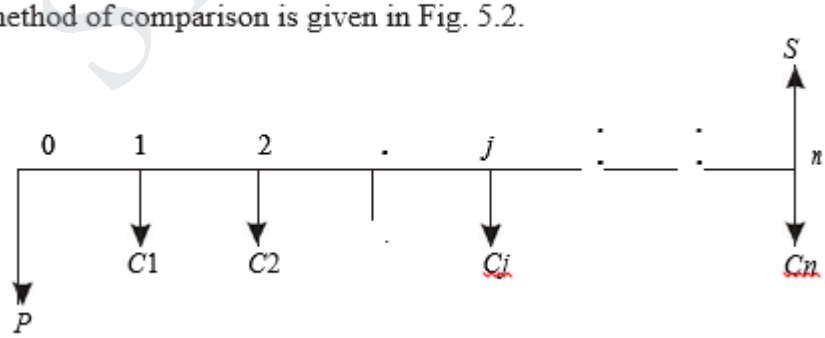



**Fig. 5.2** Cost-dominated cash flow diagram.

In Fig. 5.2, $P$ represents an initial investment, $Cj$ the net cost of operation and maintenance at the end of the $j$th year, and $S$ the salvage value at the end of the $n$th year.

The formula for the future worth of the above cash flow diagram for a given interest rate, $i$ is

$$FW(i) = P(1+i)^n + C1(1+i)^{n-1} + C2(1+i)^{n-2} + \ldots + Cj(1+i)^{n-j} + \ldots + Cn - S$$

In this formula, the expenditures are assigned with positive sign and revenues with negative sign. If we have some more alternatives which are to be compared with this alternative, then the corresponding future worth amounts are to be computed and compared. Finally, the alternative with the minimum future worth amount should be selected as the best alternative.

## 6.3 COST-DOMINATED CASH FLOW DIAGRAM

A generalized cost-dominated cash flow diagram to demonstrate the annual equivalent method of comparison is illustrated in Fig. 6.2.

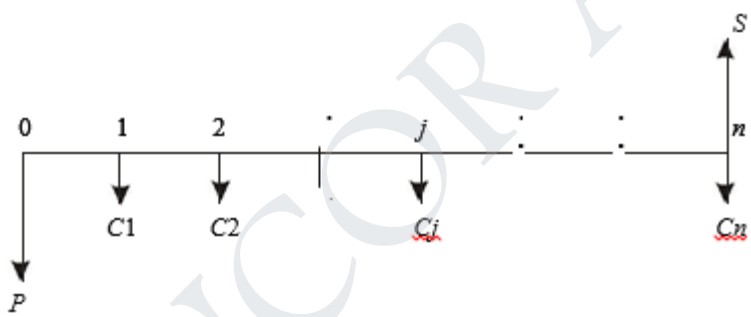



**Fig. 6.2** Cost-dominated cash flow diagram.

In Fig. 6.2, $P$ represents an initial investment, $Cj$ the net cost of operation and maintenance at the end of the $j$th year, and $S$ the salvage value at the end of the $n$th year.

The first step is to find the net present worth of the cash flow diagram using the following relation for a given interest rate, $i$.

$$PW(i) = P + C1/(1+i)^1 + C2/(1+i)^2 + \ldots + Cj/(1+i)^j + \ldots + Cn/(1+i)^n - S/(1+i)^n$$

In the above formula, each expenditure is assigned with positive sign and the salvage value with negative sign. Then, in the second step, the annual equivalent cost is computed using the following equation:

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

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

As in the previous case, if we have some more alternatives which are to be compared with this alternative, then the corresponding annual equivalent costs are to be computed and compared. Finally, the alternative with the minimum annual equivalent cost should be selected as the best alternative.

If we have some non-standard cash flow diagram, then we will have to follow the general procedure for converting each and every transaction to time zero and then convert the net present worth into an annual equivalent cost/ revenue depending on the type of the cash flow diagram. Such procedure is to be applied to all the alternatives and finally, the best alternative is to be selected.

## 6.4 ALTERNATE APPROACH

Instead of first finding the present worth and then figuring out the annual equivalent cost/revenue, an alternate method which is as explained below can be used. In each of the cases presented in Sections 6.2 and 6.3, in the first step, one can find the future worth of the cash flow diagram of each of the alternatives. Then, in the second step, the annual equivalent cost/revenue can be obtained by using the equation:

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

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

***11. Calculate the Average rate of return for projects A and B from the following:***

| ***Project*** | ***A*** | ***B*** |
|---|---|---|
| ***Investment*** | ***Rs.20,000*** | ***Rs.30,000*** |
| ***Expected Life*** | ***1 year*** | ***5 year*** |

***No salvage value.***

***Projected Net Income (after interest, depreciation and taxes)***

| ***Years*** | ***Project A Rs.*** | ***Project B Rs.*** |
|---|---|---|
| ***1*** | ***2,000*** | ***3,000*** |
| ***2*** | ***1,500*** | ***3,000*** |
| ***3*** | ***1,500*** | ***2,000*** |
| ***4*** | ***1,000*** | ***1,000*** |
| ***5*** | ***-*** | ***1,000*** |
| | ***Total: 6,000*** | ***10,000*** |

***(May 2013.***

**Sol.**

To find: Average rate of return for project A & B.

Average rate of return for project A:

Total returns = R.s 6000

Average return =Total return/Expected life

Average return=R.s 6000/4

=R.s 1500

Average rate of return = (Average return / Investment )x100

=(R.s 1500/R.s 20000)x 100

=7.5%

Average rate of return for project B:

Total return =R.s 10000

Average return=Total return/Expected life

=R.s 10000/5

=R.s 2000

Average rate of return = (Average return/Investment) x100

= (R.s 2000/R.s 30000) x 100

= 6.67%

Result Average rate return for

Project A=7.5%

Project B=6.67%

***12. A company is planning to purchase an advance machine center. Three original manufactures have responded to its tender whose particulars are tabulated as follows:***

| *Manufacturer* | *Down payment (Rs.)* | *Yearly equal installment (Rs.)* | *No of installments* |
|---|---|---|---|
| *1* | *5,00,000* | *2,00,000* | *15* |
| *2* | *4,00,000* | *3,00,000* | *15* |
| *3* | *6,00,000* | *1,50,000* | *15* |

***Determine the best alternative based on the annual equivalent method by assuming i=20%, compounded annually. (Nov 2013).***

Determine the best alternative based on the annual equivalent method by assuming $i = 20\%$, compounded annually.

***Solution Alternative 1***

Down payment, $P$ = Rs. 5, 00,000

Yearly equal installment, $A$ = Rs. 2, 00,000

$n = 15$ years

$i = 20\%$, compounded annually

The cash flow diagram for manufacturer 1 is shown in Fig. 6.4.

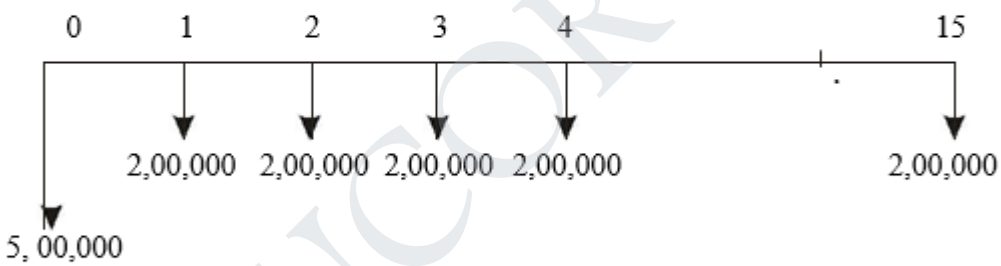



**Fig. 6.4 Cash** flow diagram for manufacturer 1.

The annual equivalent cost expression of the above cash flow diagram is

$$AE_1\,(20\%) = 5,\,00{,}000(A/P,\,20\%,\,15) + 2,\,00{,}000$$
$$= 5{,}00{,}000(0.2139) + 2{,}00{,}000$$
$$= 3{,}06{,}950$$

***Alternative 2***

Down payment, $P$ = Rs. 4,00,000

Yearly equal installment, $A$ = Rs. 3,00,000

$n = 15$ years

$i = 20\%$, compounded annually

The cash flow diagram for the manufacturer 2 is shown in Fig. 6.5.

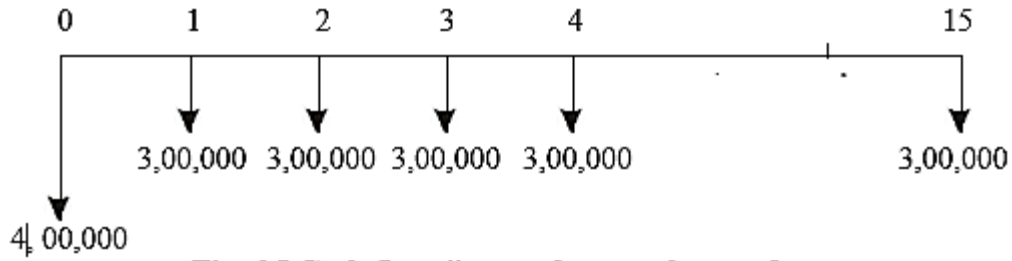



**Fig. 6.5 Cash** flow diagram for manufacturer 2.

The annual equivalent cost expression of the above cash flow diagram is

$$AE_2\ (20\%) = 4,\ 00{,}000(A/P,\ 20\%,\ 15) + 3,\ 00{,}000$$
$$= 4{,}00{,}000(0.2139) + 3{,}00{,}000$$
$$= \text{Rs. } 3,\ 85{,}560.$$

***Alternative 3***

Down payment, $P$ = Rs. 6, 00,000
Yearly equal installment, $A$ = Rs. 1, 50,000
$n$ = 15 years
$i$ = 20%, compounded annually

The cash flow diagram for manufacturer 3 is shown in Fig. 6.6.

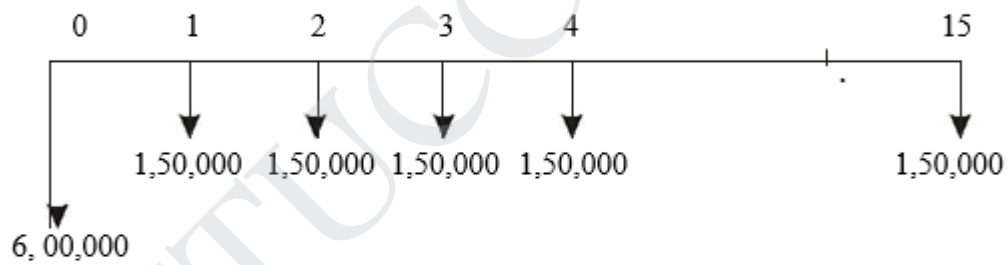



**Fig. 6.6 Cash** flow diagram for manufacturer 3.

The annual equivalent cost expression of the above cash flow diagram is

$$AE_3\ (20\%) = 6,\ 00{,}000(A/P,\ 20\%,\ 15) + 1,\ 50{,}000$$
$$= 6{,}00{,}000(0.2139) + 1{,}50{,}000$$
$$= \text{Rs. } 2,\ 78{,}340.$$

The annual equivalent cost of manufacturer 3 is less than that of manufacturer 1 and manufacturer 2. Therefore, the company should buy the advanced machine centre from manufacturer 3.

***13. A company must decide whether to buy machine A or machine B:***

| | ***Machine A*** | ***Machine B*** |
|---|---|---|
| ***Initial cost*** | ***Rs.4,00,000*** | ***Rs.8,00,000*** |
| ***Useful life in years*** | ***4*** | ***4*** |
| ***Salvage value at the end of machine life*** | ***Rs.2,00,000*** | ***Rs.5,50,000*** |
| ***Annual maintenance cost*** | ***Rs.40,000*** | ***0*** |

***At 12% interest rate, which machine should be selected? (Use Future worth method of comparison). (Nov 2012)***

***Solution Machine A***

Initial cost of the machine, $P$ = Rs. 4, 00,000

Life, $n$ = 4 years

Salvage value at the end of machine life, $S$ = Rs. 2, 00,000

Annual maintenance cost, $A$ = Rs. 40,000

Interest rate, $i$ = 12%, compounded annually.

The cash flow diagram of machine $A$ is given in Fig. 5.12.

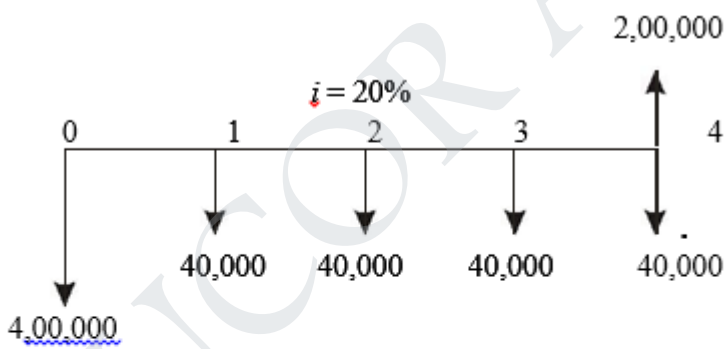



**Fig. 5.12** Cash flow diagram for machine $A$.

The future worth function of Fig. 5.12 is

$$FW_A(12\%) = 4{,}00{,}000 \times (F/P, 12\%, 4) + 40{,}000 \times (F/A, 12\%, 4) - 2{,}00{,}000$$
$$= 4{,}00{,}000 \times (1.574) + 40{,}000 \times (4.779) - 2{,}00{,}000$$
$$= \text{Rs. } 6{,}20{,}760$$

***Machine B***

Initial cost of the machine, $P$ = Rs. 8, 00,000

Life, $n$ = 4 years

Salvage value at the end of machine life, $S$ = Rs. 5, 50,000

Annual maintenance cost, $A$ = zero.

Interest rate, $i = 12\%$, compounded annually.

The cash flow diagram of the machine $B$ is illustrated in Fig. 5.13.

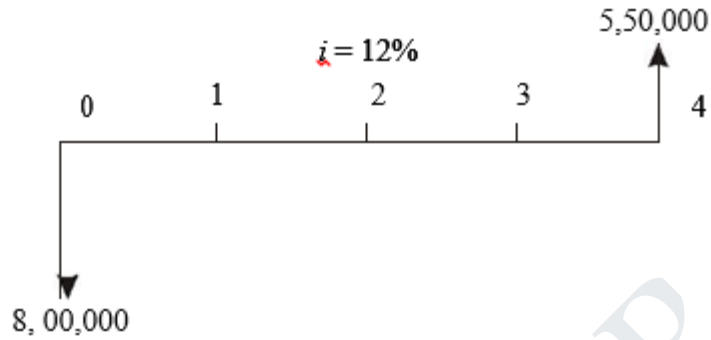



**Fig. 5.13 Cash** flow diagram for machine $B$.

The future worth function of Fig 5.13 is

$$FW_B(12\%) = 8,00,000 \times (F/P, 12\%, 4) - 5,50,000$$
$$= 8,00,000 \times (1.574) - 5,50,000$$
$$= \text{Rs. } 7,09,200$$

The future worth cost of machine A is less than that of machine B. Therefore, machine A should be selected.

***14. A Transport company has been looking for a new tyre for its truck and has located the following alternatives:***

| ***Brand*** | ***Tyre warranty (month)*** | ***Price per tyre (R.s.)*** |
|---|---|---|
| ***A*** | ***12*** | ***1,200*** |
| ***B*** | ***24*** | ***1,800*** |
| ***C*** | ***36*** | ***2,100*** |
| ***D*** | ***48*** | ***2,700*** |

***If the company feels that the warranty period is a good estimate of the tyre life and that a normal interest rate (compound annually) of 12% I appropriate, which tyre should it buy?***
***(Nov2012).***

***Solution*** In all the cases, the interest rate is 12%. This is equivalent to 1% per month.

***Brand A***

Tyre warranty = 12 months

Price/tyre = Rs. 1,200

The cash flow diagram for brand A is shown in Fig. 6.22.

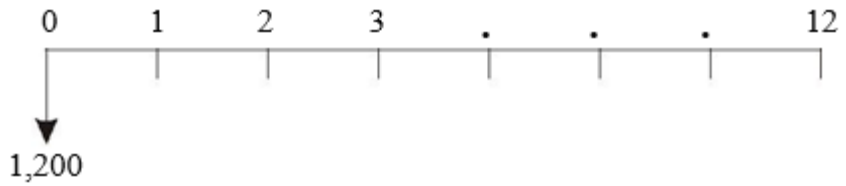



Fig. 6.22 Cash flow diagram of brand A.

The annual equivalent cost expression of the above cash flow diagram is

$$AE\ (1\%) = 1{,}200(A/P,\ 1\%,\ 12)$$
$$= 1{,}200(0.0888)$$
$$= \text{Rs. } 106.56$$

***Brand B***

Tyre warranty = 24 months

Price/tyre = Rs. 1,800

The cash flow diagram for brand B is shown in Fig. 6.23.

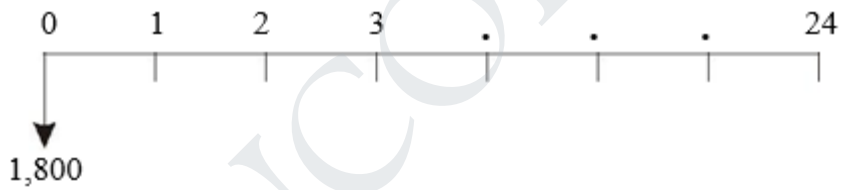



**Fig. 6.23** Cash flow diagram of brand B.

The annual equivalent cost expression of the above cash flow diagram is

$$AE\ (1\%) = 1{,}800(A/P,\ 1\%,\ 24)$$
$$= 1{,}800(0.0471)$$
$$= \text{Rs. } 84.78$$

***Brand C***

Tyre warranty = 36 months

Price/tyre = Rs. 2,100

The cash flow diagram for brand C is shown in Fig. 6.24.

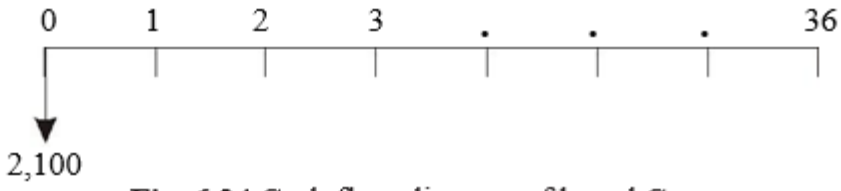



**Fig. 6.24** Cash flow diagram of brand C.

The annual equivalent expression of the above cash flow diagram is

$$AE\ (1\%) = 2{,}100(A/P,\ 1\%,\ 36)$$
$$= 2{,}100(0.0332)$$
$$= \text{Rs. } 69.72$$

***Brand D***

Tyre warranty = 48 months

Price/tyre = Rs. 2,700

The cash flow diagram for brand D is shown in Fig. 6.25.


**Fig. 6.25** Cash flow diagram of brand D.

The annual equivalent cost expression of the above cash flow diagram is

$$AE\ (1\%) = 2{,}700(A/P,\ 1\%,\ 48)$$
$$= 2{,}700(0.0263)$$
$$= \text{Rs. } 71.01$$

Here, minimum common multiple lives of tyres is considered. This is 144 months. Therefore, the comparison is made on 144 month's basis.

The annual equivalent cost of brand C is less than that of other brands. Hence, it should be used in the vehicles of the trucking company. It should be replaced four times during the 144-month period.

***15. Explain annual equivalent cost method and net present worth with appropriate examples. Justify which method should be used for company assets having unequal lives. (May 2012).***

***Answer: Refer Question No: 5 & 6***

***16. A person invest a sum of R.s.2, 00,000 in a business and receives equal net revenue of R.s.50000 for the next 10 years. At the end 10th year the salvage value of the business is R.s 25,000. Find the rate of return of the business. (May 2012).***

Sol.

Given:

Initial Investment =R.s 200000

Annual revenue= R.s 50000

Life =10 Years

Salvage value= R.s 25000

To find:

Rate of return of the business.

The cash flow diagram for the business is shown in fig 3.51

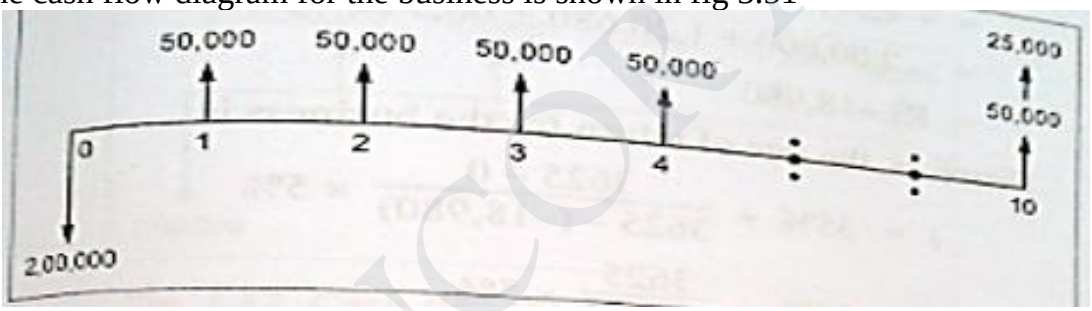



Figure 3.51

Solution

PW (15%) =-200000+50000(P/A, 15%, 10)+25000 (P/A, 15% 10)

= -200000 + 50000 x 5.0188 + 25000 x 5.0188

=-200000+250940+125470

=176410 R.s

PW (25%) = -200000+50000(P/A, 25%, 10)+25000 (P/A, 25% 10)

=-200000 + 50000 x 3.5705 + 25000 x 3.5705

= -200000+178525+89262.5

= -67787.5 R.s

PW (35%) = -200000+50000(P/A, 35%, 10) + 25000 (P/A, 35% 10)

=-200000+50000 x 2.7150 + 25000 x 2.7150

= -3625 R.s

PW (40%) = -200000+50000(P/A, 40%, 10) + 25000 (P/A, 40% 10)

=-200000+50000 x 2.4136 + 25,000 x 2.416

= -18,980 R.s

There for, the rate of return for the business is

i = 35% + (3625-0)/(3625-(-18980)) x 5%
= 35% + (3625/22605) x 5%
= 35% + 0.80%
=35.80% The rate return for the business is 35.80%

***17. A suburban taxi company is analyzing the proposal of buying cars with diesel engines instead of petrol engines. The cars average 60,000 km a year with a useful life of three years for the petrol taxi and four years for the diesel taxi. Other comparative details are as follows:***

| | *Diesel* | *Petrol* |
|---|---|---|
| *Vehicle cost (Rs.)* | *3,90,000* | *3,60,000* |
| *Fuel cost per litre (Rs.)* | *8* | *20* |
| *Mileage in km/litre* | *30* | *20* |
| *Annual repairs (Rs.)* | *9,000* | *6,000* |
| *Annual insurance premium (Rs.)* | *15,000* | *15,000* |
| *Resale value at the end of vehicle life (Rs.)* | *60,000* | *90,000* |

***Determine the more economical choice if interest rate is 20%, compounded annually. (May 2011)***

**Solution Alternative 1— Purchase of diesel taxi**

Vehicle cost = Rs. 3,90,000 Life = 4 years
Number of litres/year 60,000/30 = 2,000 litres Fuel cost/yr = 2,000 ´ 8 = Rs. 16,000
Fuel cost, annual repairs and insurance premium/yr
= Rs. 16,000 + Rs. 9,000 + Rs. 15,000 = Rs. 40,000 Salvage value at the end of vehicle life = Rs. 60,000
The cash flow diagram for alternative 1 is shown in Fig. 6.13.

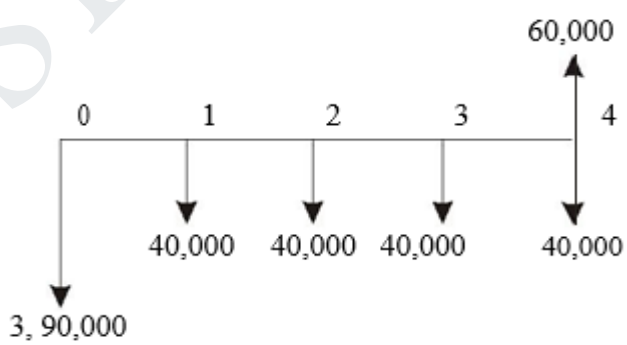



**Fig. 6.13 Cash flow diagram for alternative 1.**

The annual equivalent cost expression of the above cash flow diagram is

AE(20%) = 3,90,000(A/P, 20%, 4) + 40,000 – 60,000(A/F, 20%, 4)
= 3,90,000(0.3863) + 40,000 – 60,000(0.1863)

= Rs. 1, 79,479

**Alternative 2— Purchase of petrol taxi**
Vehicle cost = R.s. 3,60,000
Life = 3 years
Number of litres/year 60,000/20 = 3,000 litres
Fuel cost/yr = 3,000 ´ 20 = R.s. 60,000
Fuel cost, annual repairs and insurance premium/yr

= Rs. 60,000 + R.s. 6,000 + R.s. 15,000 = R.s. 81,000 Salvage value at the end of vehicle

life = Rs. 90,000
The cash flow diagram for alternative 2 is shown in Fig. 6.14.

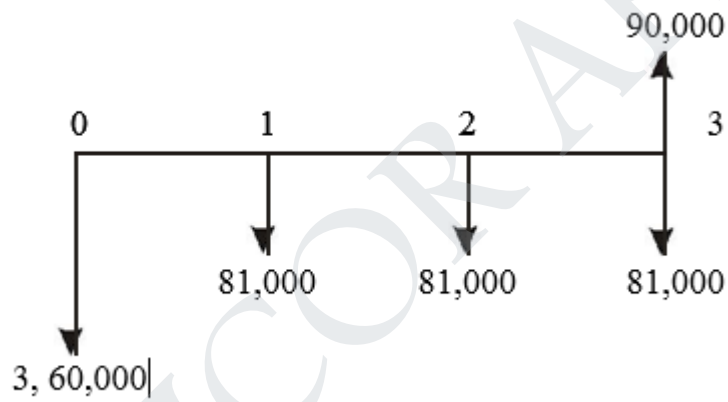


**Fig. 6.14** Cash flow diagram for alternative 2.

The annual equivalent cost expression of the above cash flow diagram is

AE(20%) = 3,60,000(A/P, 20%, 3) + 81,000 – 90,000(A/F, 20%, 3)

= 3,60,000(0.4747) + 81,000 – 90,000(0.2747)

= Rs. 2,27,169

The annual equivalent cost of purchase and operation of the cars with diesel engine is less than that of the cars with petrol engine. Therefore, the taxi company should buy cars with diesel engine. (Note: Comparison is done on common multiple lives of 12 years.)

***18. A company that manufacturers amplified transducers is trying to divide between the machines shown below. Compare them on the basis of annual worth using an interest rate of 15% per year.***

| | *Variable speed* | *Dual speed* |
|---|---|---|
| *First cost Rs.* | *4, 50,000* | *2, 40,000* |
| *Annual operating cost Rs.* | *3, 10,000* | *3, 50,000* |
| *Overhaul in years 2 and 4* | *--* | *60,000* |
| *Overhaul in year 5,* | *1, 20,00* | *--* |
| *Salvage value, Rs.* | *1, 00,000* | *80,000* |
| *Life years* | *8* | *6* |

***(May 2011)***

**Variable speed: Alternative1**

Given:

First cost = R.s 450000.

Annual operating cost= R.s 310000

Overhaul in year 5= R.s 120000

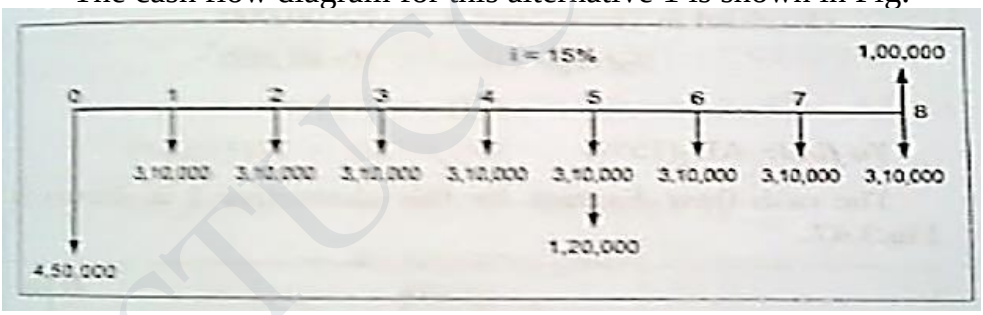
Salvage value = R.s 100000

Life =8 Years

Interest rate= 15% compounded annually

To find

The cash flow diagram for this alternative 1 is shown in Fig.




<u>Sol.</u>

PW1 (15%) =4500000+3100000(P/A, 15%, 1) +310000(P/A, 15%, 2)-100000(P/F, 15%, 8)

=450000+310000(0.8696)+310000(1.6257)+430000(3.3522) +310000(4.4873)-100000(0.3269).

= 4043360.

AE(15%) =4043360 (A/P, 15%, 8)

=4043360x 0.2229

=901264.94 R.s

**Dual Speed: Alternative 2**

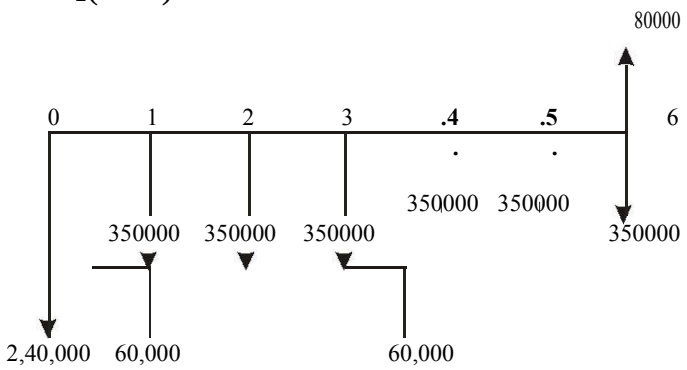
First cost= R.s 240000

Annual operating cost =R.s 350000

Overhaul in Year 2 and 4 =R.s 60000

Salvage Value= R.s 80000
Life=6 years
To find: $AE_2(15\%)$




$PW_2(15\%)$=240000+350000(P/A,15%,1)+410000(P/A,15%,2)+350000(P/A,15%, 3)+410000(P/A, 15% 4)+350000(P/F, 15%, 6)-80000(P/F, 15%, 6)
= 240000+350000(0.8696) +410000(1.6257) +350000(2.2832) +410000(2.8550) +350000
(3.7845)-80000(0.4323)
=240000+304360+666537+799120+1170550+1324575-34584
=4470558
$AE_2$ (15%)=4470558 (A/P, 15%, 6)
=4470558 (0.2642)
=1181121.42

The annual equivalent cost of variable speed is less than that of dual speed. Therefore, the best alternative is variable cost.

***19. (i) What is net present value method of appraising capital budgeting proposal?(***

***(ii) The cash flow of two project proposals are given below. Each of the project has an expected life of 10years. Select the best project based on present worth method of comparison***
***Using an interest rate of 18% compounded annually.***

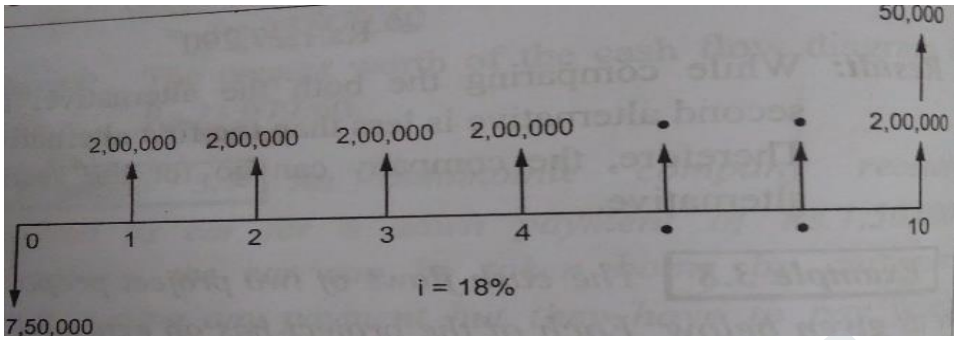
| | *Initial Outlay* | *Annual equivalent* | *Salvage value after 10 years* |
|---|---|---|---|
| | *(Rs.)* | *(Rs.)* | *(Rs.)* |
| *Project A* | *-7, 50,000* | *2,00,000* | *50,000* |
| *Project B* | *-9, 50,000* | *2,50,000* | *1,00,000(Nov 2011* |

(ii)

**Project 1:**
**Given:** Initial outlay=-750000

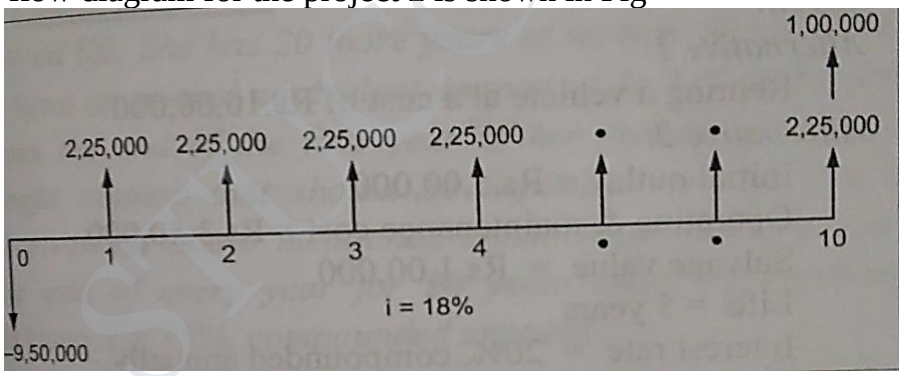
Annual revenue=200000, Salvage Value=50000, Interest rate (i) =18 % Compounded annually
Life =10 Years.




To find: The present worth for the project 1 PW1 (18%)
PW1 (18%)= -750000+200000(P/A,18%, 10)+50000(P/F, 18%, 10)
=-750000+200000 x 4.4941+50000 x 0.1911
=-750000+898820+9555 =R.s 158375

**Project 2**: Initial outlay =-950000
Annual Revenue= 225000
Salvage Value= 100000
Interest rate (i) =18% Compounded annually
Life =10 Year

To find: The present worth for the project 2 PW2 (18%)
The cash flow diagram for the project 2 is shown in Fig




**Sol.**
PW2 (18%)=-950000+225000(P/A, 18%, 10)+100000(P/F, 18%, 10)
=-950000+225000 x 4.4941+ 100000 x 0.1911
= Rs. 80282.5

Result: While comparing the present worth of the project 1 & Project 2. The project one is more than the project one is the best alternative.

***20. A company is planning to expand its present business activity. It has two alternatives for the expansion programme and the corresponding cash flows are given in the following table. Each alternative has a life of 5 years and a negligible salvage value. The minimum attractive rate of return for the company is 15%. Suggest the best alternative to the company.***

| | *Initial investment (Rs.)* | *Yearly Revenue(Rs.)* |
|---|---|---|
| *Alternative 1* | *4,50,000* | *1,50,000* |
| *Alternative 2* | *7,50,000* | *2,50,000* |

***(Nov 2011).***

***Solution Alternative 1***

Down payment, $P$ = Rs. 450000

Yearly equal installment, $A$ = R.s. 150000 $n$ = 5 years

$i$ = 20%, compounded annually

The cash flow diagram for manufacturer 1 is shown in Fig.

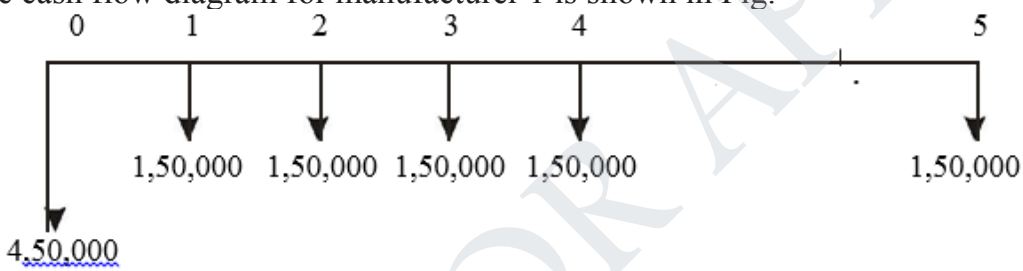



**Fig.** Cash flow diagram for manufacturer 1.

The annual equivalent cost expression of the above cash flow diagram is

AE1(20%) = 4,50,000(A/P, 20%, 15) + 1,50,000

= 4,50,000(0.2139) + 1,50,000 **= 246255**

**Alternative 2**

Down payment, P = Rs. 7,50,000

Yearly equal installment, A = Rs. 2,50,000 n = 55 years

i = 20%, compounded annually

The cash flow diagram for the manufacturer 2 is shown in Fig.

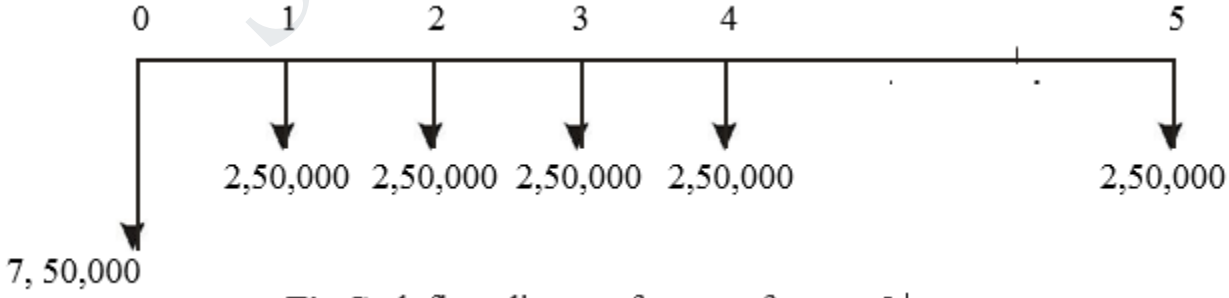



**Fig.**Cash flow diagram for manufacturer 2.

The annual equivalent cost expression of the above cash flow diagram is

AE1 (20%) = 7, 50,000(A/P, 20%, 15) + 2, 50,000

= 7, 50,000(0.2139) + 2, 50,000 **= 410425**

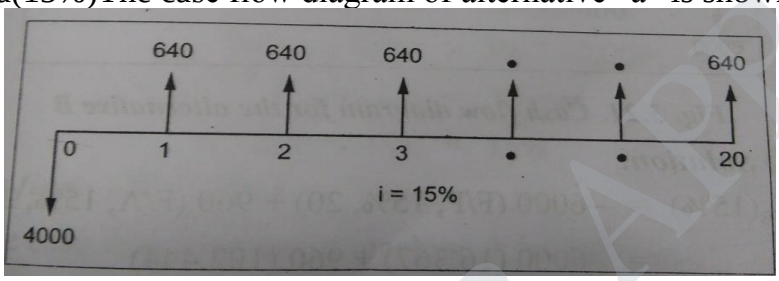
 

***21. Consider the following two mutually exclusive alternatives.***

| ***Particulars*** | ***A*** | ***B*** |
|---|---|---|
| ***Cost*** | ***Rs. 4,000*** | ***Rs. 6,000*** |
| ***Uniform annual benefit*** | ***Rs. 640*** | ***Rs. 960*** |
| ***Useful life (Years)*** | ***20*** | ***20*** |

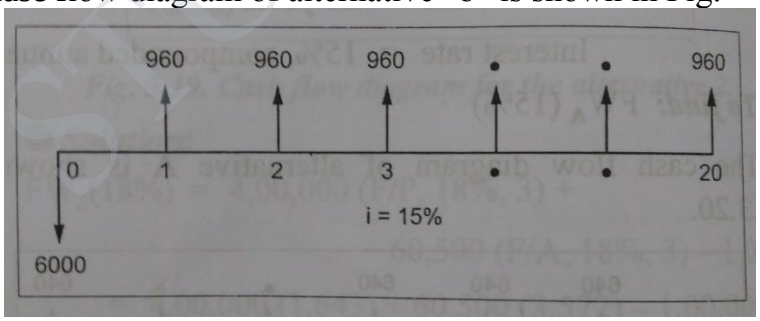
***Using a 15% interest rate, determine which alternative should be selected based on the future worth method of comparison.(Nov 2010)***

Alternative A:
Given: cost =Rs. 4000, Uniform annual benefit =640 Rs., Useful life= 20 Years
Interest rate= 15%, compounded annually,
To find: FWa(15%)The case flow diagram of alternative "a" is shown in Fig.




FWa(15%)= -4000(F/P, 15%, 20) +640 (F/A, 15%, 20)
=-4000(16.374)+640(102.444)
=-65468+65564.16
=Rs 96.16

Alternative B:
Given: Cost=R.s 6000, Uniform annual benefit= R.s 960,Useful life=20Years
Interest rate=15% compounded annually.
To find: The case flow diagram of alternative "b" is shown in Fig.




FWb(15%)=-6000(F/P,15%,20)+960 (F/A, 15% 20)
=-6000 x 16.367 +960 x 102.444
= R s. 144.24

Result: Base on the future worth method of comparison the alternative B is more than the alternative A. there the alternative B should be selected.

***22. The cost of erecting an oil well is Rs. 1, 50, 00,000. The annual equivalent yield from the oil well is Rs. 30, 00,000. The salvage value after itself useful life of 10 years is Rs. 2, 00,000. Assuming an interest rate of 18%, compounded annually, find out whether the erection of the oil well is financially feasible, based on the present worth method. (May2010)***

Sol

Given:

Initial cost = R.s 15000000

Annual Equivalent yield =R.s 3000000

Salvage Value = R.s 200000

Life=10 Years

Interest rate =18%, compounded annually

To find: The present worth of the oil well PW (18%)

The cash flow diagram for the oil well is shown in Fig 3.7

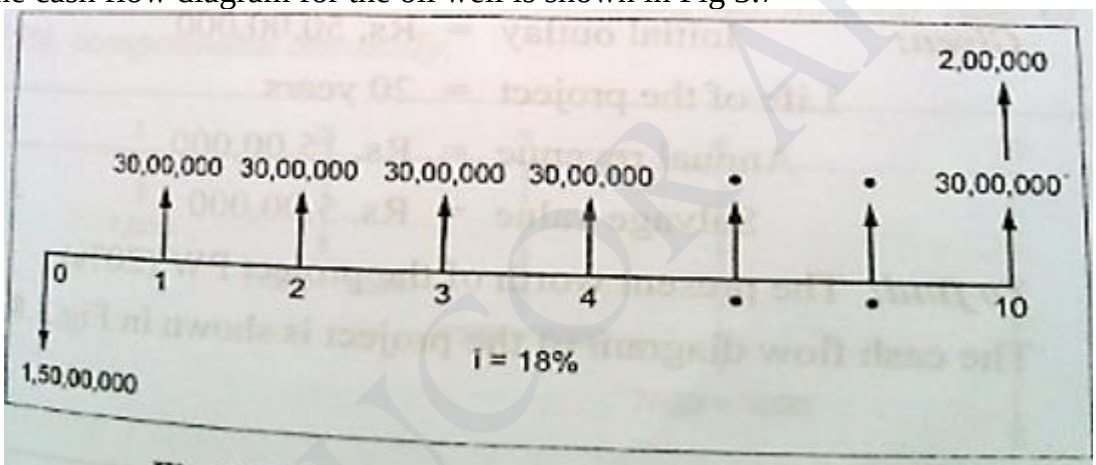



*Fig. 3.7. Cash flow diagram for the oil well*

PW (18%) = -15000000+3000000(P/A, 18%, 10) + 200000 (P/F, 18%, 10)

= -15000000+3000000 x 4.4941+ 200000 x 0.1942.

= -15000000+13482300+38220

= -1479480 R.s.

Result: The present worth of the oil well is Rs. -1479480. As it is in Negative sign. Not Feasible.

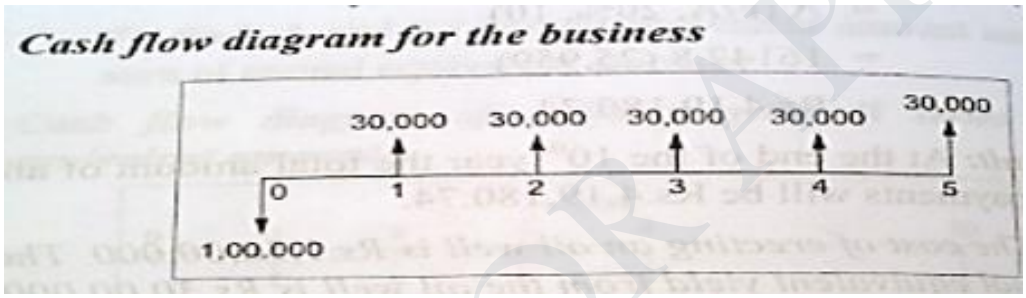
***23. A person is planning a new business. The initial outlay and cash flow pattern for the new business are as listed below. The expected life of the business is five years find the rate for return for the new business. (May2010)***

| ***Period*** | ***0*** | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** |
|---|---|---|---|---|---|---|
| ***Cash flow R.s.*** | ***-1, 00,000*** | ***30,000*** | ***30,000*** | ***30,000*** | ***30,000*** | ***30,000*** |

Given Data: P= R.s 1000000
R=R.s 30000
N = 5 years

Sol. Rate of Return:

$P\,W(i) = -P + R_i/(1+i)1 + R_2/(1+i)^2 + \ldots\ldots + R_j/(1+i)^3 + \ldots\ldots\ldots + R_n/(1+i)^n + S/(1+i)^n$




P(W) (5%) = -100000+30000(P/A, 5%,5)
= -100000+30000 x 4.3295
=29,885,

P(W) (10%) = -100000+30000(P/A, 10%,5)
= -100000+30000 x 3.7906
=13724

P(W) (15%) = -100000+30000(P/A, 15%,5)
= -100000+30000 x 3.3522
= 566

P(W) (15%) = -100000+30000(P/A, 20%,5)
= -100000+30000 x 2.9906
= -10282

Therefore the rate of return for the business.
i =15%+ {(566-0)/ (566-(-10.282))} x 5
=15 %+( 566/10848) x 5
=15%+0.26
i =15.26%

Rate of return for the new business is 15.26%

***24. Compare annual equivalent method and rate of return method of comparing alternatives with appropriate examples. (Nov2009 May2009, Nov2008, Nov 2017)***

Refer Question: -6 for Annual Equivalent Method.

**Rate of Return Method.**

The rate of return of a cash flow pattern is the interest rate at which the present worth of that cash flow pattern reduces to zero. In this method of comparison, the rate of return for each alternative is computed. Then the alternative which has the highest rate of return is selected as the best alternative.

In this type of analysis, the expenditures are always assigned with a negative sign and the revenues/inflows are assigned with a positive sign.

A generalized cash flow diagram to demonstrate the rate of return method of comparison is presented in Fig. 7.1.

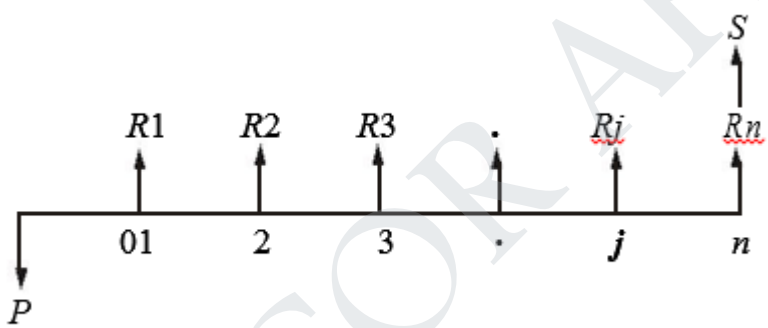



**Fig. 7.1 Generalized** cash flow diagram.

In the above cash flow diagram, P represents an initial investment, Rj the net revenue at the end of the jth year, and S the salvage value at the end of the nth year. The first step is to find the net present worth of the cash flow diagram using the following expression at a given interest rate, i.

$$PW(i) = -P + R1/(1+i)^1 + R2/(1+i)^2 + \ldots + Rj/(1+i)^j + \ldots + Rn/(1+i)^n + S/(1+i)^n$$

Now, the above function is to be evaluated for different values of i until the present worth function reduces to zero, as shown in Fig. 7.2.

In the figure, the present worth goes on decreasing when the interest rate is increased. The value of i at which the present worth curve cuts the X-axis is the rate of return of the given proposal/project. It will be very difficult to find the exact value of i at which the present worth function reduces to zero.

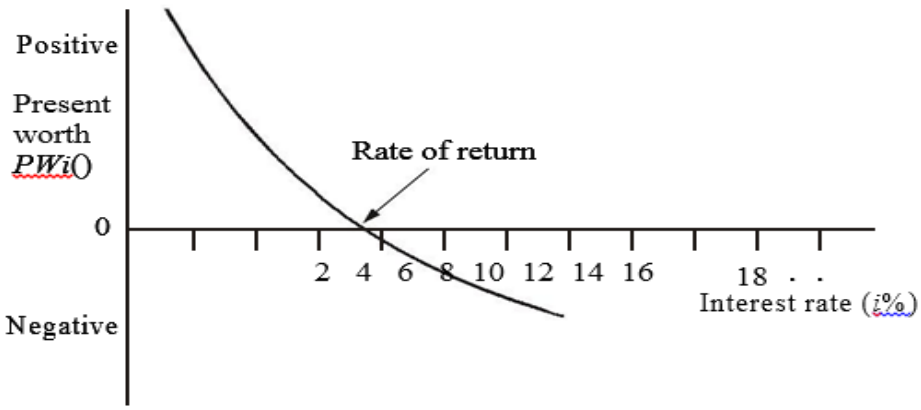



**Fig. 7.2 Present** worth function graph.

So, one has to start with an intuitive value of i and check whether the present worth function is positive. If so, increase the value of i until PW (i) becomes negative. Then, the rate of return is determined by interpolation method in the range of values of i for which the sign of the present worth function changes from positive to negative.

***24. (i) Explain present work method.***

***(ii) Data on two mutually exclusive investment options are as follows:***

***Alternative cash flow in Lakhs of rupees at the end of year***

| | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| A | -45 | 20 | 20 | 20 | 20 |
| B | -40 | 18 | 18 | 18 | 18 |

***Find the best option taking 18% interest by future worth method (Nov 2017).***

***Solution Alternative A***

Initial investment, $P$ = Rs. 45,00,000
Annual equivalent revenue, $A$ = Rs. 20,00,000
Interest rate, $i$ = 18%, compounded annually
Life of alternative A = 4 years

The cash flow diagram of alternative A is shown in Fig. 5.3.

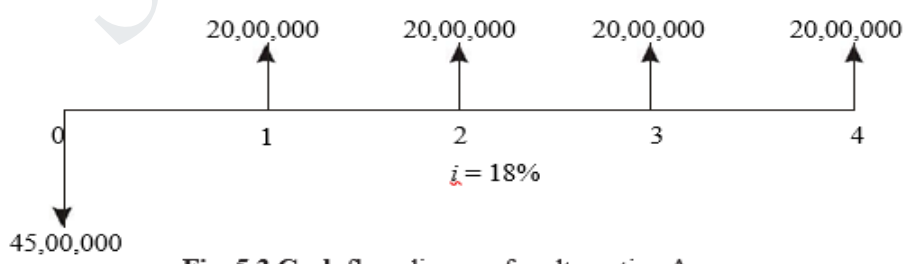



**Fig. 5.3 Cash** flow diagram for alternative A.

The future worth amount of alternative B is computed as

$$FW_A(18\%) = -45,00,000(F/P, 18\%, 4) + 20,00,000(F/A, 18\%, 4)$$
$$= -45,00,000(1.939) + 20,00,000(5.215)$$
$$= \text{Rs. } 1704500$$

***Alternative B***

Initial investment, $P$ = Rs. 40,00,000

Annual equivalent revenue, $A$ = Rs. 18,00,000

Interest rate, $i$ = 18%, compounded annually

Life of alternative B = 4 years

The cash flow diagram of alternative B is illustrated in Fig. 5.4.

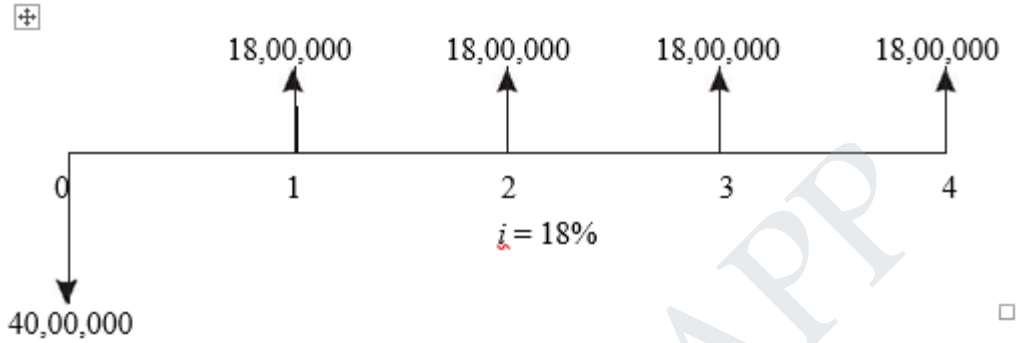



**Fig. 5.4** Cash flow diagram for alternative B.

The future worth amount of alternative B is computed as

$$FW_B(18\%) = -40,00,000(F/P, 18\%, 4) + 18,00,000\,(F/A, 18\%, 4)$$
$$= -40,00,000(1.939) + 18,00,000(5.215)$$
$$= \text{Rs. } 1631000$$

***25. Explain the importance of "cash flow" and how does the financial statement analysis play a role in the internal Economical environment for an organization. (Nov 2008)***

Answer Refer Question 5, 6 & 7

## UNIT IV - REPLACEMENT AMD MAINTAINENCE ANALYSIS

**PART – A** **2 Marks**

1. ***Write the types of replacement problem? (May 2011, Nov 2016 May 2010, Nov 2009, Nov 2010, May 2009, May 2008, and Nov 2015).***

1. Replacement of assets that deteriorate with time (replacement due gradual failure or wear and tear of the compound of the machines). This can be further classified into the following types:
   a. Determination of economic life of an asset.
   b. Replacement of an existing asset with a new asset.
2. Simple probabilistic model for assets which fail completely (replacement due to sudden failure).

2. ***What are reasons for replacement? (Nov 2013, Nov 2015, May2014)***

a. Deterioration.
b. Obsolescence.
c. Inadequacy.
d. Working Conditions.

3. ***Explain Predictive maintenance. (May 2013, May 2012, Nov 2011, May2010, Nov2015, May 2015).***

It is comparatively a newer maintenance technique. It makes use of human senses or other sensitive instruments such as Audio gauges, vibration analyzers, Amplitude meters, pressure, temperature and resistance strain gauges etc., to predict troubles before the equipment fails.

4. ***List out the functional element of Maintenance Programme.(Nov 2014)***

Preventive maintenance
1. Process of preventive Maintenance
a. process of preventive maintenance.
b. objectives of preventive maintenance.
c. procedure of the preventive maintenance
d. Advantages of preventive maintenance.
2. Predictive Maintenance.

5. ***List out the preventive maintenance activities. (Nov 2014)***

Process of preventive Maintenance
a. process of preventive maintenance.
b. objectives of preventive maintenance.
c. procedure of the preventive maintenance
d. Advantages of preventive maintenance.

***6. What is defender? (May 2014)***

The terms challenger and defender are commonly used in the boxing world. In every boxing class, the current defending champion in constantly faced with a new challenger. In replacement analysis the definer is the existing machine and the challenger is the best available replacement equipment.

***7. What is meant by economic life of an asset? (May 2013 May 2013, May 2012, May 2009).***

The economics services life of an asset is defined to be the period of useful life that minimizes the annual equivalent cost of owning and operating the asset.

***8. List the different types of maintenance. (Nov 2013, May 2011, May 2008, May 2009)***

1. Correction or Breakdown maintenance.
2. Scheduled Maintenance.
3. Preventive Maintenance.
4. Predictive Maintenance.

***9. Distinguish between breakdown maintenance and preventive maintenance. (Nov 2012)***

| SI.No | Breakdown | Preventive Maintenance |
|---|---|---|
| 1. | Lack of lubrication | Lubrication |
| 2. | Delays in production | Reduction in production down time |

***10. Write short notes on reasons for replacement. (Nov 2012).***

Replacement project are decision problems involving the replacement of existing obsolete or worn-out assets. The contribution of operation is dependent on these assets. Failure to make an appropriate decision result in a slowdown or shutdown of the operations. The problems often face by management of industries are whether to replace the existing equipment with new and more efficient equipment or to continue to use existing equipment's? And when exist equipment should be replace with more efficient equipment? This class of decision analysis is known as replacement analysis.

***11. Define Break down maintenance? (May 2011).***

Breakdown maintenance is maintenance performed on equipment that has broken down and is unusable. It is based on a breakdown maintenance trigger. It may be either planned or it can be unplanned.

***12. What is annual equivalent method of comparing alternatives? (May 2008)***

In the annual equivalent method of comparison, first the annual equivalent cost or the revenue of each alternative will be computed. Then the alternative with the maximum annual equivalent revenue in the case of revenue-based comparison or with the minimum annual equivalent cost in the case of cost-based comparison will be selected as the best alternative.

***13. What is revenue dominated cash flow? (May 2008)***

***Refer unit -3 Question -18.***

***14. Write the different types of Replacement? (Nov 2011).***

a. Determination of Economic life of an Asset
2. Capital costs.
3. Operating cost.
4. Total cost.
b. Replacement of Existing Asset with a New Asset.

***15. What is future worth method? (Nov 2008)***

Net future worth measures the surplus at a time period other then 0. Future worth analysis is particularly useful in an investment situation where we need to compute the equivalent worth of a project at the end of its investment period.

***16. Write the need of studying economics for the engineering. (Nov 2017)***

Science is a field of study where the basic principles of different physical systems are formulated and tested. Engineering is the application of science. It establishes varied application systems based on different scientific principles. From the discussions in the previous section, it is clear that price has a major role in deciding the demand and supply of a product. Hence, from the organization's point of view, efficient and effective functioning of the organization would certainly help it to provide goods/services at a lower cost which in turn will enable it to fix a lower price for its goods or services. The following section discusses the different types of efficiency and their impact on the operation of businesses and the definition and scope of engineering economics.

***17. Define Economics Life of an assets. (Nov 2017)***

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.

***18. Distinguish between challengers and defenders.***

| | ***Challengers*** | ***Defenders*** |
|---|---|---|
| 1 | We propose a high-efficiency condensing boiler from manufacturer "m" of type "p". | We have a low-efficiency boiler from manufacturer "k" of type "j". |
| 2 | The cost to supply and install the new boiler is $x. | Currently, the boiler is exhibiting deficient conditions "a", "b", and "c" and will cost $x to correct. |
| 3 | The incremental cost between the defender (low efficiency) and the challenger (high efficiency) is $x. | The deficient conditions are prioritized as level-1, level-2, level-3. Therefore, some must be fixed now and others can be deferred until boiler replacement or upgrade. |

**PART –B** **16-Marks**

***1. 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%? (Nov 2016)***

**Table 8.1 Calculations** to Determine Economic Life (First cost = Rs. 4,000, Interest = 0%)

| *End of year (n)* | *Maintenance cost at end of year* | *Summation of maintenance costs* | *Average cost of maintenance through year given* | *Average first cost if replaced at year end given* | *Average total cost through year given* |
|---|---|---|---|---|---|
| | | SB | C/A | 4,000/A | D + E |
| A | B (Rs.) | C (Rs.) | D (Rs.) | E (Rs.) | F (Rs.) |
| 1 | 0 | 0 | 0 | 4,000.00 | 4,000.00 |
| 2 | 200 | 200 | 100 | 2,000.00 | 2,100.00 |
| 3 | 400 | 600 | 200 | 1,333.33 | 1,533.33 |
| 4 | 600 | 1,200 | 300 | 1,000.00 | 1,300.00 |
| 5 | 800 | 2,000 | 400 | 800.00 | 1,200.00 |
| 6 | 1,000 | 3,000 | 500 | 666.67 | 1,166.67* |
| 7 | 1,200 | 4,200 | 600 | 571.43 | 1,171.43 |

*Economic life of the machine = 6 years

Column C summarizes the summation of maintenance costs for each replacement period. The value corresponding to any end of year in this column represents the total maintenance cost of using the equipment till the end of that particular year.

$$\text{Average total cost} = \frac{\text{First cost (FC)} + \text{Summation of maintenance cost}}{\text{Replacement period}}$$

$$= \frac{\text{FC}}{n} + \frac{\text{Column C}}{n}$$

Column F = Column E + Column D

The value corresponding to any end of year ($n$) in Column F represents the average total cost of using the equipment till the end of that particular year.

For this problem, the average total cost decreases till the end of year 6 and then it increases. Therefore, the optimal replacement period is six years, i.e. economic life of the equipment is six years.

(b) When interest rate, $i$ = 12%. When the interest rate is more than 0%, the steps to be taken for getting the economic life are summarized with reference to Table 8.2.

**Table 8.2** Calculations to Determine Economic Life (First cost = Rs. 4,000, Interest = 12%)

| *End of year* ($n$) | *Maintenance cost at end of year* | *P/F, 12%, n* | *Present worth as of beginning of year 1 of maintenance costs* | *Summation of present worth of maintenance costs through year given* | *Present worth of cumulative maintenance cost & first cost* | *A/P, 12%, n* | *Annual equivalent total cost through year given* |
|---|---|---|---|---|---|---|---|
| | | | (B ´ C) | S D | E + Rs. 4,000 | | F ´ G |
| A | B (Rs) | C | D (Rs.) | E (Rs.) | F (Rs.) | G | H (Rs.) |
| 1 | 0 | 0.8929 | 0.00 | 0.00 | 4,000.00 | 1.1200 | 4,480.00 |
| 2 | 200 | 0.7972 | 159.44 | 159.44 | 4,159.44 | 0.5917 | 2,461.14 |
| 3 | 400 | 0.7118 | 284.72 | 444.16 | 4,444.16 | 0.4163 | 1,850.10 |
| 4 | 600 | 0.6355 | 381.30 | 825.46 | 4,825.46 | 0.3292 | 1,588.54 |
| 5 | 800 | 0.5674 | 453.92 | 1,279.38 | 5,279.38 | 0.2774 | 1,464.50 |
| 6 | 1,000 | 0.5066 | 506.60 | 1,785.98 | 5,785.98 | 0.2432 | 1,407.15 |
| 7 | 1,200 | 0.4524 | 542.88 | 2,328.86 | 6,328.86 | 0.2191 | 1,386.65* |
| 8 | 1,400 | 0.4039 | 565.46 | 2,894.32 | 6,894.32 | 0.2013 | 1,387.83 |
| 9 | 1,600 | 0.3606 | 576.96 | 3,471.28 | 7,471.28 | 0.1877 | 1,402.36 |
| 10 | 1,800 | 0.3220 | 579.60 | 4,050.88 | 8,050.88 | 0.1770 | 1,425.00 |

*Economic life of the machine = 7 years

The steps are summarized now:

1. Discount the maintenance costs to the beginning of year 1.

$$\text{Column D} = \text{Column B} \times \frac{1}{(1+i)^n}$$

$$= \text{Column B} \times (P/F, i, n) = \text{Column B} \times \text{Column C}.$$

2. Find the summation of present worth of maintenance costs through the year given (Column E = S Column D).

3. Find Column F by adding the first cost of Rs. 4,000 to Column E. 4.

Find the annual equivalent total cost through the years given.

$$\text{Column H} = \text{Column F} \times \frac{i(1+i)^n}{(1+i)^n - 1}$$

$$= \text{Column F} \times (A/P, 12\%, n) = \text{Column F} \times \text{Column G}$$

5. Identify the end of year for which the annual equivalent total cost is minimum.

For this problem, the annual equivalent total cost is minimum at the end of year 7. Therefore, the economic life of the equipment is seven years.

***2. What are all various type of Maintenance? Evaluate their merits and Demerits. (Nov 2016).***

## 8.2 TYPES OF MAINTENANCE.

Maintenance activity can be classified into two types: preventive maintenance and breakdown maintenance. Preventive maintenance (PM) is the periodical inspection and service activities which are aimed to detect potential failures and perform minor adjustments or repairs which will prevent major operating problems in future.

Breakdown maintenance is the repair which is generally done after the equipment has attained down state. It is often of an emergency nature which will have associated penalty in terms of expediting cost of maintenance and down time cost of equipment.

Preventive maintenance will reduce such cost up to a point. Beyond that point, the cost of preventive maintenance will be more when compared to the breakdown maintenance cost. The total cost, which is the sum of the preventive maintenance cost and the breakdown maintenance cost, will go on decreasing with an increase in the level of maintenance up to a point. Beyond that point, the total cost will start increasing.

The level of maintenance corresponding to the minimum total cost is the optimal level of maintenance. The concepts are demonstrated in Fig. 8.1.

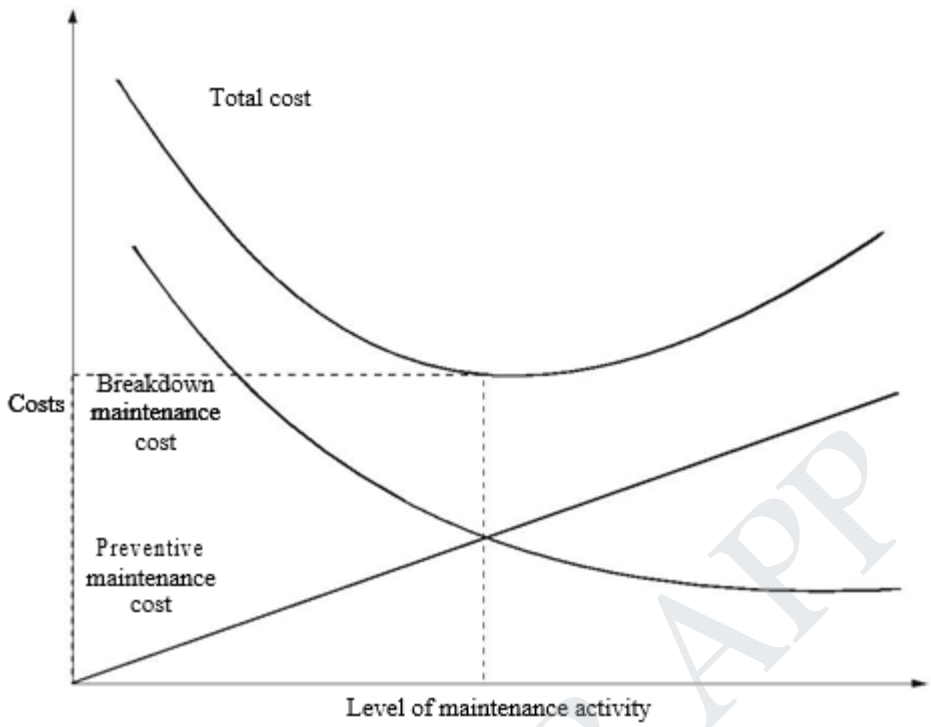



**Fig. 8.1 Maintenance costs.**

## 8.3 TYPES OF REPLACEMENT PROBLEM

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).

## 8.4 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.

A typical shape of each of the above costs with respect to life of the machine is shown in Fig. 8.2.

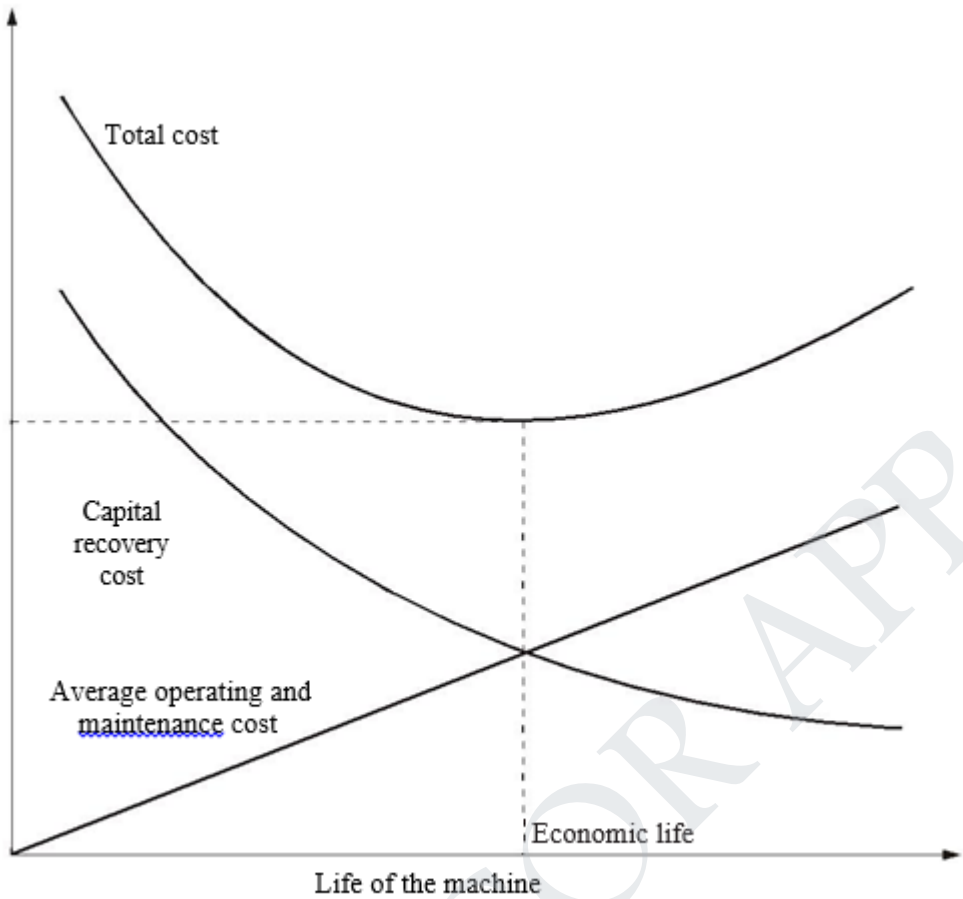



**Fig. 8.2** Chart showing economic life.

From Fig. 8.2, it is clear that the capital recovery cost (average first cost) goes on decreasing with the life of the machine and the average operating and maintenance cost goes on increasing with the life of the machine.

From the beginning, the total cost continues to decrease up to a particular life and then it starts increasing. The point where the total cost is minimum is called the economic life of the machine.

If the interest rate is more than zero per cent, then we use interest formulas to determine the economic life.

***3. Identify the replacement problem and suggest your idea to eradicate it. (Nov 2015).***

***Or***

***Give a detailed account on the various types of replacement problems with examples. (May 2012).***

**TYPES OF REPLACEMENT PROBLEM**

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.

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**DETERMINATION OF ECONOMIC LIFE OF AN ASSET..**

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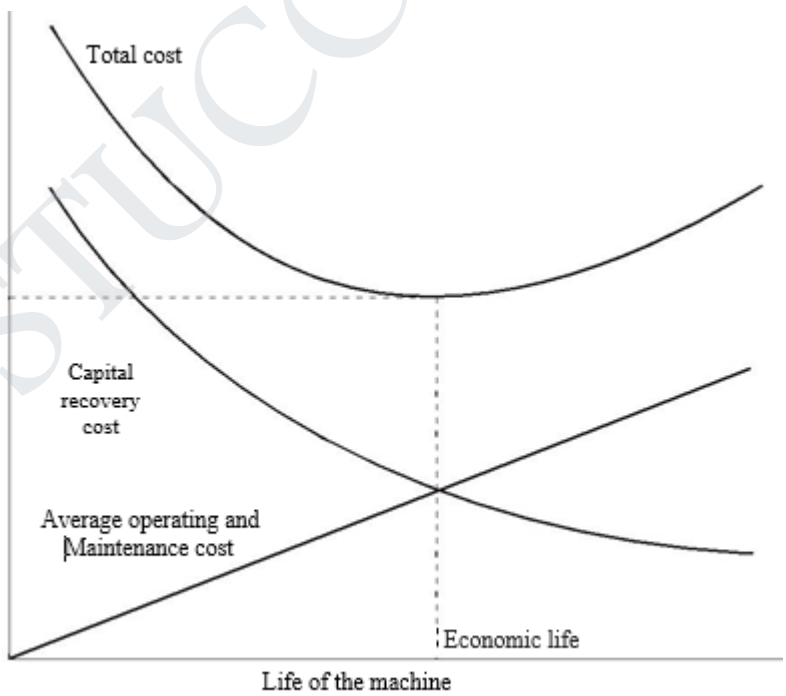


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From the beginning, the total cost continues to decrease up to a particular life and then it starts increasing. The point where the total cost is minimum is called the economic life of the machine.

If the interest rate is more than zero per cent, then we use interest formulas to determine the economic life.

The replacement alternatives can be evaluated based on the present worth criterion and annual equivalent criterion.

**REPLACEMENT OF EXISTING ASSET WITH A NEW ASSET.**

In this section, the concept of comparison of replacement of an existing asset with a new asset is presented. In this analysis, the annual equivalent cost of each alternative should be computed first. Then the alternative which has the least cost should be selected as the best alternative. Before discussing details, some preliminary concepts which are essential for this type of replacement analysis are presented.

## Capital Recovery with Return

Consider the following data of a machine. Let

$P$ = purchase price of the machine,

$F$ = salvage value of the machine at the end of machine life,

$n$ = life of the machine in years, and

$i$ = interest rate, compounded annually

The corresponding cash flow diagram is shown in Fig. 8.3.

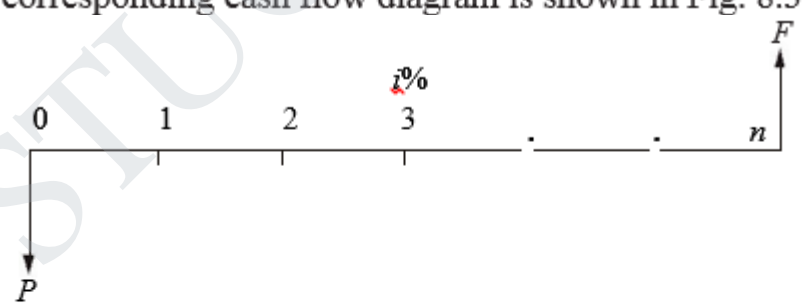



**Fig. 8.3 Cash** flow diagram of machine.

The equation for the annual equivalent amount for the above cash flow diagram is

$$AE(i) = (P - F) \times (A/P, i, n) + F \times i$$

This equation represents the *capital recovery with return*.

**CONCEPT OF CHALLENGER AND DEFENDER.**

If an existing equipment is considered for replacement with a new equipment, then the existing equipment is known as the defender and the new equipment is known as challenger.

Assume that an equipment has been purchased about three years back for Rs. 5, 00,000 and it is considered for replacement with a new equipment. The supplier of the new equipment will take the old one for some money, say, Rs. 3, 00,000. This should be treated as the present value of the existing equipment and it should be considered for all further economic analysis. The purchase value of the existing equipment before three years is now known as sunk cost, and it should not be considered for further analysis.

***4. What are the factors involved in determination of economic life of an asset. (Nov 2015).***

A general inflationary trend in the cost of goods is common everywhere due to various interacting factors. If the rate of inflation is very high, it will produce extremely serious consequences for both individuals and institutions. Inflation is the rate of increase in the prices of goods per period. So, it has a compounding effect. Thus, prices that are inflated at a rate of 7% per year will increase 7% in the first year, and for the next year the expected increase will be 7% of these new prices.

The same is true for succeeding years and hence the rate of inflation is compounded in the same manner that an interest rate is compounded. If the average inflation over six years period is 7%, then the prices at the beginning of the seventh year would be 150% that of the first year by assuming 100% for the prices at the beginning of the first year of the six-year period. If economic decisions are taken without considering the effect of inflation into account, most of them would become meaningless and as a result the organizations would end up with unpredictable return.

But there is always difficulty in determining the rate of inflation. The world-wide trend/wish is to curtail inflation. But due to various reasons, it is very difficult to have zero inflation. For practical decision making, an average estimate may be assumed depending on the period of the proposals under consideration. Hence, we need a procedure which will combine the effects of inflation rate and interest rate to take realistic economic decision.

PROCEDURE TO ADJUST INFLATION

A procedure to deal with this situation is summarized now.

1. Estimate all the costs/returns associated with an investment proposal in terms of today's rupees.
2. Modify the costs/returns estimated in step 1 using an assumed inflation rate so that at each future date they represent the costs/returns at that date in terms of the rupees that must be expended/received at that time, respectively.
3. As per our requirement, calculate either the annual equivalent amount or future amount or present amount of the cash flow resulting from step 2 by considering the time value of money.

## INFLATION ADJUSTED ECONOMIC LIFE OF MACHINE

In any industrial/service organization, equipment/machinery forms an important element. The productivity of any organization is a function of many factors. It is largely affected by efficient and effective use of machinery and equipment. So, operations and maintenance of these equipment are very important to the organization.

A machine which is purchased today cannot be used forever. It has a definite economic lifetime. After the economic life, the machine should be replaced with a substitute machine with similar operational capabilities. This kind of analysis is called replacement analysis.

The elements of costs involved in the replacement analysis are as follows:

1. Purchase cost (initial cost) , 2.Annual operation and maintenance cost
3 Salvage value at the end of every year, if it is significant

The trade-off between different cost elements is shown in Fig. 11.3.

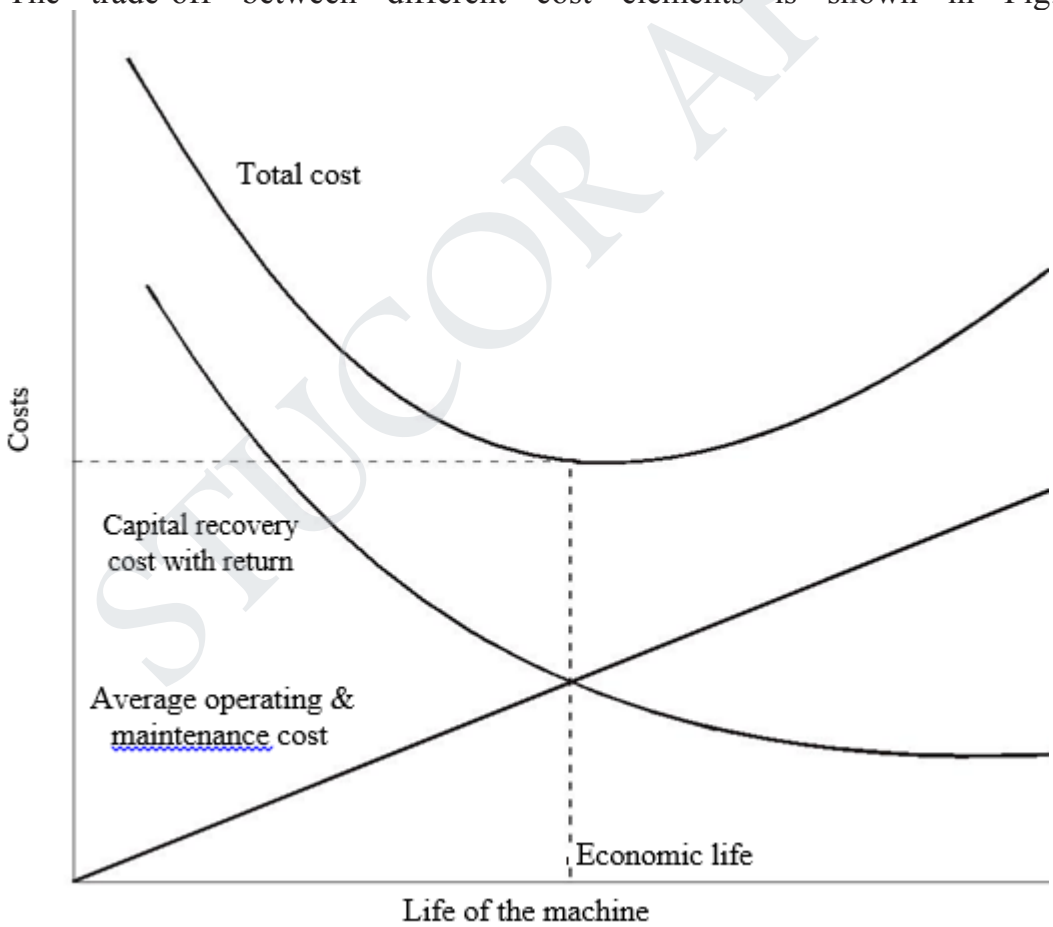



**Fig. 11.3 Chart** showing economic life.

From Fig. 11.3, it is clear that the sum of operation and maintenance cost increases with the life of the machine. But the capital recovery with return decreases with the life of the machine.

The total cost of the machine goes on decreasing initially but it starts increasing after some years. The year with the minimum total cost is called as the economic life of the machine.

***5. The following table gives the operation cost, maintenance cost and salvage value at the end of every year of a machine whose purchase value is Rs. 20,000.***
***Find the economic life of the machine assuming interest rate, i = 15%.***

| *End of year (n)* | *Operation cost at the end of year (Rs.)* | *Maintenance cost at the end of year (Rs.)* | *Salvage value at the end of year (Rs.)* |
|---|---|---|---|
| *1* | *3,000* | *300* | *9,000* |
| *2* | *4,000* | *400* | *8,000* |
| *3* | *5,000* | *500* | *7,000* |
| *4* | *6,000* | *600* | *6,000* |
| *5* | *7,000* | *700* | *5,000* |
| *6* | *8,000* | *800* | *4,000* |
| *7* | *9,000* | *900* | *3,000* |
| *8* | *10,000* | *1,000* | *2,000* |
| *9* | *11,000* | *1,100* | *1,000* |
| *10* | *12,000* | *1,200* | *0* |

Sol

First cost = Rs. 20,000
Interest rate = 15%
The other details are summarized in Table 8.3 along with regular calculations for determining the economic life.

= {cumulative sum of the present worth as of beginning of year 1 of + Fist cost- Present worth salvage} x (A/P, 15%, n) operation and maintenance
Colum L= (Column G+20000-Column I) x Column K

**Table 8.3** Calculations to Determine Economic Life

(First Cost = Rs. 20,000, Interest Rate = 15%)

| *End of year (n)* | *Operation cost at the end of year* | *Maintenance cost at the end of year* | *Sum of operation and maintenance costs at the end of year* | *P/F, 15%, n* | *Present worth as of beginning of year 1 of sum of operation & maintenance cost* | *Cumulative sum of column F through year designated* | *Salvage value at the end of year* | *Present worth as of beginning of year 1 of salvage value* | *Total present worth* | *A/P, 15%, n* | *Annual equlant total cost through year given* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | B + C | | D´E | SF | | H´E | G + 20,000 – I | | J´K |
| A | B (Rs.) | C (Rs.) | D (Rs.) | E | F (Rs.) | G (Rs.) | H (Rs.) | I (Rs.) | J (Rs.) | K | L (Rs.) |
| 1 | 3,000 | 300 | 3,300 | 0.8696 | 2,869.68 | 2,869.68 | 9,000 | 7,826.40 | 15,043.28 | 1.1500 | 17,299.77 |
| 2 | 4,000 | 400 | 4,400 | 0.7562 | 3,326.84 | 6,196.52 | 8,000 | 6,048.80 | 20,147.72 | 0.6151 | 12,392.86 |
| 3 | 5,000 | 500 | 5,500 | 0.6575 | 3,616.25 | 9,812.77 | 7,000 | 4,602.50 | 25,210.27 | 0.4380 | 11,042.01 |
| 4 | 6,000 | 600 | 6,600 | 0.5718 | 3,773.88 | 13,586.65 | 6,000 | 3,430.80 | 30,155.85 | 0.3503 | 10,563.59 |
| 5 | 7,000 | 700 | 7,700 | 0.4972 | 3,828.44 | 17,415.09 | 5,000 | 2,486.00 | 34,929.09 | 0.2983 | 10,419.35 * |
| 6 | 8,000 | 800 | 8,800 | 0.4323 | 3,804.24 | 21,219.33 | 4,000 | 1,729.20 | 39,490.13 | 0.2642 | 10,433.29 |
| 7 | 9,000 | 900 | 9,900 | 0.3759 | 3,721.41 | 24,940.74 | 3,000 | 1,127.70 | 43,813.04 | 0.2404 | 10,532.66 |

*Economic Life = 5 years

***6. Discuss the types of Maintenance (Nov 2014, May 2014, May 2017)).***
***(Or).***

***Analyze the various types of maintenance and their relative metrics and demerits. (Nov2009)***

Maintenance activity may be classified into following categories
1. Corrective or breakdown maintenance
2. Scheduled maintenance.
3. Preventive maintenance.
4. Predicative maintenance.

Maintenance activity can be classified into two types: preventive maintenance and breakdown maintenance.

*Preventive maintenance* (PM) is the periodical inspection and service activities which are aimed to detect potential failures and perform minor adjustments or repairs which will prevent major operating problems in future.

*Breakdown maintenance* is the repair which is generally done after the equipment has attained down state.

It is often of an emergency nature which will have associated penalty in terms of expediting cost of maintenance and down time cost of equipment. Preventive maintenance will reduce such cost up to a point.

Beyond that point, the cost of preventive maintenance will be more when compared to the breakdown maintenance cost.

The total cost, which is the sum of the preventive maintenance cost and the breakdown maintenance cost, will go on decreasing with an increase in the level of maintenance up to a point. Beyond that point, the total cost will start increasing.

The level of maintenance corresponding to the minimum total cost is the optimal level of maintenance. The concepts are demonstrated in Fig. 8.1.

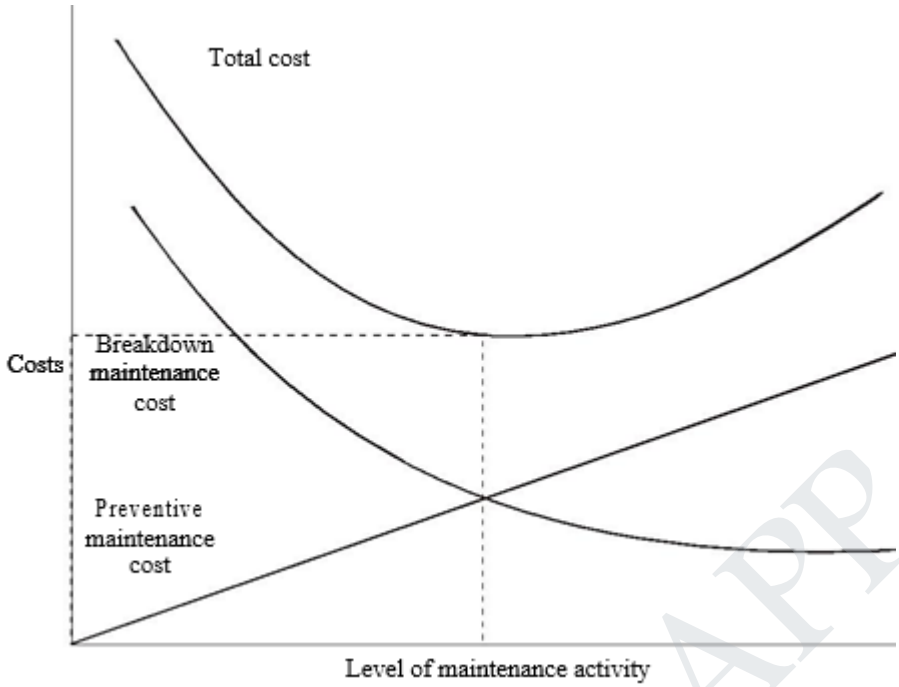



**Fig. 8.1 Maintenance** costs.

**TYPES OF REPLACEMENT PROBLEM**

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

***7. There are 10,000 bulbs in a decorative set. When any bulb fails to be replaced, the cost of replacing a bulb individually is Rs.1 Only. If all the bulbs are replaced at the same time, the cost per bulb would be reduced to Rs. 0.35. the percentages of bulbs surviving at the end of Month(t)n i.e S(t) and the probability of failure during the month(t) i.e P(t) are given below.***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ***t*** | ***0*** | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** | ***6*** |
| ***S(t)*** | ***100*** | ***97*** | ***90*** | ***70*** | ***30*** | ***15*** | ***0*** |
| ***P(t)*** | ***-*** | ***0.03*** | ***0.07*** | ***0.20*** | ***0.40*** | ***0.15*** | ***0.15*** |

***sol***

$N0 = 1{,}000$
$N1 = N0p1 = 1{,}000 \times 0.03 = 30$
$N2 = N0p2 + N1p1 = 1{,}000 \times 0.07 + 30 \times 0.03 = 70.9$
$N3 = N0p3 + N1p2 + N2p1 = 1{,}000 \times 0.20 + 30 \times 0.07 + 70.9 \times 0.03 = 20+2.1+2.127=24.227$
$N4 = N0p4 + N1p3 + N2p2 + N3p1$
$= 1{,}000 \times 0.40 + 30 \times 0.20 + 70.9 \times 0.07 + 24 \times 0.03 = 51.68$
$N5 = N0p5 + N1p4 + N2p3 + N3p2 + N4p1$
$= 1{,}000 \times 0.15 + 30 \times 0.40 + 70.9 \times 0.20 + 24 \times 0.07 + 51.68 \times 0.03 = 179.410$
$N6 = N0p6 + N1p5 + N2p4 + N3p3 + N4p2 + N5p1$
$= 1{,}000 \times 0.03 + 30 \times 0.15 + 70.9 \times 0.40 + 24.227 \times 0.20 + 51.68 \times 0.07 + 179.410 \times 0.03$
$= 76.7053$

Determination of individual replacement cost
Expected life of each transistor= sum i x Pi
=1x0.03+2x0.07+3x0.02+4x0.40+5x0.15+6x0.15
=2.04 months
Average number of failures/ month=1000/2.04 =490.19

***8. Two years ago, a machine was purchased at a cost of Rs. 2,00,000 to be useful for eight years. Its salvage value at the end of its life is Rs. 25,000. The annual maintenance cost is Rs. 25,000. The market value of the present machine is Rs. 1,20,000. Now, a new machine to cater to the need of the present machine is available at Rs. 1,50,000 to be useful for six years. Its annual maintenance cost is Rs. 14,000. The salvage value of the new machine is Rs. 20,000. Using an interest rate of 12%, find whether it is worth replacing the present machine with the new machine. (May 2014, Nov2013)***

***Solution Alternative 1—Present machine***

Purchase price = Rs. 2,00,000
Present value (P) = Rs. 1,20,000
Salvage value (F) = Rs. 25,000
Annual maintenance cost (A) = Rs. 25,000
Remaining life = 6 years
Interest rate = 12%
The cash flow diagram of the present machine is illustrated in Fig. 8.4. The

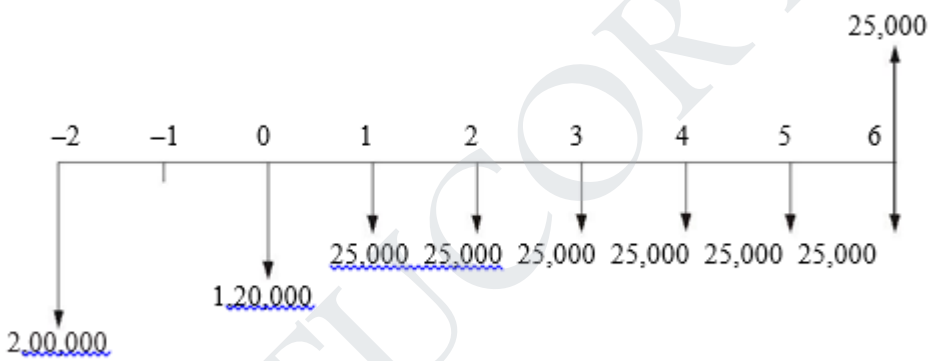



**Fig. 8.4** Cash flow diagram for alternative 1.

annual maintenance cost for the preceding periods are not shown in this figure. The annual equivalent cost is computed as

$$AE(12\%) = (P - F)(A/P, 12\%, 6) + F \times i + A$$
$$= (1,20,000 - 25,000)(0.2432) + 25,000 \times 0.12 + 25,000$$
$$= \text{Rs. } 51,104$$

***Alternative 2 — New machine***

Purchase price ($P$) = Rs. 1,50,000
Salvage value ($F$) = Rs. 20,000
Annual maintenance cost ($A$) = Rs. 14,000
Life = 6 years
Interest rate = 12%

The cash flow diagram of the new machine is depicted in Fig. 8.5.

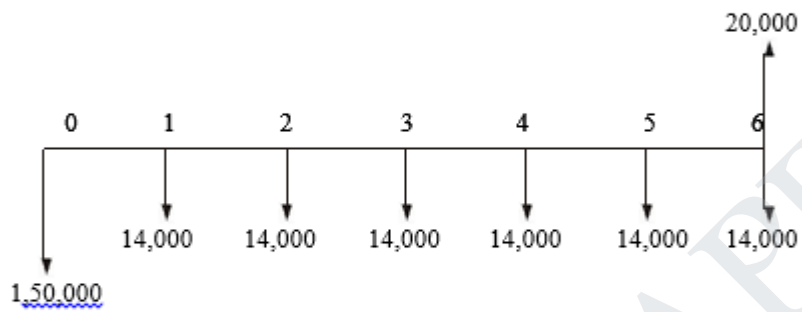



**Fig. 8.5** Cash flow diagram for alternative 2.

The formula for the annual equivalent cost is

$$AE(12\%) = (P - F)(A/P, 12\%, 6) + F \times i + A$$
$$= (1,50,000 - 20,000)(0.2432) + 20,000 \times 0.12 + 14,000$$
$$= \text{Rs. } 48,016$$

Since the annual equivalent cost of the new machine is less than that of the present machine, it is suggested that the present machine be replaced with the new machine.

***9. (a) Write short notes on 'economic life' of an equipment.***
***(b) A firm is considering replacement of 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. When should the equipment be replace if i=0%? (Nov2013).***

## 8.4 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.

A typical shape of each of the above costs with respect to life of the machine is shown in Fig. 8.2.

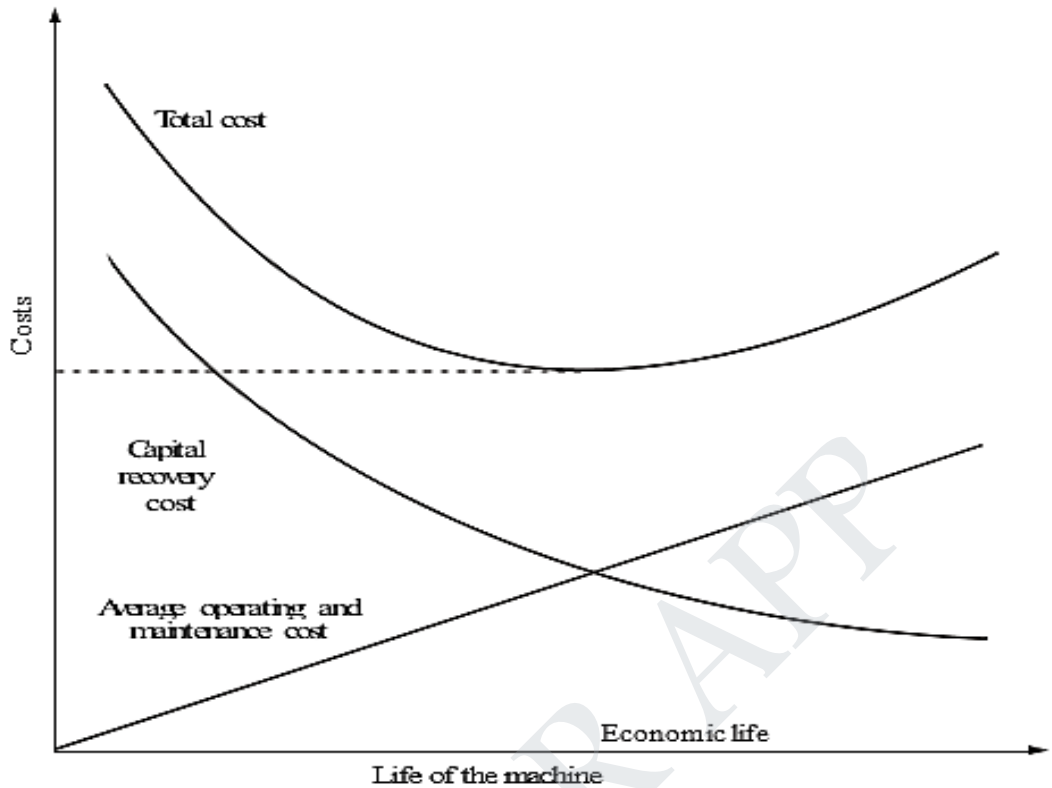



**Fig. 8.2** Chart showing economic life.

From Fig. 8.2, it is clear that the capital recovery cost (average first cost) goes on decreasing with the life of the machine and the average operating and maintenance cost goes on increasing with the life of the machine. From the beginning, the total cost continues to decrease up to a particular life and then it starts increasing. The point where the total cost is minimum is called the *economic life* of the machine.

If the interest rate is more than zero per cent, then we use interest formulas to determine the economic life.

The replacement alternatives can be evaluated based on the present worth criterion and annual equivalent criterion. The basics of these criteria are already presented in Chapter 3.

(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.

This is summarized in column B of Table 8.1.

**Table 8.1 Calculations** to Determine Economic Life (First cost = Rs. 4,000, Interest = 0%)

| *End of year* (*n*) | *Maintenance cost at end of year* | *Summation of maintenance costs* | *Average cost of maintenance through year given* | *Average first cost if replaced at year end given* | *Average total cost through year given* |
|---|---|---|---|---|---|
| | | SB | C/A | 4,000/A | D + E |
| A | B (Rs.) | C (Rs.) | D (Rs.) | E (Rs.) | F (Rs.) |
| 1 | 0 | 0 | 0 | 4,000.00 | 4,000.00 |
| 2 | 200 | 200 | 100 | 2,000.00 | 2,100.00 |
| 3 | 400 | 600 | 200 | 1,333.33 | 1,533.33 |
| 4 | 600 | 1,200 | 300 | 1,000.00 | 1,300.00 |
| 5 | 800 | 2,000 | 400 | 800.00 | 1,200.00 |
| 6 | 1,000 | 3,000 | 500 | 666.67 | 1,166.67* |
| 7 | 1,200 | 4,200 | 600 | 571.43 | 1,171.43 |

*Economic life of the machine = 6 years

Column C summarizes the summation of maintenance costs for each replacement period. The value corresponding to any end of year in this column represents the total maintenance cost of using the equipment till the end of that particular year.

$$\text{Average total cost} = \frac{\text{First cost (FC)} + \text{Summation of maintenance cost}}{\text{Replacement period}}$$

$$= \frac{\text{FC}}{n} + \frac{\text{Column C}}{n}$$

$$= \text{Average first cost for the given period} + \text{Average maintenance cost for the given period}$$

$$\text{Column F} = \text{Column E} + \text{Column D}$$

The value corresponding to any end of year ($n$) in Column F represents the average total cost of using the equipment till the end of that particular year.

For this problem, the average total cost decreases till the end of year 6 and then it increases. Therefore, the optimal replacement period is six years, i.e. economic life of the equipment is six years.

**(b) When interest rate, $i$ = 12%.** When the interest rate is more than 0%, the steps to be taken for getting the economic life are summarized with reference to Table 8.2.

**Table 8.2** Calculations to Determine Economic Life (First cost = Rs. 4,000, Interest = 12%)

| *End of year* ($n$) | *Maintenance cost at end of year* | *P/F, 12%, n* | *Present worth as of beginning of year 1 of maintenance costs* | *Summation of present worth of maintenance costs through year given* | *Present worth of cumulative maintenance cost & first cost* | *A/P, 12%, n* | *Annual equivalent total cost through year given* |
|---|---|---|---|---|---|---|---|
| | | | (B ´ C) | S D | E + Rs. 4,000 | | F ´ G |
| A | B (Rs) | C | D (Rs.) | E (Rs.) | F (Rs.) | G | H (Rs.) |
| 1 | 0 | 0.8929 | 0.00 | 0.00 | 4,000.00 | 1.1200 | 4,480.00 |
| 2 | 200 | 0.7972 | 159.44 | 159.44 | 4,159.44 | 0.5917 | 2,461.14 |
| 3 | 400 | 0.7118 | 284.72 | 444.16 | 4,444.16 | 0.4163 | 1,850.10 |
| 4 | 600 | 0.6355 | 381.30 | 825.46 | 4,825.46 | 0.3292 | 1,588.54 |
| 5 | 800 | 0.5674 | 453.92 | 1,279.38 | 5,279.38 | 0.2774 | 1,464.50 |
| 6 | 1,000 | 0.5066 | 506.60 | 1,785.98 | 5,785.98 | 0.2432 | 1,407.15 |
| 7 | 1,200 | 0.4524 | 542.88 | 2,328.86 | 6,328.86 | 0.2191 | 1,386.65* |
| 8 | 1,400 | 0.4039 | 565.46 | 2,894.32 | 6,894.32 | 0.2013 | 1,387.83 |
| 9 | 1,600 | 0.3606 | 576.96 | 3,471.28 | 7,471.28 | 0.1877 | 1,402.36 |
| 10 | 1,800 | 0.3220 | 579.60 | 4,050.88 | 8,050.88 | 0.1770 | 1,425.00 |

*Economic life of the machine = 7 years

The steps are summarized now:

1. Discount the maintenance costs to the beginning of year 1.

$$\text{Column D} = \text{Column B} \times \frac{1}{(1+i)^n}$$

$$= \text{Column B} \times (P/F, i, n) = \text{Column B} \times \text{Column C}.$$

2. Find the summation of present worth of maintenance costs through the year given (Column E = S Column D).

***10 (i) What do you mean by replacement and maintenance analysis? State and explain different types of replacement.***

***(iii) Explain the concept of Life Cycle Analysis cost. (May 2013, Nov 2008, May2010)***

(OR)

***10.1 (a) What is defender challenger concept in replacement? Illustrate with an example.***

***(b) Explain the causes for replacement of assets, in detail with examples. (June2012, May200, May 201, May2012).***

***(i)***

## 8.1 INTRODUCTION

Organizations providing goods/services use several facilities like equipment and machinery which are directly required in their operations. In addition to these facilities, there are several other items which are necessary to facilitate the functioning of organizations.

All such facilities should be continuously monitored for their efficient functioning; otherwise, the quality of service will be poor. Besides the quality of service of the facilities, the cost of their operation and maintenance would increase with the passage of time. Hence, it is an absolute necessity to maintain the equipment in good operating conditions with economical cost. Thus, we need an integrated approach to minimize the cost of maintenance. In certain cases, the equipment will be obsolete over a period of time.

If a firm wants to be in the same business competitively, it has to take decision on whether to replace the old equipment or to retain it by taking the cost of maintenance and operation into account.

There are two basic reasons for considering the replacement of an equipment—physical impairment of the various parts or obsolescence of the equipment.

Physical impairment refers only to changes in the physical condition of the machine itself. This would lead to a decline in the value of the service rendered, increased operating cost, increased maintenance cost or a combination of these.

Obsolescence is due to improvement of the tools of production, mainly improvement in technology.

So, it would be uneconomical to continue production with the same machine under any of the above situations. Hence, the machines are to be periodically replaced.

Sometimes, the capacity of existing facilities may be inadequate to meet the current demand. Under such situation, the following alternatives will be considered.

- Replacement of the existing equipment with a new one.

## 8.2 TYPES OF MAINTENANCE

Maintenance activity can be classified into two types: preventive maintenance and breakdown maintenance. *Preventive maintenance* (PM) is the periodical inspection and service activities which are aimed to detect potential failures and perform minor adjustments or repairs which will prevent major operating problems in future. *Breakdown maintenance* is the repair which is generally done after the equipment has attained down state. It is often of an emergency nature which will have associated penalty in terms of expediting cost of maintenance and down time cost of equipment. Preventive maintenance will reduce such cost up to a point. Beyond that point, the cost of preventive maintenance will be more when compared to the breakdown maintenance cost. The total cost, which is the sum of the preventive maintenance cost and the breakdown maintenance cost, will go on decreasing with an increase in the level of maintenance up to a point. Beyond that point, the total cost will start increasing. The level of maintenance corresponding to the minimum total cost is the optimal level of maintenance. The concepts are demonstrated in Fig. 8.1.

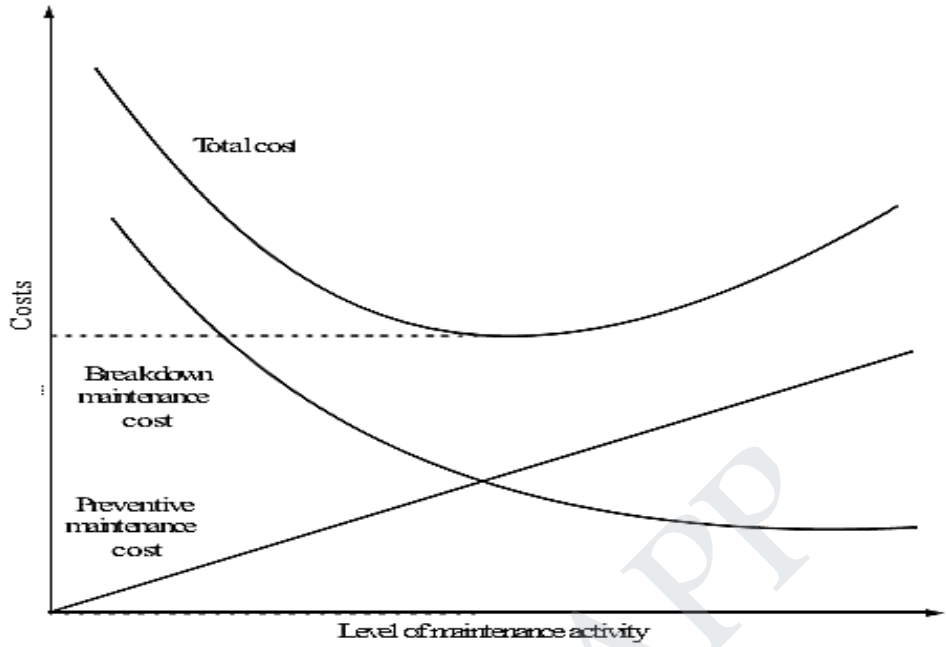



**Fig. 8.1** Maintenance costs.

## 8.3 TYPES OF REPLACEMENT PROBLEM

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).

***The same for this question :) (a) Trace out the types of replacement problem.***

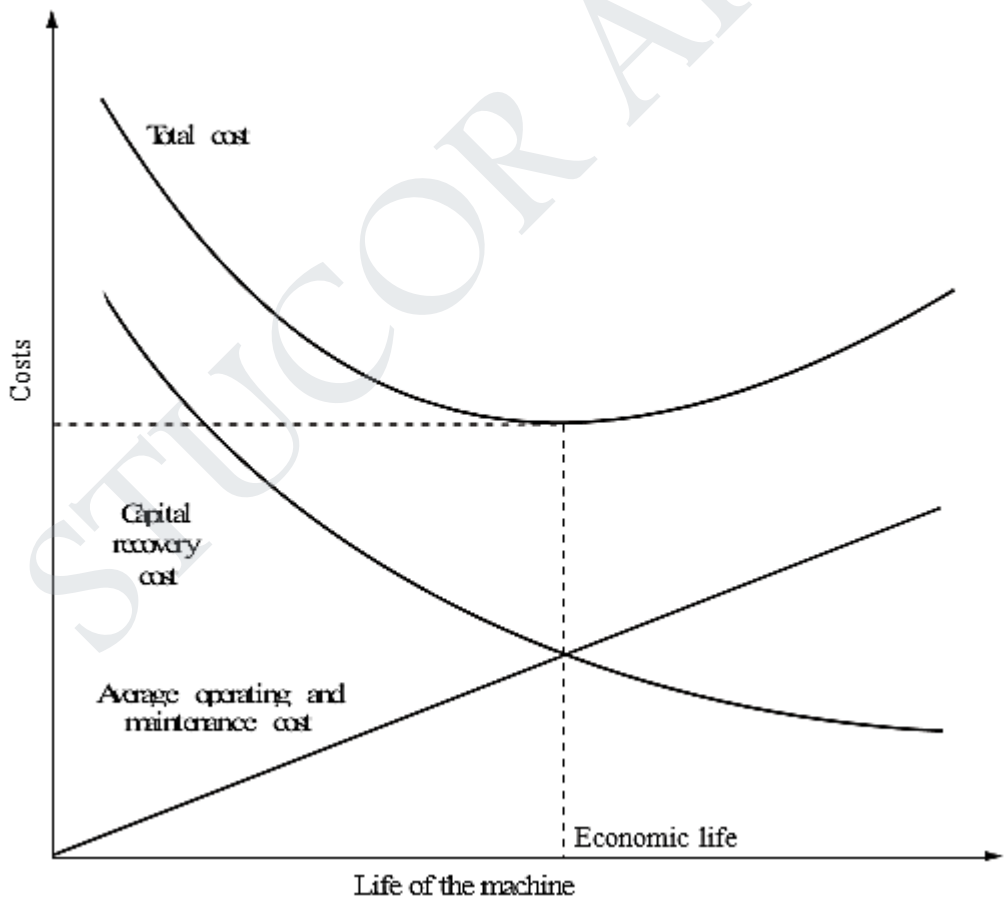
***(b) Develop a simple probabilistic model for items which fail completely. (Nov2009)***

## 8.4 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.

A typical shape of each of the above costs with respect to life of the machine is shown in Fig. 8.2.



From Fig. 8.2, it is clear that the capital recovery cost (average first cost) goes on decreasing with the life of the machine and the average operating and maintenance cost goes on increasing with the life of the machine. From the beginning, the total cost continues to decrease up to a particular life and then it starts increasing. The point where the total cost is minimum is called the *economic life* of the machine.

If the interest rate is more than zero per cent, then we use interest formulas to determine the economic life.

The replacement alternatives can be evaluated based on the present worth criterion and annual equivalent criterion. The basics of these criteria are already presented in Chapter 3.

## 8.5 REPLACEMENT OF EXISTING ASSET WITH A NEW ASSET

In this section, the concept of comparison of replacement of an existing asset with a new asset is presented. In this analysis, the annual equivalent cost of each alternative should be computed first. Then the alternative which has the least cost should be selected as the best alternative. Before discussing details, some preliminary concepts which are essential for this type of replacement analysis are presented.

### 8.5.1 Capital Recovery with Return

Consider the following data of a machine. Let

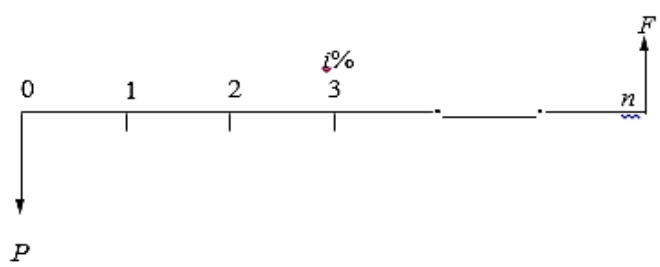
$P$ = purchase price of the machine,

$F$ = salvage value of the machine at the end of machine life,

$n$ = life of the machine in years, and

$i$ = interest rate, compounded annually

The corresponding cash flow diagram is shown in Fig. 8.3.



### 8.5.2 Concept of Challenger and Defender

If an existing equipment is considered for replacement with a new equipment, then the existing equipment is known as the *defender* and the new equipment is known as *challenger*.

Assume that an equipment has been purchased about three years back for Rs. 5,00,000 and it is considered for replacement with a new equipment. The supplier of the new equipment will take the old one for some money, say, Rs. 3,00,000. This should be treated as the present value of the existing equipment and it should be considered for all further economic analysis. The purchase value of the existing equipment before three years is now known as *sunk cost*, and it should not be considered for further analysis.

***11. (i) What are the objectives of plant maintenance? Explain different types of maintenance adopted on an industry.***

***(ii) Explain concepts of Challenger and Defender. (May 2013)***

**1. OBJECTIVES OF PLANT MAINTENANCE.**

1. To achieve minimum break-down.
2. To keep plant in good working condition at the lowest possible cost.
3. To keep machines at their optimum capacity without any interruption or hindrance.
4. To ensure the availability of machines, building and services.
5. To achieve efficient functioning of machines
6. To reduce operation and maintenance cost.

### 8.5.2 Concept of Challenger and Defender

If an existing equipment is considered for replacement with a new equipment, then the existing equipment is known as the *defender* and the new equipment is known as *challenger*.

Assume that an equipment has been purchased about three years back for Rs. 5,00,000 and it is considered for replacement with a new equipment. The supplier of the new equipment will take the old one for some money, say, Rs. 3,00,000. This should be treated as the present value of the existing equipment and it should be considered for all further economic analysis. The purchase value of the existing equipment before three years is now known as *sunk cost*, and it should not be considered for further analysis.

***12. A diesel engine was installed 10 years ago at a cost of Rs. 50,000. It has a present realizable market value of Rs. 15,000. If kept, it can be expected to last five years more, with operating and maintenance cost of Rs. 14,000 per year and to have a salvage value of Rs. 8,000 at the end of the fifth year. This engine can be replaced with an improved version costing Rs. 65,000, which has an expected life of 20 years. This improved version will have an estimated annual operating and maintenance cost of Rs. 9,000 and ultimate salvage value of Rs. 13,000. Using an interest rate of 15%, make an annual equivalent cost analysis to determine whether to keep or replace the old engine. (Dec2012)***

***Solution Alternative 1— Old diesel engine***

Purchase price = Rs. 50,000
Present value ($P$) = Rs. 15,000
Salvage value ($F$) = Rs. 8,000
Annual operating and maintenance cost ($A$) = Rs. 14,000
Remaining life ($n$) = 5 years
Interest rate = 15%

The cash flow diagram of the old diesel engine is shown in Fig. 8.6.

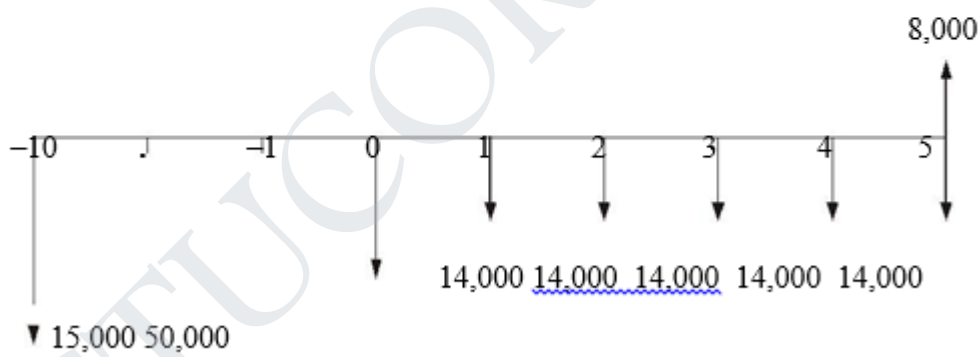



**Fig. 8.6 Cash** flow diagram for alternative 1.

The formula for the annual equivalent cost is

$$AE(15\%) = (P - F)(A/P, 15\%, 5) + F \times i + A$$
$$= (15{,}000 - 8{,}000)(0.2983) + 8{,}000 \times 0.15 + 14{,}000$$
$$= \text{Rs. } 17{,}288.10$$

***Alternative 2 — New diesel engine***

Present value ($P$) = Rs. 65,000
Salvage value ($F$) = Rs. 13,000
Annual operating and maintenance cost ($A$) = Rs. 9,000
Life ($n$) = 20 years
Interest rate = 15%

The cash flow diagram of the new diesel engine is shown in Fig. 8.7.

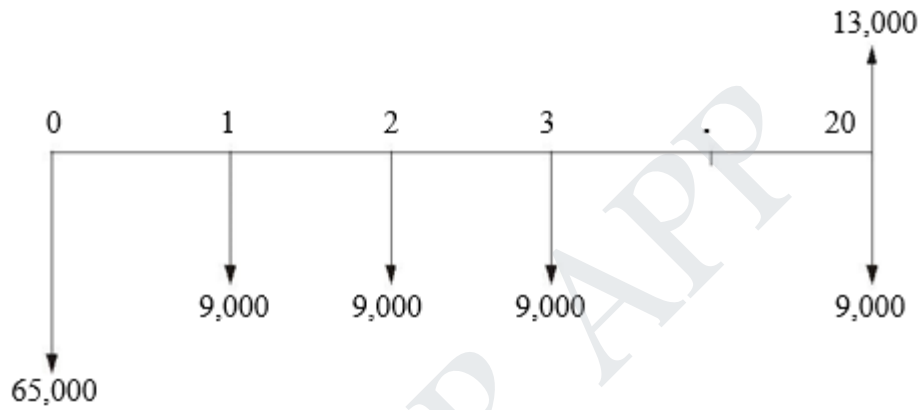
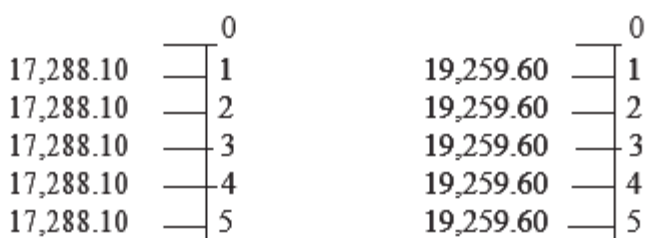



**Fig. 8.7** Cash flow diagram for alternative 2.

The formula for the annual equivalent cost is

$$AE(15\%) = (P - F)(A/P, 15\%, 20) + F \times i + A$$
$$= (65{,}000 - 13{,}000)(0.1598) + 13{,}000 \times 0.15 + 9{,}000$$
$$= \text{Rs. } 19{,}259.60$$

For comparing the engines based on equal lives (20 years), the annual equivalent figures are given in Fig. 8.8. Equal lives are nothing but the least common multiple of the lives of the alternatives.



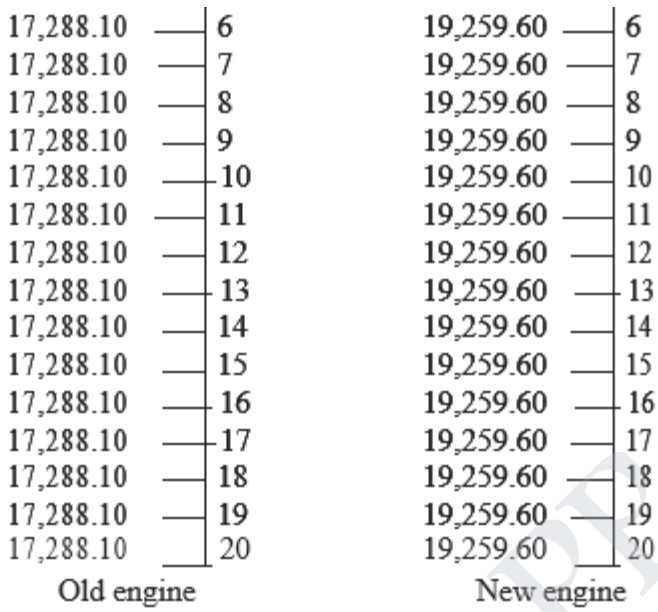



**Fig. 8.8** Cash flow diagram of alternatives based on common lives.

Since the annual equivalent cost of the old diesel engine is less than that of the new diesel engine, it is suggested to keep the old diesel engine. Here, an important assumption is that the old engine will be replaced four times during the 20 years period of comparison.

***13. An electronic equipment contains 1,000 resistors. When any resistor fails, it is replaced. The cost of replacing a resistor individually is Rs. 10. If all the resistors are replaced at the same time, the cost per resistor is Rs. 4. The per cent surviving, S (i) at the end of month is tabulated as follows:***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ***I*** | ***0*** | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** | ***6*** |
| ***S(i)*** | ***100*** | ***96*** | ***89*** | ***68*** | ***37*** | ***13*** | ***0*** |

***Which is the optimum replacement plan? (Dec2012).***

***Solution Let*** *pi* be the probability of failure during the month *i*. Then,

$p1 = (100 - 96)/100 = 0.04$ $\quad$ $p4 = (68 - 37)/100 = 0.31$

$p2 = (96 - 89)/100 = 0.07$ $\quad$ $p5 = (37 - 13)/100 = 0.24$

$p3 = (89 - 68)/100 = 0.21$ $\quad$ $p6 = (13 - 0)/100 = 0.13$

It is clear that no resistor can survive beyond six months. Hence, a resistor which has survived for five months would certainly fail during the sixth month. We assume that the resistors failing during a month are accounted at the end of the month.

Let

$N_i$ = No. of resistors replaced at the end of the $i$th month.

$N_0 = 1{,}000$

$N_1 = N_0 p_1 = 1{,}000 \times 0.04 = 40$

$N_2 = N_0 p_2 + N_1 p_1 = 1{,}000 \times 0.07 + 40 \times 0.04 = 72$

$N_3 = N_0 p_3 + N_1 p_2 + N_2 p_1 = 1{,}000 \times 0.21 + 40 \times 0.07 + 72 \times 0.04 = 216$

$N_4 = N_0 p_4 + N_1 p_3 + N_2 p_2 + N_3 p_1$
$= 1{,}000 \times 0.31 + 40 \times 0.21 + 72 \times 0.07 + 216 \times 0.04 = 332$

$N_5 = N_0 p_5 + N_1 p_4 + N_2 p_3 + N_3 p_2 + N_4 p_1$
$= 1{,}000 \times 0.24 + 40 \times 0.31 + 72 \times 0.21 + 216 \times 0.07 + 332 \times 0.04 = 296$

$N_6 = N_0 p_6 + N_1 p_5 + N_2 p_4 + N_3 p_3 + N_4 p_2 + N_5 p_1$
$= 1{,}000 \times 0.13 + 40 \times 0.24 + 72 \times 0.31 + 216 \times 0.21 + 332 \times 0.07 + 296 \times 0.04$
$= 242$

**Determination of individual replacement cost**

Expected life of each resistor $= \sum_{i=1}^{6} i \times p_i$

$= 1 \times 0.04 + 2 \times 0.07 + 3 \times 0.21 + 4 \times 0.31 + 5 \times 0.24 + 6 \times 0.13$

$= 4.03$ months.

Average number of failures/month = 1,000/4.03 = 248 (approx.)

Therefore,

Cost of individual replacement
= (No. of failures/month × individual replacement cost/resistor)
= 248 × 10 = Rs. 2,480.

**Determination of group replacement cost**

Cost/resistor when replaced simultaneously = Rs. 4.00
Cost/resistor when replaced individually = Rs. 10.00

The costs of group replacement policy for several replacement periods are summarized in Table 8.7.

**Table 8.7 Calculations** of Costs for Preventive Maintenance

**Table 8.7 Calculations** of Costs for Preventive Maintenance

| *End of month* | *Cost of replacing 1,000 resistors at a time* | *Cost of replacing resistors individually during given replacement period* | *Total cost (B + C)* | *Average cost/ month (D/A)* |
|---|---|---|---|---|
| A | B (Rs.) | C (Rs.) | D (Rs.) | E (Rs.) |
| 1 | 4,000 | 40 ´ 10 = 400 | 4,400 | 4,400.00 |
| 2 | 4,000 | (40 + 72)10 = 1,120 | 5,120 | 2,560.00 |
| 3 | 4,000 | (40 + 72 + 216)10 = 3,280 | 7,280 | 2,426.67* |
| 4 | 4,000 | (40 + 72 + 216 + 332)10 = 6,600 | 10,600 | 2,650.00 |

*Indicates the minimum average cost/month.

From Table 8.7, it is clear that the average cost/month is minimum for the third month. Thus, the group replacement period is three months.

**Summary**

Individual replacement cost/month = Rs. 2,480.00
Minimum group replacement cost/month = Rs. 2,426.67

Since the minimum group replacement cost/month is less than the individual replacement cost/month, the group replacement policy is the best and hence all the resistors are to be replaced once in three months and the resistors which fail during this three months period are to be replaced individually.

***14. Initial cost of a machine is Rs. 6, 00,000, with other details as below:***

| *Year* | *1* | *2* | *3* | *4* | *5* |
|---|---|---|---|---|---|
| *Resale Value (Rs. )* | *4,20,000* | *3,00,000* | *2,04,000* | *1,44,000* | *96,500* |
| *Cost of spares (Rs.)* | *40,000* | *42,700* | *48,800* | *57,000* | *68,000* |
| *Cost of labour (Rs.)* | *1,40,000* | *1,60,000* | *1,80,000* | *2,10,000* | *2,50,000* |

***Determine the optimum period for replacement of the machine. (May 2008)***

***Calculations to determine economic life***

| Operating cost | Cumulative operating cost | Resale value | Total cost | Average Total Cost |
|---|---|---|---|---|
| | Σ B | | C+600000–D | |
| B (Rs.) | C (Rs.) | D (Rs.) | E (Rs.) | F (Rs.) |
| 1,80,000 | 1,80,000 | 4,20,000 | 3,60,000 | 3,60,000 |
| 2,02,700 | 3,82,700 | 3,00,000 | 6,82,700 | 3,41,350 |
| 2,28,800 | 6,11,500 | 2,04,000 | 10,07,500 | 3,35,833.33 |
| 2,67,000 | 8,78,500 | 1,44,000 | 13,34,500 | 3,33,625* |
| 3,18,000 | 11,96,500 | 96,500 | 17,00,000 | 3,40,000 |

*lt:* The above table shows that the average total cost decreases till the end of year 4 and then it increases. Therefore, the economic service life of the machine is four years. *i.e.*, the optimal replacement period is 4 years.

***15. Discuss the importance of maintenance. Analyses the various types of maintenance and their relative merits and demerits. (Nov 2011)***

***15.1. (i) Explain the various maintenance types with examples (May 2012, Nov 2011)***

***(ii) What are the general guidelines in framing a replacement policy?***

## 4.11. FUNCTIONS OF MAINTENANCE DEPARTMENT

The different functions and responsibilities of the maintenance department are as follows.

(*i*) Inspection

(*ii*) Engineering

(*iii*) Maintenance

(*iv*) Repair

(*v*) Overhaul

(*vi*) Construction

(*vii*) Salvage

(*viii*) Clerical jobs

(*ix*) Generation and distribution of power

(*x*) Administration and supervision of labour force in maintenance department.

(*xi*) Providing plant protection including fire protection

(*xii*) Insurance administration

(*xiii*) Maintaining store of maintenance materials

(*xiv*) House keeping

## 4.12. TYPES OF MAINTENANCE

Maintenance activity may be classified into following categories.

(*a*) Corrective or breakdown maintenance

(*b*) Scheduled maintenance

(*c*) Preventive maintenance and

(*d*) Predictive maintenance

## 4.13. CORRECTIVE OR BREAKDOWN MAINTENANCE

Corrective or breakdown maintenance implies that repairs are made after the equipment is out of order and it can not perform its normal functions any longer. Under such conditions, production department calls on the maintenance department to rectify the defect. The maintenance department checks into the difficulty and makes the necessary repairs. After removing the fault, the maintenance engineers do not attend the equipment again until another failure or breakdown occurs.

### 4.13.1. Causes of Equipment Breakdown

(*i*) Failure to replace worn out parts

(*ii*) Lack of lubrication

(*iii*) Neglected cooling system

(*iv*) Indifferent towards minor faults

(*v*) External factors such as too low or high voltage, wrong fuel etc.

(*vi*) Indifferent towards equipment vibrations, unusual sounds etc.

### 4.13.2. Disadvantages of Breakdown Maintenance

(*i*) Delays in production

(*ii*) Faster plant deterioration

(*iii*) Increased chances of accidents and less safety

(*iv*) More spoilt material

(*v*) Direct loss of profit

(*vi*) Breakdown maintenance practice can not be employed for those plant items which are regulated by statutory provisions, for examples cranes, lifts, hoists and pressure vessels.

## 4.14. SCHEDULED MAINTENANCE

Scheduled maintenance practice incorporated (in it), inspection, repair and overhaul of certain equipments which if neglected can result in breakdown. Inspection, lubrication, servicing etc., of these equipments are included in the predetermined schedule. Scheduled maintenance is a stich-in-time procedure aimed at avoiding breakdowns.

## 4.15. PREVENTIVE MAINTENANCE

Preventive maintenance is defined as any action performed in an attempt to keep a machine in a specified operating condition by means of systematic inspection, detection, and prevention of incipient failures.

Preventive maintenance tries to minimize the problems of breakdown maintenance. It is a stich-in-time procedure. It works on the principle of "prevention is better than cure". It locates weak spots in all equipments, provides them with regular inspection and minor repairs and thereby reduces the danger of un-anticipated breakdown.

### 4.15.1. Process of Preventive Maintenance

A typical preventive maintenance process has been shown below.

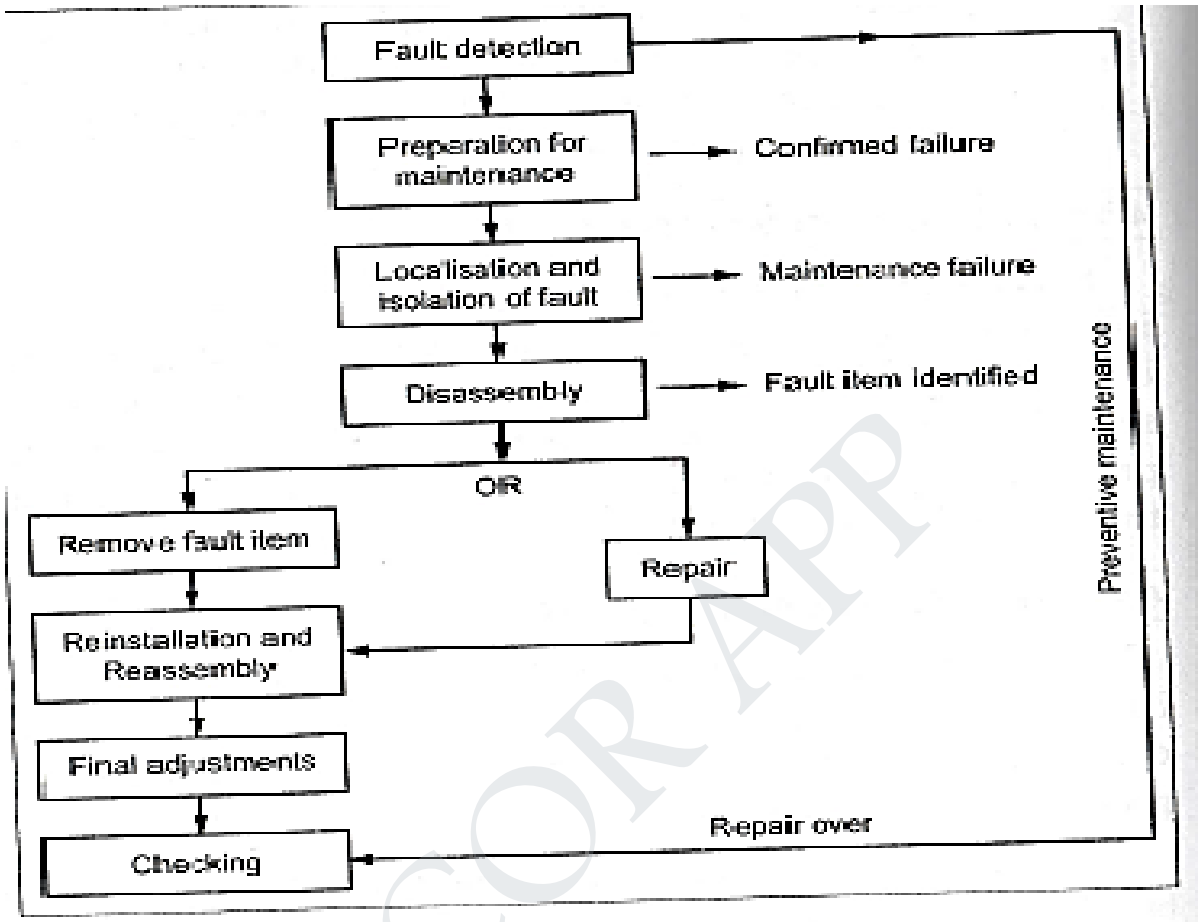



*Fig. 4.3. Process of preventive maintenance*

### 4.15.2. Objectives of Preventive Maintenance

(*i*) To identify small problems in equipment and to rectify it so that breakdown are minimized.

(*ii*) To keep always the equipment available

(*iii*) To maintain the value of the equipment by periodic inspection, repairs and overhauls etc.,

(*iv*) To maintain optimum production efficiency of the equipment.

(*v*) To maintain the operational accuracy of the equipment.

(*vi*) To ensure safety of workers

(*vii*) To reduce the work content of maintenance jobs.

### 4.15.3. Procedure of Preventive Maintenance

The preventive maintenance procedure must be tailor made for each industry. The general preventive maintenance program contains the following steps.

(*i*) Inspection or checkups

(*ii*) Lubrication

(*iii*) Planning and scheduling

(*iv*) Record keeping and analysis to forecast maintenance

(*v*) Training of maintenance personnel

(*vi*) Storage of spare parts

(*vii*) Control and evaluation of preventive maintenance.

### 4.15.4. Advantages of Preventive Maintenance

(*i*) Reduction in production down time

(*ii*) Less overtime pay for maintenance personnel

(*iii*) lesser number of stand-by equipments are needed.

(*iv*) Lesser expenditure on repairs

(*v*) Greater safety to employees because of reduced breakdowns.

(*vi*) Fewer large scale and repetitive repairs.

(*vii*) Lower unit cost of manufacture

(*viii*) Better product quality and fewer rejections.

## 4.16. PREDICTIVE MAINTENANCE

It is comparatively a newer maintenance technique. It makes use of human senses or other sensitive instruments such as Audio gauges, Vibration analyzers, Amplitude meters, Pressure, Temperature and Resistance strain gauges etc., to predict troubles before the equipment fails.

Unusual sounds coming out of a rotating equipment predict a trouble.

Simple hand touch can point out many unusual equipment conditions and thus predict a trouble.

In predictive maintenance, equipment conditions are measured periodically or on a continuous basis and this enables maintenance men to take a timely action such as equipment adjustments, repair or overhaul.

Predictive maintenance extends the service life of an equipment without fear of failure.

***16. A machine was purchased at a cost of Rs. 2,00,000 to be useful for eight years, two years age. Its salvage value at the end of its life is Rs. 25,000. The annual maintenance cost is Rs. 25,000. Now, a new machine to cater the need of the present machine is available at Rs. 1, 50,000 to be useful for six years. Its annual maintenance cost is Rs. 14,000. The salvage value of the new machine is Rs. 20,000. Using an interest rate of 12%, find whether it is worth replacing the present machine with the new machine. (Nov 2011).***

***1. Find the comparative use value of the old machine.***

***2. Is it advisable to replace the old machine?***

***Solution Old machine*** let the comparative use value of the old machine be $X$.

Remaining life ($n$) = 4 years.
Salvage value of the old machine ($F$) = Rs. 1,000
Annual maintenance cost ($A$) = Rs. 750
Interest rate, $i$ = 12%

The cash flow diagram of the old machine is depicted in Fig. 8.14.

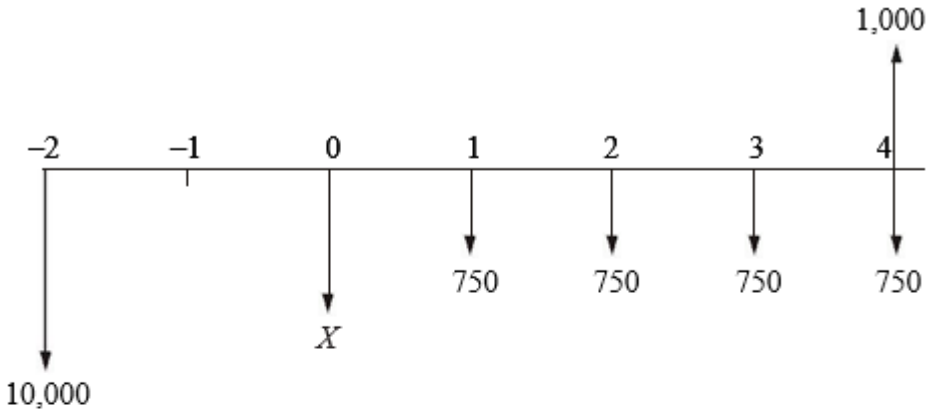



**Fig. 8.14** Cash flow diagram for old machine.

The annual equivalent cost of the old machine is computed as

$$AE(12\%) = (X - F)(A/P, 12\%, 4) + F \times i + A$$
$$= (X - 1{,}000)(0.3292) + 1{,}000 \times 0.12 + 750$$

***New machine***

Cost of the new Machine ($P$) = Rs. 10,000
Life ($n$) = 4 years.
Salvage value of the new machine ($F$) = Rs. 4,000
Annual Maintenance cost ($A$) = Rs. 500
Interest rate, $i$ = 12%

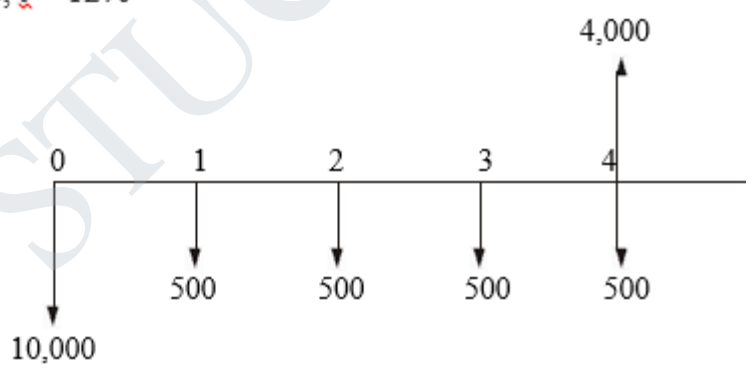



**Fig. 8.15** Cash flow diagram for new machine.

The annual equivalent cost of the new machine is illustrated as

$$AE(12\%) = (P - F)(A/P, 12\%, 4) + F \times i + A$$
$$= (10{,}000 - 4{,}000)(0.3292) + 4{,}000 \times 0.12 + 500$$
$$= \text{Rs. } 2{,}955.20$$

Now, equate the annual equivalent costs of the two alternatives and solve for $X$.

$$(X - 1{,}000)(0.3292) + 1{,}000 \times 0.12 + 750 = 2{,}955.20$$

$$X = \text{Rs. } 7{,}334.14$$

The comparative use value of the old machine is Rs. 7,334.14, which is less than the price (Rs. 8,000) offered by the company which is supplying the new machine in the event of replacing the old machine by the new machine.

Therefore, it is advisable to replace the old machine with the new one.

***17. A firm is considering replacement of equipment, whose first cost is Rs. 1,750 and the scrap value is negligible at any year. Based on experience, it was found that the maintenance cost is zero during the first year and it increases by Rs. 100 every year thereafter.***

***(i) When should the equipment be replaced if i=0%***

***(ii) When should the equipment be replaced if i=12% (May2010)***

***(i) When i = 0%:***

***Given Data:***

First cost = 1750

Maintenance cost is Rs.0 during the first year and it increases by Rs.100 every year thereafter.

***To find:*** Economic service life.

☺ ***Solution:*** Calculations to determine economic life.

| Year of service | Maintenance cost | Cumulative maintenance cost | Average maintenance cost | Average first cost | Average total cost |
|---|---|---|---|---|---|
| | | Σ B | C/A | 1750/A | D + E |
| A | B (Rs.) | C (Rs.) | D (Rs.) | E (Rs.) | F (Rs.) |
| 1 | 0 | 0 | 0 | 1750 | 1750 |
| 2 | 100 | 100 | 50 | 875 | 925 |
| 3 | 200 | 300 | 100 | 583.33 | 683.3 |
| 4 | 300 | 600 | 150 | 437.50 | 587.50 |
| 5 | 400 | 1000 | 200 | 350 | 550 |
| 6 | 500 | 1500 | 250 | 291.66 | 541.66* |
| 7 | 600 | 2100 | 300 | 250 | 550 |
| 8 | 700 | 2800 | 350 | 218.75 | 568.75 |

***Result:*** The above table shows that the average total cost decreases till the end of year 6 and then it increases. Therefore, the economic service life of this machine is six years, *i.e.*, the optimal replacement period is six years.

(*ii*) When $i = 12\%$

| Year of service | Maintenance cost | P/F, 12%, N | Present worth as beginning of year 1 of maintenance cost | Cumulative sum of column D through year designated | Present worth of cumulative maintenance cost and first cost | A/P, 12%, N | Annual equivalent total cost through the year given |
|---|---|---|---|---|---|---|---|
| | | | B × C | Σ D | E + 1750 | | F × G |
| A | B | C | D | E | F | G | H |
| 1 | 0 | 0.8929 | 0 | 0 | 1750 | 1.1200 | 1960 |
| 2 | 100 | 0.7972 | 79.72 | 79.72 | 1829.72 | 0.5917 | 1082.65 |
| 3 | 200 | 0.7118 | 142.36 | 222.08 | 1972.08 | 0.4163 | 820.98 |
| 4 | 300 | 0.6355 | 190.65 | 412.73 | 2162.73 | 0.3292 | 711.97 |
| 5 | 400 | 0.5674 | 226.96 | 639.69 | 2389.69 | 0.2774 | 662.90 |
| 6 | 500 | 0.5066 | 253.3 | 892.99 | 2642.99 | 0.2432 | 642.78 |
| 7 | 600 | 0.4523 | 271.38 | 1164.37 | 2914.37 | 0.2191 | 638.54* |
| 8 | 700 | 0.4039 | 282.73 | 1447.1 | 3197.1 | 0.2013 | 643.57 |

***18. Explain the following with example***

***(1) Capital recovery with return***

***(2) Concept of challenger and defender. (May 2009).***

***or***

***Write in detail the mode of recovery of capital and returns and explain the simple probabilistic model for items which fail completely. (Nov 2017***

***1. CAPITAL RECOVERY WITH RETURN***

Consider the following data of a machine. Let

P = Purchase cost of the machine

F = Salvage value at the end of machine life

N = Life of the machine in years and

¡ = Interest rate compounded annually.

The corresponding cash flow diagram is shown in Fig.42.

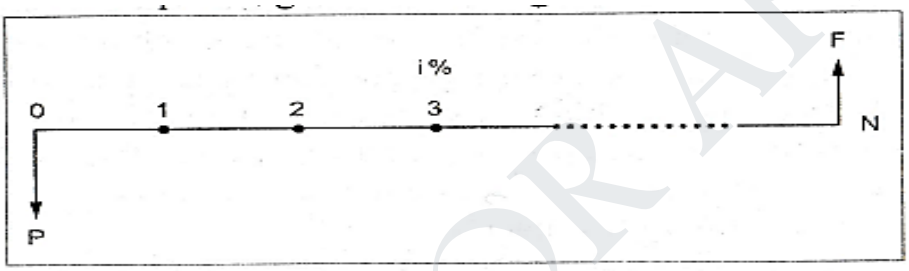



***Fig. 4.2. Cash flow diagram***

The equation for the annual equivalent cost for the above diagram is

$$AE(i) = (P - F)(A/P, i, N) + F \times i$$

***2. CONCEPT OF CHALLENGER AND DEFENDER***

The terms challenger and defender are commonly used in the boxing world. In every boxing class, the current Defending champion is constantly faced with a new Challenger. In replacement analysis, the defender is the Existing machine and the challenger is the best available Replacement equipment. An existing piece of equipment will be removed at some Point of time, either when the task it performs is no longer necessary or when the task can be performed more efficiently by newer and better equipment. The question is not whether the existing piece of equipment will be removed, but when it will be removed. A variation of this question is why we should replace existing equipment at this time rather than Postponing replacement of the equipment by repairing or

Overhauling it. Another aspect of the defender-challenger comparison concerns deciding exactly which equipment is the best challenger. If the defender is to be replaced by the challenger, we would generally want to install the very best of the possible alternatives.

***19.A company is trying to diversify its business in a new product line. The life of the project is 10 years with no salvage value at the end of its life. The initial outlay of the project is Rs. 20,00,000. The annual net profit is Rs. 3,50,000. Find the rate of return for the new business.***

***Solution***

Life of the product line ($n$) = 10 years
Initial outlay = Rs. 20,00,000
Annual net profit = Rs. 3,50,000
Scrap value after 10 years = 0

The cash flow diagram for this situation is shown in Fig. 7.4.

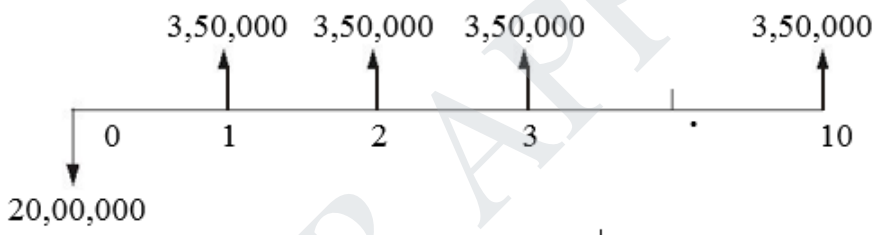



**Fig. Cash** flow diagram.

The formula for the net present worth function of the situation is

$$PW(i) = -20,00,000 + 3,50,000(P/A, i, 10)$$

When $i$ = 10%,

$$PW(10\%) = -20,00,000 + 3,50,000(P/A, 10\%, 10)$$
$$= -20,00,000 + 3,50,000(6.1446)$$
$$= \text{Rs. } 1,50,610.$$

When $i$ = 12%,

$$PW(12\%) = -20,00,000 + 3,50,000(P/A, 12\%, 10)$$
$$= -20,00,000 + 3,50,000(5.6502)$$
$$= \text{Rs. } -22,430.$$

$$i = 10\% + \frac{1,50,610 - 0}{1,50,610 - (-22,430)} \times (2\%)$$
$$= 11.74\ \%$$

Therefore, the rate of return of the new product line is 11.74%

***20. Write an essay about Replacement and Maintenance Analysis. (Nov 2017).***

Answer refer question no.3 and 6.

***21. Three years back, a Coimbatore Corporation purchased a 10 HP motor for pumping drinking water. Its useful life was estimated to be 10 years. Due to the fast development of that locality, the municipality is unable to meet the current demand for water with the existing motor. The municipality can cope with the situation either by augmenting an additional 5 HP motor or replacing the existing 10 HP motor with a new 15 HP motor. The details of these motors are now tabulated.***

| | *Old 10 hp motor* | *New 5 hp motor* | *New 15 hp motor* |
|---|---|---|---|
| Purchase cost ($P$) Rs. | 25,000 | 10,000 | 35,000 |
| Life in years ($n$) | 10 | 7 | 7 |
| Salvage value at the end of machine life (Rs.) | 1,500 | 800 | 4,000 |
| Annual operating & maintenance cost (Rs.) | 1,600 | 1,000 | 500 |

The current market value of the 10 hp motor is Rs. 10,000. Using an interest rate of 15%, find the best alternative.

***Solution*** There are two alternatives to cope with the situation:

1. Augmenting the present 10 hp motor with an additional 5 hp motor.
2. Replacing the present 10 hp motor with a new 15 hp motor.

***Alternative 1—Augmenting the present 10 hp motor with an additional 5 hp motor***

Total annual equivalent cost = Annual equivalent cost of 10 hp motor + Annual equivalent cost of 5 hp motor

**Calculation of annual equivalent cost of 10 hp Motor**

Present market value of the 10 hp motor ($P$) = Rs. 10,000
Remaining life ($n$) = 7 years
Salvage value at the end of motor life ($F$) = Rs. 1,500
Annual operation and maintenance cost ($A$) = Rs. 1,600
Interest rate, $i$ = 15%

The cash flow diagram of this alternative is shown in Fig. 8.11.

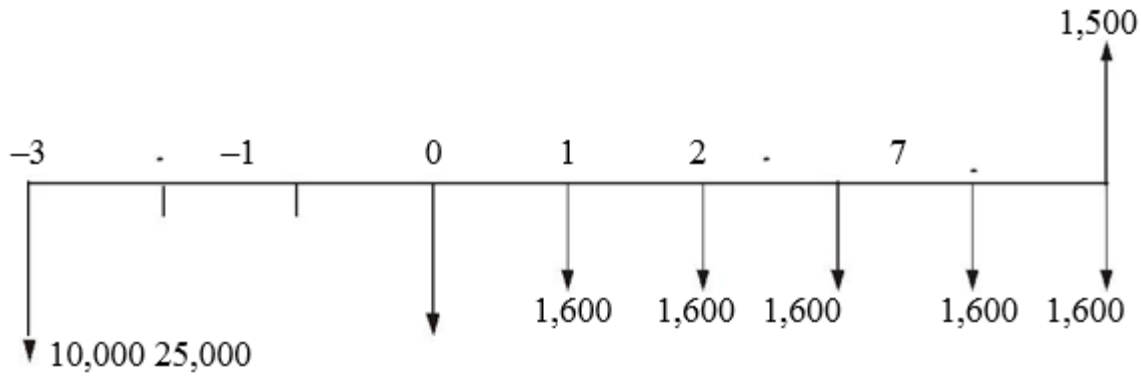



**Fig. 8.11** Cash flow diagram for 10 hp motor.

The annual equivalent cost of the 10 hp motor is calculated as

$$AE(15\%) = (P - F)(A/P, 15\%, 7) + F \times i + A$$
$$= (10{,}000 - 1{,}500)(0.2404) + 1{,}500 \times 0.15 + 1{,}600$$
$$= \text{Rs. } 3{,}868.40$$

**Calculation of annual equivalent cost of 5 hp motor**

**Calculation of annual equivalent cost of 5 hp motor**

Purchase value of the 5 hp motor ($P$) = Rs. 10,000
Life ($n$) = 7 years
Salvage value at the end of motor life ($F$) = Rs. 800
Annual operation and maintenance cost ($A$) = Rs. 1,000
Interest rate, $i$ = 15%

The cash flow diagram of the 5 hp motor is illustrated in Fig. 8.12.

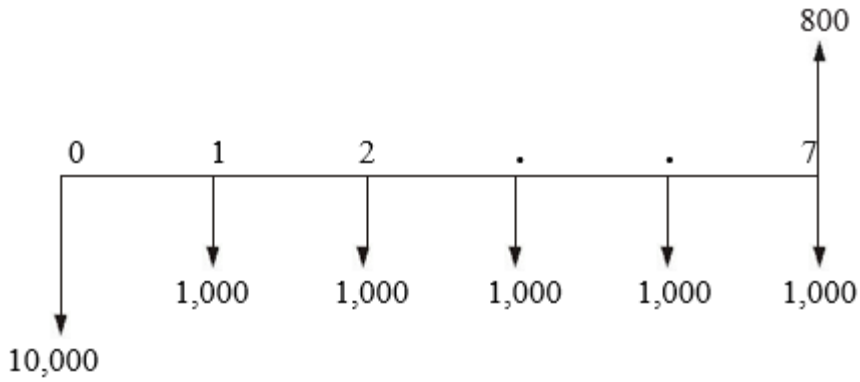



**Fig. 8.12** Cash flow diagram for 5 hp motor.

The annual equivalent cost of the 5 hp motor is computed as

$$AE(15\%) = (P - F)(A/P, 15\%, 7) + F \times i + A$$
$$= (10{,}000 - 800)(0.2404) + 800 \times 0.15 + 1{,}000$$
$$= \text{Rs. } 3{,}331.68$$

Total annual equivalent cost of the alternative 1 = Rs. 3,868.40 + Rs. 3,331.68 = Rs. 7,200.08

***Alternative 2—Replacing the present 10 hp motor with a new 15 hp motor***

Purchase value of the 15 hp motor ($P$) = Rs. 35,000
Life ($n$) = 7 years
Salvage value at the end of motor life ($F$) = Rs. 4,000
Annual operation and maintenance cost ($A$) = Rs. 500
Interest rate, $i$ = 15%

The cash flow diagram of this alternative is shown in Fig. 8.13.

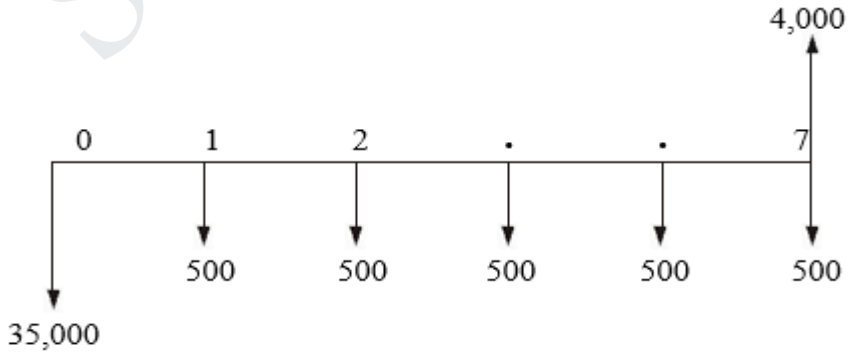



**Fig. 8.13** Cash flow diagram for alternative 2.

The annual equivalent cost of alternative 2 is

$$AE(15\%) = (P - F)\,(A/P,\ 15\%,\ 7) + F \times i + A$$
$$= (35{,}000 - 4{,}000)(0.2404) + 4{,}000 \times 0.15 + 500$$
$$= \text{Rs. } 8{,}552.40$$

The total annual equivalent cost of alternative 1 is less than that of alternative 2. Therefore, it is suggested that the present 10 hp motor be augmented with a new 5 hp motor.

# UNIT-5 DEPRECIATION.

**PART – A** **2-Marks**

***1. Why do we provide depreciation on Fixed Assets? (May 2016).***

**Fixed assets** must be revalued regularly to ensure that the right cost is included in the accounting books. **Depreciation** is very much necessary for **fixed assets** because the **fixed asset** would lose its residual value due to the wear and tear, depletion, passage of time, obsolescence or accidents over a time period.

***2. Define Depreciation? (Nov 2013, Nov 2015, May 2015, Nov 2014, May 2017, Nov2017)***

Depreciation is the process of allocating the acquisition cost of the tangible assets less salvage value if any in a systematic and a rational manner over the estimated life of the asset.

***3. Differentiate Straight line method of depreciation and declining balance method of depreciation. (Nov 2015).***

| BASIS FOR COMPARISON | SLM | WDV |
|---|---|---|
| Meaning | A method of depreciation in which the cost of the asset is spread uniformly over the life years by writing off a fixed amount every year. | A method of depreciation in which a fixed rate of depreciation is charged on the book value of the asset, over its useful life. |
| Calculation of depreciation | On the original cost | On the written down value of the asset. |
| Annual depreciation charge | Remains fixed during the useful life. | Reduces every year |
| Value of asset | Completely written off | Not completely written off |
| Amount of depreciation | Initially lower | Initially higher |
| Impact of repairs and depreciation on P&L A/c | Increasing trend | Remains constant |

***4. Write any two difference in evaluating alternatives of private and public sector organizations. (Nov 2013).***

To provide goods and services to the public at the minimum cost is the main objective of public alternatives. In this situation of public alternative evaluation must consider a point that whether the benefits of the public activity are at least equal to its cost of consumption during the job.

***5. What is Sinking Fund? (May 2013, Nov 2009, Nov 2011)***

In this method, a depreciation fund equal to be actual loss in the value of the asset is estimated for each year. This amount is invested outside the business in a separated account called sinking find investment A/C at a certain rate and the interest will be earned on the fund. Therefore the sinking fund investment will rise year after year.

***6. What is amortization? (May 2013)***

Amortization is a routine decrease in value of an intangible asset, or the process of paying off a debt over time through regular payments. Amortization refers to the expensing of intangible capital assets in order to show their decrease in value as a results of use or passage of time.

***7. Define the following: depreciation and book value. (Nov 2012)***

Depreciation is the process of allocating the acquisition cost of the tangible assets less salvage value, if any, in a systematic and a rational manner over the estimated life of the asset.

***8. Distinguish between declining balance method of depreciation and double declining balance method of depreciation. (Nov 2012).***

Businesses produce revenue through selling their products to customers. Businesses can acquire these products through two methods--either producing them in-house or purchasing them from manufacturers. Choosing between these two methods is called the make-or-buy decision, or the outsourcing decision. Factors that influence the make-or-buy decision include both quantitative factors such as cost and time and qualitative factors such as the suppliers' trustworthiness and the quality of their products. Businesses should first conduct an analysis of quantitative factors before factoring in qualitative factors to complete their make-or-buy decisions.

***9. Define inflation. (April 2008, May 2012, Nov 2008, Nov 2011,Nov201)***

Inflation may be defined as a sustained rise in the general price level. It is an economic condition where there is a rise in prices resulting in the fall in the purchasing power of money.

***10. State the objectives behind the provision of depreciation (Nov 2009, Nov 2011, and May 2012).***

1. To know the correct profits.
2. To show correct financial position.
3. To make provision for replacement of assets.
4. To compute tax liability.
5. To decide for how much to buy or sell the assets in the second-hand market.

***11. What is depreciation fund? (April 2010, May 2008)***

Apart from providing depreciation on asset, it provides the required fund for the replacement of asset, when the asset is to replace by new asset.

***12. List few causes of deprecation. (May 2012t, May 2016)***

1. Wear and tear.
2. Depletion.
3. Obsolescence.
4. Lapse of Time.

***13. Give the expression for the calculation of depreciation under sum of year's digits method of depreciation. (May 2010).***

In this method of deprecation, the scrap value of the asset is deducted from its original cost and it is assumed that the book value of the asset decreases at a decreasing rate. The asset has a life of six year. Then the sum of digits of the year will be computed as

Sum of the years = 1+2+3+4+5+6=21

21=n (n+1)/2, n=6.

***14. What is service output method of depreciation? (May 2008, May 2010, May 2011)***

In this method, the life of a machine is expressed in terms of number of units machine is expected to produce over its estimated life. Therefore in some situation it may not be realistic to compute depreciation based in time period. In such cases the deprecation is computed based on service rendered by an asset. P=first cost of the asset, F=salvage value of the asset.

X= Maximum capacity service of the asset during its lifetime. x= Quality of series rendered in a period

Depreciation/unit of service = (P-F)/X

Depreciation for x unit of service in a period = ((P-F)/X). x.

***15. What are the types of Depreciation? (May 2011, Nov 2014).***

Wear and Tear -Result from friction, vibration, strains and chemical reaction e.g. machinery, furniture. Etc.

Depletion -Decrease in the value of assets such as mines, oil wells, forests stands etc.

Obsolescence -The asset going out of use due to new invention and loss of demand due to change in fashion and technology.

Lapse of the time- The value of assets goes down whether utilized or not. That means, some intangible fixed assets which decrease in value as time lapse.eg.lease.

***16. What are the causes of deprecation? (Nov 2010)***

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Lapse of the time- The value of assets goes down whether utilized or not. That means, some intangible fixed assets which decrease in value as time lapse. e.g. Lease.

***17. What is budget? (Nov 2017)***

A budget is a financial plan for a defined period of time, usually a year. It may also include planned sales volumes and revenues, resource quantities, costs and expenses, assets, liabilities and cash flows. Companies, governments, families and other organizations use it to expresses strategic plans of activities or events in measurable terms.

A budget is the sum of money allocated for a particular purpose and the summary of intended expenditures along with proposals for how to meet them. It may include a budget surplus, providing money for use at a future time, or a deficit in which expenses exceed income.

**PART – B** **16-Marks.**

***1. Himalaya Drug Company has just purchased a copulating machine for Rs. 10,00,000. The plant engineer estimate that the machine has a useful life of 5 Years and a salvage Value of Rs. 10,000 at the end of its useful life. Compute the depreciation schedule for the machine by each of the following deprecation Method:***
***(i) Straight line method of depreciation.***
***(ii) Sum-of the year's digits method of depreciation. (May 2016).***

Given: P= R.s 1000000
F=R.s10000
n=5 Years.
Dt=Depreciation charges for the period t.
Bt= Book value asset at the end of the period t.
Sol.
$D_t$ =(P-F)/n =(1000000-10000)/5
=198000
Rate of Depreciation= ($D_t$/ $P_t$ ) x 100= (198000/1000000) x 100= 19.8%

| End of Years (f) | Depreciation ($D_t$) | Book value $B_t = B_{t-1} - D_t$ |
|---|---|---|
| 0 | - | 1000000 |
| 1 | 198000 | 802000 |
| 2 | 198000 | 604000 |
| 3 | 198000 | 406000 |
| 4 | 198000 | 208000 |
| 5 | 198000 | 10000 |

***2. Two mutually exclusive projects are being considered for investment. Project A1 requires an initial outlay of Rs. 30,00,000 with net receipts estimated as Rs. 9,00,000 per year for the next 5 years. The initial outlay for the project A2 is Rs. 60,00,000, and net receipts have been estimated at Rs. 15,00,000 per year for the next seven years. There is no salvage value associated with either of the projects. Using the benefit cost ratio, which project would you select? Assume an interest rate of 10%. (May 2016).***

***Solution Alternative A1***

Initial cost ($P$) = Rs. 30,00,000

Net benefits/year ($B$) = Rs. 9,00,000

Life ($n$) = 5 years

Annual equivalent of initial cost = $P$ ´ ($A/P$, 10%, 5)

= 30,00,000 ´ 0.2638

= Rs. 7,91,400

$$\text{Benefit-cost ratio} = \frac{\text{Annual equivalent benefit}}{\text{Annual equivalent cost}}$$

= 9,00,000/7,91,400

= 1.137

***Alternative A2***

Initial cost ($P$) = Rs. 60,00,000

Net benefits/year ($B$) = Rs. 15,00,000

Life ($n$) = 7 years

Annual equivalent of initial cost = $P$ ´ ($A/P$, 10%, 7)

= 60,00,000 ´ 0.2054

= Rs. 12,32,400

$$\text{BC ratio} = \frac{\text{Annual equivalent benefit}}{\text{Annual equivalent cost}}$$

= 15,00,000/12,32,400 = 1.217

The benefit-cost ratio of alternative $A2$ is more than that of alternative $A1$. Hence, alternative $A2$ is to be selected. The comparison is made on a 35-year period which is the minimum common multiple of the lives of alternatives 1 and 2.

***3.Robert & Co. Purchased a machinery on 1st April 2002 for Rs. 70,000 After having used it for three years it was sold for Rs.35000. Depreciation is to provide every year at the of 10% per annum on declining balance method. Accounts are closed on 30st March every year. Find out the profit or loss on loss of machinery (Nov 2015).***

Given: P= R.s 70000
F=R.s 35000
n=3 Years.
i=10%

To find
A= (P-F) x (A/F, I, n)
Dt=(P-F) x (A/F, I, n) x (F/P, i, t-1)

Sol.
A= (P-F) x (A/F, 10%,3)
= (75000-35000) x 0.320
=11200 R.s = D1

=11200 +11200 x 0.10= D2=12320 R.s

D3==11200 + (11200+12320) x 0.10 =13552 R.s

| End of year t | Fixed ($D_t$) Rs. | Net ($D_t$) Rs. | Book Value $B_t$ Rs. |
|---|---|---|---|
| 0 | 11200 | - | 70000 |
| 1 | 11200 | 11200 | 58800 |
| 2 | 11200 | 12320 | 46480 |
| 3 | 11200 | 13552 | 32928 |

***4. Explain the procedure to adjust inflation and discuss the determination of economics life of asset. (May 2015).***

Inflation is the rate of increase in the prices of goods per period. So, it has a compounding effect. Thus, prices that are inflated at a rate of 7% per year will increase 7% in the first year, and for the next year the expected increase will be 7% of these new prices. The same is true for succeeding years and hence the rate of inflation is compounded in the same manner that an interest rate is compounded. If the average inflation over six years period is 7%, then the prices at the beginning of the seventh year would be 150% that of the first year by assuming 100% for the prices at the beginning of the first year of the six-year period.

If economic decisions are taken without considering the effect of inflation into account, most of them would become meaningless and as a result the organizations would end up with unpredictable return.

But there is always difficulty in determining the rate of inflation. The world-wide trend/wish is to curtail inflation. But due to various reasons, it is very difficult to have zero inflation. For practical decision making, an average estimate may be assumed depending on the period of the proposals under consideration. Hence, we need a procedure which will combine the effects of inflation rate and interest rate to take realistic economic decision.

**PROCEDURE TO ADJUST INFLATION**

A procedure to deal with this situation is summarized now.

1. Estimate all the costs/returns associated with an investment proposal in terms of today's rupees.
2. Modify the costs/returns estimated in step 1 using an assumed inflation rate so that at each future date they represent the costs/returns at that date in terms of the rupees that must be expended/received at that time, respectively.
3. As per our requirement, calculate either the annual equivalent amount or future amount or present amount of the cash flow resulting from step 2 by considering the time value of money.

In any industrial/service organization, equipment/machinery forms an important element. The productivity of any organization is a function of many factors. It is largely affected by efficient and effective use of machinery and equipment. So, operations and maintenance of these equipment are very important to the organization.

A machine which is purchased today cannot be used forever. It has a definite economic lifetime. After the economic life, the machine should be replaced with a substitute machine with similar operational capabilities. This kind of analysis is called *replacement analysis*

The elements of costs involved in the replacement analysis are as follows:
1. Purchase cost (initial cost)
2. Annual operation and maintenance cost
3. Salvage value at the end of every year, if it is significant

The trade-off between different cost elements is shown in Fig. 11.3.

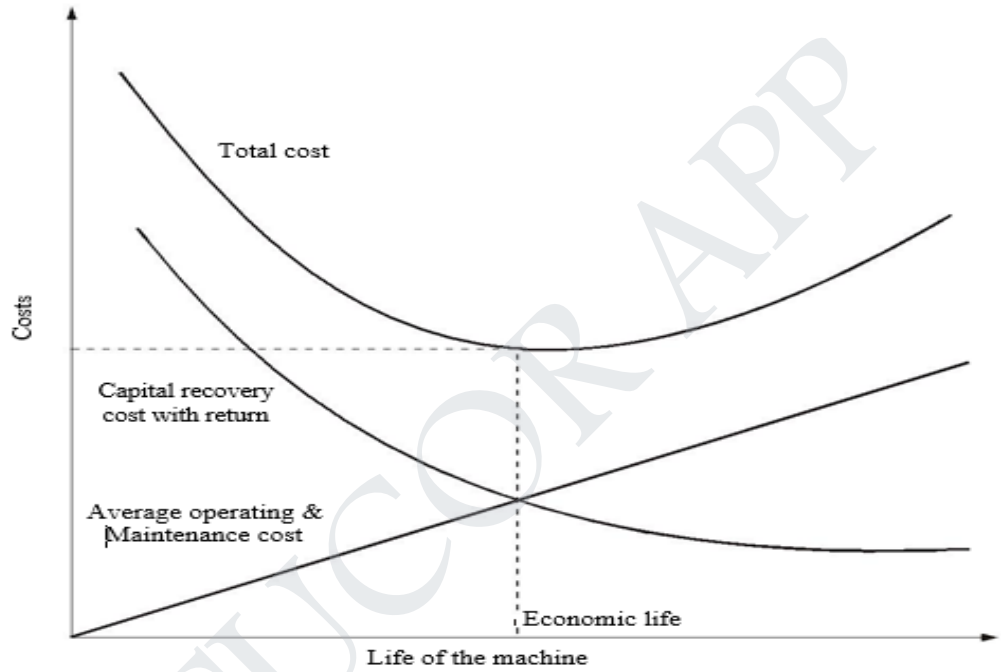


**Fig. 11.3 Chart** showing economic life.

From Fig. 11.3, it is clear that the sum of operation and maintenance cost increases with the life of the machine. But the capital recovery with return decreases with the life of the machine. The total cost of the machine goes on decreasing initially but it starts increasing after some years. The year with the minimum total cost is called as the economic life of the machine.

**5. *A machine is purchase for Rs. 45,000 and has a life of 20 years. Its salvage value is estimated to be Rs. 3,000. Using the sum of year's digital method, calculate Annual Depreciation charges for first, sixth and eleventh, sixteenth and twentieth years. (Nov 2014).***

P= R.s 45000
F=R.s 3000
n=20 Years.
Dt=Depreciation charges for the period t.
Bt= Book value asset at the end of the period t.
Sol.
$D_t$ =(P-F)/n =(45000-3000)/20
=2100
Rate of Depreciation= ($D_t$/ $P_t$ ) x 100= (2100/45000) x 100= 4.6%

| End of Years (f) | Depreciation ($D_t$) | Book value $B_t = B_{t-1} - D_t$ |
|---|---|---|
| 0 | - | 45000 |
| 1 | 2100 | 42900 |
| 2 | 2100 | 40800 |
| 3 | 2100 | 38700 |
| 4 | 2100 | 36600 |
| 5 | 2100 | 34500 |
| 6 | 2100 | 32400 |
| 7 | 2100 | 30300 |
| 8 | 2100 | 28200 |
| 9 | 2100 | 26100 |
| 10 | 2100 | 24000 |
| 11 | 2100 | 21900 |
| 12 | 2100 | 19800 |
| 13 | 2100 | 17700 |
| 14 | 2100 | 15600 |
| 15 | 2100 | 13500 |
| 16 | 2100 | 11450 |
| 17 | 2100 | 9350 |
| 18 | 2100 | 7350 |
| 19 | 2100 | 5150 |
| 20 | 2100 | 3050 |

***6. Calculate the Depreciation, accumulate Depreciation and book valve for the following Data using declined balance Method.***
***Initial Investment =Rs. 24,000***
***Salvage Value =Rs.3,000***
***Time=5 Years. (Nov 2014)***
***Answer Refer Question:5***

***7. (a) Distinguish between declining balance method of depreciation and double declining balance method of depreciation.(b)A company has purchased an equipment whose first cost is Rs. 1,00,000 with an estimated life of eight years. The estimated salvage value of the equipment at the end of its lifetime is Rs. 20,000. Determine the depreciation charge and book value at the end of various years using the straight line method of depreciation. (Nov2013).***

***Solution***

$$
\begin{aligned}
P &= \text{Rs. } 1{,}00{,}000 \\
F &= \text{Rs. } 20{,}000 \\
n &= 8 \text{ years} \\
D_t &= (P - F)/n \\
&= (1{,}00{,}000 - 20{,}000)/8 \\
&= \text{Rs. } 10{,}000
\end{aligned}
$$

In this method of depreciation, the value of $D_t$ is the same for all the years. The calculations pertaining to $B_t$ for different values of $t$ are summarized in Table 9.1.

**Table 9.1** $D_t$ and $B_t$ Values under Straight line Method of Depreciation

| *End of year* ($t$) | *Depreciation* ($D_t$) | *Book value* ($B_t = B_{t-1} - D_t$) |
|---|---|---|
| 0 | | 1,00,000 |
| 1 | 10,000 | 90,000 |
| 2 | 10,000 | 80,000 |
| 3 | 10,000 | 70,000 |
| 4 | 10,000 | 60,000 |
| 5 | 10,000 | 50,000 |
| 6 | 10,000 | 40,000 |
| 7 | 10,000 | 30,000 |
| 8 | 10,000 | 20,000 |

If we are interested in computing $D_t$ and $B_t$ for a specific period ($t$), the formulae can be used. In this approach, it should be noted that the depreciation is the same for all the periods.

***8. A state government is planning a hydroelectric project for river basin. In addition to the production of electric power, this project will provide flood control, irrigation and recreation benefits. The estimated benefits and the cost that are expected to be deprived from this project are as follows:***
***Initial cost = Rs. 8,00,00,000***
***Annual power sales = Rs. 60,00,000***
***Annual flood control savings = Rs. 30,00,000***
***Annual irrigation benefits = Rs. 50,00,000***
***Annual recreation benefits = Rs. 20,00,000***
***Annual operating and maintaining cost = Rs. 30, 00,000***
***Life of the project = 50 years***
***Check whether the state government should implement the project (assume i = 12%). (Nov2013).***

***Solution***

Initial cost = Rs. 8,00,00,000
Annual power sales = Rs. 60,00,000
Annual flood control savings = Rs. 30,00,000
Annual irrigation benefits = Rs. 50,00,000
Annual recreation benefits = Rs. 20,00,000
Annual operating and maintenance costs = Rs. 30,00,000
Life of the project = 50 years, $i$ = 12%

Total annual benefits = Flood control savings + Irrigation benefits + Recreation benefits
= Rs. 30,00,000 + Rs. 50,00,000 + Rs. 20,00,000
= Rs. 1,00,00,000

Present worth of the benefits = Total annual benefits **x** ($P/A$, 12%, 50)
= 1,00,00,000 **x** (8.3045)
= Rs. 8,30,45,000

Present worth of costs = Initial cost + Present worth of annual operating and maintenance cost – Present worth of power sales
= Rs. 8,00,00,000 + 30,00,000 **x** ($P/A$, 12%, 50) – 60,00,000 ($P/A$, 12%, 50)
= Rs. 8,00,00,000 + 30,00,000 **x** 8.3045 – 60,00,000 **x** 8.3045
= Rs. 5,50,86,500

$$\text{BC ratio} = \frac{\text{Present worth of benefits}}{\text{Present worth of costs}}$$

$$= \frac{8,30,45,000}{5,50,86,500} = 1.508$$

Since, the BC ratio is more than 1, the state government can implement the hydroelectric project.

***9. (i) What is functional depreciation?***
***(ii) A Company purchased Machinery for Rs.1, 00,000.Its installation costs amounted to***

 

***Rs.10, 000.Its estimated life is 5 years and the scrap value is Rs.5,000. Calculate the amount and rate of depreciation. (May 2013).***

(i) **FUNCTIONAL DEPRECIATION:**

Functional deprecation occurs as a result of changes in the organization or in technology that decreases or eliminate the need for an asset. Example of functional deprecation include obsolescence attributable to advances in technology, a declining need for the services performed by an asset, or the inability to meet increased quantity demands.

(ii)

***Given:*** P = Rs. 1,00,000 + Rs. 10,000

= Rs. 1,10,000

F = Rs. 5000

$n$ = 5 years

***To find:*** 1. Depreciation for the period $t$, $D_t$

2. Rate of depreciation

☺ ***Solution:***

Formula to find $D_t = \frac{(P-F)}{n}$

$$D_5 = \frac{(1,10,000 - 5,000)}{5}$$

= Rs. 21,000

***Rate of depreciation:***

Formula to find rate of depreciation

$$= \frac{D_t}{P} \times 100$$

$$= \frac{21,000}{1,10,000} \times 100$$

= 19.09%

***10. (i) What do you mean by depreciation? Explain any 4 methods with example.***

***(ii) Write on: Inflation Accelerated Depreciation. (May 2013, May 2014,May2017).***

### 5.1.1. Definitions

Carter defines "Depreciation is the gradual and permanent decrease in the value of an asset from any cause".

Depreciation may also be defined as a method for spreading the cost of a fixed asset over the life or expected years of uses of the assets.

From the accounting point of view, depreciation is an annual charge reflecting the decline in value of an asset due to such causes as wear and tear action of elements obsolescence and inadequacy.

### 5.1.4. Methods of Depreciation

There are several methods of accounting depreciation fund

1. Straight line method or fixed instalment method.
2. Declining balance method or written-down method
3. Sum of the years-digits method.
4. Sinking-fund method of Depreciation
5. Service output method or production unit method.

## 9.2.1 Straight Line Method of Depreciation

In this method of depreciation, a fixed sum is charged as the depreciation amount throughout the lifetime of an asset such that the accumulated sum at the end of the life of the asset is exactly equal to the purchase value of the asset. Here, we make an important assumption that inflation is absent.

Let

$P$ = first cost of the asset,

$F$ = salvage value of the asset,

$n$ = life of the asset,
$B_t$ = book value of the asset at the end of the period $t$,
$D_t$ = depreciation amount for the period $t$.

The formulae for depreciation and book value are as follows:

$$D_t = (P - F)/n$$
$$B_t = B_{t-1} - D_t = P - t \times [(P - F)/n]$$

### 9.2.2 Declining Balance Method of Depreciation

In this method of depreciation, a constant percentage of the book value of the previous period of the asset will be charged as the depreciation amount for the current period. This approach is a more realistic approach, since the depreciation charge decreases with the life of the asset which matches with the earning potential of the asset. The book value at the end of the life of the asset may not be exactly equal to the salvage value of the asset. This is a major limitation of this approach.

Let

$P$ = first cost of the asset,

$F$ = salvage value of the asset,

$n$ = life of the asset,

$B_t$ = book value of the asset at the end of the period $t$,

$K$ = a fixed percentage, and

$D_t$ = depreciation amount at the end of the period $t$.

The formulae for depreciation and book value are as follows:

$$D_t = K \times B_{t-1}$$
$$B_t = B_{t-1} - D_t = B_{t-1} - K \times B_{t-1}$$
$$= (1 - K) \times B_{t-1}$$

The formulae for depreciation and book value in terms of $P$ are as follows:

$$D_t = K(1 - K)^{t-1} \times P$$

$$B_t = (1 - K)^t \times P$$

While availing income-tax exception for the depreciation amount paid in each year, the rate $K$ is limited to at the most $2/n$. If this rate is used, then the corresponding approach is called the *double declining balance method of depreciation.*

### 9.2.3 Sum-of-the-Years-Digits Method of Depreciation

In this method of depreciation also, it is assumed that the book value of the asset decreases at a decreasing rate. If the asset has a life of eight years, first the sum of the years is computed as

$$\text{Sum of the years} = 1 + 2 + 3 + 4 + 5 + 6 + 7 + 8$$
$$= 36 = n(n + 1)/2$$

The rate of depreciation charge for the first year is assumed as the highest and then it decreases. The rates of depreciation for the years 1–8, respectively are as follows: 8/36, 7/36, 6/36, 5/36, 4/36, 3/36, 2/36, and 1/36.

For any year, the depreciation is calculated by multiplying the corresponding rate of depreciation with $(P - F)$.

$$D_t = \text{Rate} \times (P - F)$$

$$B_t = B_{t-1} - D_t$$

The formulae for $D_t$ and $B_t$ for a specific year $t$ are as follows:

$$D_t = \frac{n - t + 1}{n(n + 1)/2} (P - F)$$

$$B_t = (P - F) \frac{(n - t)}{n} \frac{(n - t + 1)}{(n + 1)} + F$$

### 9.2.4 Sinking Fund Method of Depreciation

In this method of depreciation, the book value decreases at increasing rates with respect to the life of the asset. Let

$P$ = first cost of the asset,

$F$ = salvage value of the asset,

$n$ = life of the asset,

$i$ = rate of return compounded annually,

$A$ = the annual equivalent amount,

$B_t$ = the book value of the asset at the end of the period $t$, and

$D_t$ = the depreciation amount at the end of the period $t$.

The loss in value of the asset $(P - F)$ is made available an the form of cumulative depreciation amount at the end of the life of the asset by setting up an equal depreciation amount $(A)$ at the end of each period during the lifetime of the asset.

$$A = (P - F) \times [A/F, i, n]$$

The fixed sum depreciated at the end of every time period earns an interest at the rate of $i$% compounded annually, and hence the actual depreciation amount will be in the increasing manner with respect to the time period. A generalized formula for $D_t$ is

$$D_t = (P - F) \times (A/F, i, n) \times (F/P, i, t - 1)$$

The formula to calculate the book value at the end of period $t$ is

$$B_t = P - (P - F)\ (A/F, i, n)\ (F/A, i, t)$$

The above two formulae are very useful if we have to calculate $D_t$ and $B_t$ for any specific period. If we calculate $D_t$ and $B_t$ for all the periods, then the tabular approach would be better.

***11. A company has purchased an equipment whose first cost is Rs. 1,00,000 with an estimated life of eight years. The estimated salvage value of the equipment at the end of its lifetime is Rs. 20,000. Determine the depreciation charge and book value at the end of various years using the straight-line method of depreciation. (Nov2012).***

### 9.2.5 Service Output Method of Depreciation

In some situations, it may not be realistic to compute depreciation based on time period. In such cases, the depreciation is computed based on service rendered by an asset. Let

$P$ = first cost of the asset

$F$ = salvage value of the asset

$X$ = maximum capacity of service of the asset during its lifetime

$x$ = quantity of service rendered in a period.

Then, the depreciation is defined per unit of service rendered:

Depreciation/unit of service = $(P - F)/X$

Depreciation for $x$ units of service in a period = $\frac{P - F}{X}(x)$

***Solution***

$$\begin{aligned} P &= \text{Rs. } 1{,}00{,}000 \\ F &= \text{Rs. } 20{,}000 \\ n &= 8 \text{ years} \\ D_t &= (P - F)/n \\ &= (1{,}00{,}000 - 20{,}000)/8 \\ &= \text{Rs. } 10{,}000 \end{aligned}$$

In this method of depreciation, the value of $D_t$ is the same for all the years. The calculations pertaining to $B_t$ for different values of $t$ are summarized in Table 9.1.

 

**Table 9.1** $D_t$ and $B_t$ Values under Straight line Method of Depreciation

| *End of year* ($t$) | *Depreciation* ($D_t$) | *Book value* ($B_t = B_{t-1} - D_t$) |
|---|---|---|
| 0 | | 1,00,000 |
| 1 | 10,000 | 90,000 |
| 2 | 10,000 | 80,000 |
| 3 | 10,000 | 70,000 |
| 4 | 10,000 | 60,000 |
| 5 | 10,000 | 50,000 |
| 6 | 10,000 | 40,000 |
| 7 | 10,000 | 30,000 |
| 8 | 10,000 | 20,000 |

If we are interested in computing $D_t$ and $B_t$ for a specific period ($t$), the formulae can be used. In this approach, it should be noted that the depreciation is the same for all the periods.

***12. A company has purchased a bus for its officers for Rs. 10,00,000. The expected life of the bus is eight years. The salvage value of the bus at the end of its life is Rs. 1, 50,000. Find the following using the sinking fund method of depreciation:***

***(1) Depreciation at the end of the third and fifth year.***

***(2) Book value at the end of the second year and sixth year. (Nov2012 ).***

GIVEN

(i) $P = 10,00,000$ RS

$F = 1,50,000$ RS.

$n = 8$ years.

TO FIND

$D_i$ = Depreciation charges for the Period t.

$B_i$ = Book value of the assets at the end of the Period t.

Sol

$$D_t = \frac{[P-F]}{n}$$

$$= \frac{[10,00,000 - 150,000]}{8}$$

$$D_i = 10,6250$$



 

$$\text{Rate of Depreciation} = \frac{D_j}{P_j} \times 100$$

$$= \left[\frac{10,6250}{10,00,000}\right] \times 100$$

$$= 10.625\ \%$$

| END OF YEAR(t) | DEPRECIATION ($D_t$) | BOOK VALUE $B_i = B_{t-1} - D_t$ |
|---|---|---|
| 0 | – | 10,00,000 |
| 1 | 10,6250 | 893750 |
| 2. | | |
| 3 | 106250 | 787500 |
| 4 | 106250 | 681250 |
| 5 | 106250 | 575000 |
| 6 | 106250 | 468750 |
| 7 | 106250 | 362500 |
| 8 | 106250 | 256250 |

 

***13. The Beta Drug Company has just purchased a capsulation machine for Rs. 20, 00,000. The plant engineer estimates that the machine has a useful life of five years and a salvage value of Rs. 25,000 at the end of its useful life. Compute the depreciation schedule for the machine by each of the following depreciation methods.***

***(i) Straight line method of depreciation***
***(ii) Sum-of-the-years digits method of depreciation***
***(iii) Double declining balance method of depreciation (May2010)***

***Given Data:***

$$P = \text{Rs.}20,00,000$$
$$F = \text{Rs.}25,000$$
$$n = 5 \text{ years}$$

☺ ***Solution:*** (*i*) Straight line method of depreciation

$$D_t = \frac{P - F}{n}$$
$$= \frac{20,00,000 - 25,000}{5}$$
$$= \frac{19,75,000}{5}$$
$$= \text{Rs.}3,95,000$$

$$\text{Rate of depreciation} = \frac{D_t}{P} \times 100$$
$$= \frac{3,95,000}{20,00,000} \times 100$$
$$= 20\%$$

(*ii*) Sum of the years digits method of depreciation:

***Formula:***

$$\text{Sum} = n\,(n + 1)/2$$
$$= 5\,(5 + 1)/2$$
$$= 30/2$$
$$= 15$$

Therefore the rate for 1 – 5 years respectively 5/15, 4/15, 3/15, 2/15 and 1/15.

*(iii) Double Declining balance method of depreciation:*

Formula = $D_t = k \times B_{t-1}$

where $k = 0.2 \times 200\%$ (or) $40\%$, $B = 20,00,000$

***Depreciation schedule for a machine with initial book value of Rs. 20,00,000:***

| End of years | Straight line method ($D_t$) | Sum of the years digits method ($D_t$) | Declining method ($D_t$) |
|---|---|---|---|
| 0 | – | – | – |
| 1 | 3,95,000 | 6,58,333 | 8,00,000 |
| 2 | 3,95,000 | 5,26,667 | 4,80,000 |
| 3 | 3,95,000 | 3,95,000 | 2,88,000 |
| 4 | 3,95,000 | 2,63,333 | 1,72,800 |
| 5 | 3,95,000 | 1,31,667 | 1,03,680 |

 

***14. A company has purchased a bus for its officers for Rs. 10,00,000 the expected life of the bus is eight years. The salvage value of the bus at the end of its life is Rs. 1,50,000. Find the following using the sinking fund method of depreciation:***

***(i) Depreciation at the end of the third year and fifth year.***

***(ii) Book value at the end of the second year and sixth year. (May2010)***

***Given Data:*** $P = 10,00,000$

$F = 1,50,000$

$n = 8$ years

☺ ***Solution:*** $D_t = \frac{P - F}{n}$

$= \frac{10,00,000 - 1,50,000}{8}$

$=$ Rs.1,06,250

$\text{Rate} = \frac{D_t}{P} \times 100$

$= \frac{1,06,250}{10,00,000} \times 100$

$= 10\%$ (or) $0.10$

Calculation of depriciation

$D_t = P - F \times [(A/F, i, n) \times (F/P, i, t-1)]$

$= 10,00,000 - 1,50,000 \times 0.0874$

$= 74290$

The Depriciation and book values of the bus are as below table.

Calculation of deprciation and book value of Bus

| End of year | Fixed $D_t$ | Net $D_t$ | Book value |
|---|---|---|---|
| 0 | 74,290 | – | 10,00,000 |
| 1 | 74,290 | 74,290 | 9,25,710 |
| 2 | 74,290 | 81,719 | 8,43,991 |
| 3 | 74,290 | 89,891 | 7,54,100 |
| 4 | 74,290 | 90,708 | 6,63,392 |
| 5 | 74,290 | 90,790 | 5,72,602 |
| 6 | 74,290 | 90,798 | 4,81,804 |
| 7 | 74,290 | 90,799 | 3,91,005 |
| 8 | 74,290 | 90,799 | 3,00,206 |

***Result:*** Depreciation at the end of third year is Rs.89,891, at end of fifth year is Rs.90,790.

Book value of the bus at the end of the second year is Rs.8,43,991 and at the end of sixth year is Rs.4,81,804.

 

***15. (a) Analyze the causes and objectives behind the provision of depreciation.***

***(b) Original cost of the machine Rs. 10,000***
***Life time 5 years***
***Scrap or residual value Rs. 1,000***
***Find out the rate of depreciation for the machine using straight line method. (Dec2009).***

### 5.1.2. Causes of Depreciation

1. Wear and Tear – Result from friction, vibration, strains and chemical reaction.
   *e.g.*, Machinery, Furniture etc.
2. Depletion – Decrease in the value of assets such as mines, oil wells, forests stands etc.
3. Obsolescence – The asset going out of use due to new invention and loss of demand due to change in fashion and technology.
   *e.g.*, Costumes, Computer.
4. Lapse of time – The value of assets goes down whether utilized or not. That means, some intangible fixed assets which decrease in value as time lapse.
   *e.g.*, Lease

### 5.1.3. Reasons for Providing Depreciation

1. To know the correct profits
2. To show correct financial position
3. To make provision for replacement of assets
4. To compute tax liability
5. To decide how much to buy or sell the assets in the second hand market.
6. To decide what part of the gross profit to distribute to the owners of the business.
7. To decide how much to charge the consumers of the product.

***Given Data:***

$$P = \text{Rs. } 10{,}000$$
$$F = \text{Rs. } 1{,}000$$
$$n = 5 \text{ years}$$

☺ ***Solution:***

$$\left.\begin{array}{r}\text{Amount of}\\ \text{depriciation}\end{array}\right\} = \frac{\text{Cost of Assets} - \text{Scrap value}}{\text{Estimated life of assets}}$$

(or)

$$D_t = \frac{P - F}{n}$$

$$D_t = \frac{10{,}000 - 1{,}000}{5}$$

$$D_t = \text{Rs.}1{,}800$$

$$\text{Rate of depreciation} = \frac{D_t}{P} \times 100$$

$$= \frac{1{,}800}{10{,}000} \times 100$$

$$= 18\%$$

***16. (i) Write about the procedure to adjust inflation.***

***(i) Give out examples on comparison of alternative and determination of economic life of assets. (Dec2009).***

**2. Procedure to Adjust Inflation**

procedure to deal with this situation is summarized

Estimate all the costs/returns associated with an investment proposal in terms of today's rupees.

Modify the costs/returns estimated in step 1 using an assumed inflation rate so that at each future rate they represent the costs/returns at that date in terms of the rupees that must be expended/received at that time respectively.

As per our requirement, calculate either the annual equivalent amount or future amount or present amount of the cash flow resulting from step 2 by considering the time value of money.

## 5.11. INFLATION ADJUSTED ECONOMIC LIFE OF MACHINE

In industries and service section organization, machinery takes an important place. Machinery takes vital role in productivity of the industry. The productivity of any organization is a function of many factors. As already mentioned, it is largely affected by efficient and effective use of machinery and equipment. So, handling such machinery is one of the important activity of the organization.

A machine which is purchased today cannot be used forever. It has limited economic lifetime. After finishing the economic life of the machine, a substitute machine with similar operational capabilities should be replaced. This kind of analysis is called replacement analysis.

The elements of costs involved in the replacement analysis are as follows:

1. Purchase cost (initial cost)
2. Annual operation and maintenance cost
3. Salvage value at the end of every year if it is significant.

The trade-off between different cost elements is shown in Fig.5.5.

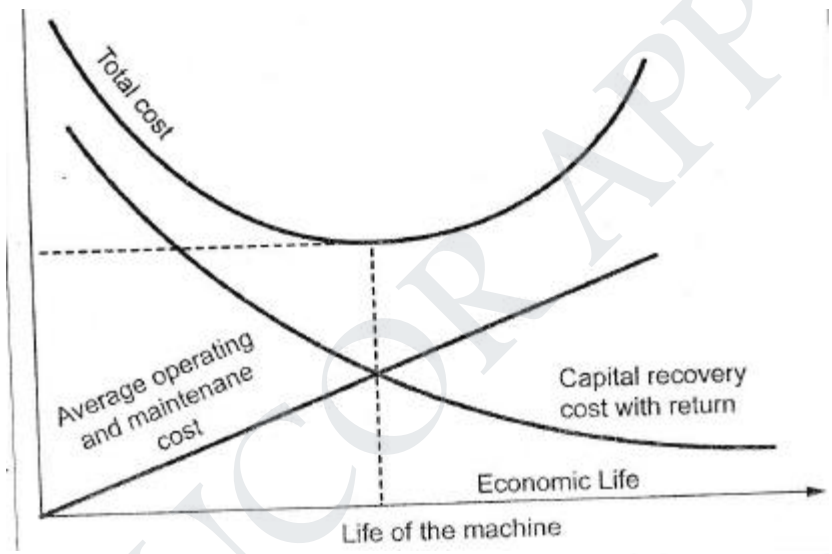


*Fig. 5.5. Life of the machine*

From the above chart, it is clear that the sum of operation and maintenance cost increase with the life of the machine. But the capital recovery with return decreases with the life of the machine. The total cost of the machine goes on decreasing initially but it starts increasing after some years. The year with the minimum total cost is called as the economic life of the machine.

### 4.5.1. Determination of Economic Life of an Asset

The cost of owning and operating an asset can be divided into three categories. They are (*a*) Capital costs (*b*) Operating costs and (*c*) Total cost.

(ii)

***(a) Capital costs***

Capital costs have two components: initial investment and the salvage value at the time of disposal. Annual equivalent of capital costs, which is called ***capital recovery cost*** computed from the first cost (Initial investment/purchase price) of the machine.

Generally speaking, as an asset becomes older, its salvage value becomes smaller. As long as the salvage value is less than the initial cost, the capital recovery cost is a decreasing function of the life of the asset. In other words, the longer we keep an asset, the lower the capital recovery cost becomes.

***(b) Operating costs***

The operating costs of an asset include operating and maintenance (O & M) costs, labour costs, material costs, and energy consumption costs. O & M costs tend to increase as a function of the age of the asset. Because of increasing trend of the O & M costs, the total operating costs of an asset usually increases as the asset ages.

As long as the annual operating costs increase with the age of the equipment, the annual equivalent operating cost is an increasing function of the life of the asset.

### *(c) Total cost*

Total cost/total annual equivalent costs of owning and operating an asset is a summation of the capital recovery cost (average first cost/annual equivalent capital cost) and the annual equivalent operating costs of the asset.

A typical shape of each of the above costs with respect to life of the machine is shown in Fig.4.1.

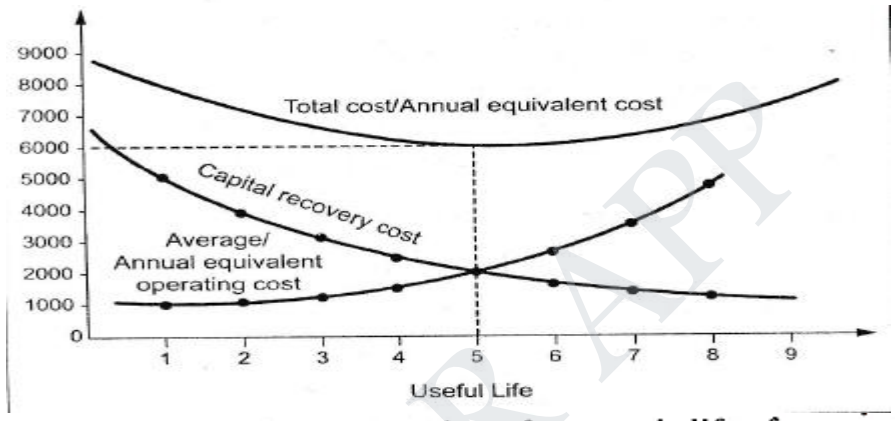


***Fig. 4.1. Graphical representation of economic life of an asset***

From Fig.4.1 it is clear that the capital recovery cost goes on decreasing with the useful life of the machine and the annual equivalent operating cost goes on increasing with the useful life of the machine. From the beginning, the total cost continues to decrease up to a particular life and then it starts increasing, the point where the total cost is minimum is called the economic life of the machine.

The economic service life of an asset is defined to be the period of useful life that minimizes the annual equivalent cost of owning and operating the asset.

The replacement alternatives can be evaluated based on the present worth criterion and annual equivalent criterion. The basics of these criteria are already presented in Chapter 2.

 

***17. (i) How to adjust inflation in evaluating public alternatives? Explain the procedure.***

***(ii) Find the depreciation annuity by annuity method after three years, when the initial cost of the machine is Rs. 8, 00,000 and salvage value at the end of three years is Rs. 4, 00,000. Rage of interest 10%. (May2008).***

(ii)

### 5.10.2. Procedure to Adjust Inflation

A procedure to deal with this situation is summarized below.

1. Estimate all the costs/returns associated with an investment proposal in terms of today's rupees.
2. Modify the costs/returns estimated in step 1 using an assumed inflation rate so that at each future rate they represent the costs/returns at that date in terms of the rupees that must be expended/received at that time respectively.
3. As per our requirement, calculate either the annual equivalent amount or future amount or present amount of the cash flow resulting from step 2 by considering the time value of money.

### 5.10.3. Types of Inflation

Inflation has been a world wide phenomenon since the second world war. It is only a general term and there are different types in it. We shall make a brief study of the different types of inflation.

(*a*) Creeping inflation
(*b*) Moderate inflation
(*c*) Galloping inflation
(*d*) Hyper-inflation

***(a) Creeping Inflation***

As the name itself suggests, creeping inflation is slow moving and very wild. The rise in prices will not be preceptible but spread over a long period.

### *(b) Moderate Inflation*

Moderate inflation takes place when 'creeping' gets momentum. In this case, the rise in prices becomes more marked.

### *(c) Galloping inflation*

Rise in price will be very sharp and vigorous.

### *(d) Hyper Inflation*

Hyper inflation is dangerous and also disastrous to the economy as it cannot controlled easily. Hence it is called "Run away inflation". Hyper inflation is the highest degree of abnormality in the monetary system and under such conditions all assets having fixed income lose their real value. The four types of inflation are indicated in the following diagram.

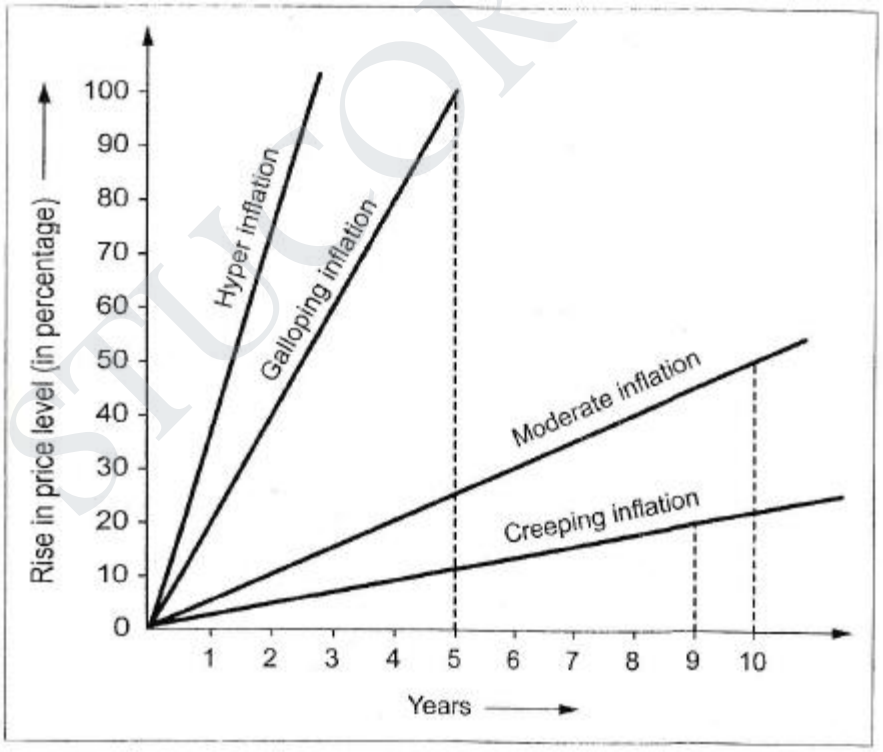


*Fig. 5.2. Different types of inflation*

The 5.2 indicates that in the case of creeping inflation it takes more than nine years to register a 10% increase in price level. In case of moderate inflation, a 50% rise in price is registered in a decade. But in the case of a galloping type, the price level increases 100% in less than five years and afterwards it shows a tendency to shoot up still more vertically. The hyper type records more than a cent percent increase in price level in less than a year and the nature of curve indicates an abnormal increase in prices in less than two or three years.

***18. (i) What is economic life of an asset? How do determine it? Explain.***
***(ii) The cost of a machine is Rs. 1, 60, 00 and its scrap value is Rs. 40,000. Estimated life 5 years. Using sum of year's digits method, determine depreciation charges for each year. (May2008)***

(i)

## 11.3 INFLATION ADJUSTED ECONOMIC LIFE OF MACHINE
(Panneerselvam, 1998)

In any industrial/service organization, equipment/machinery forms an important element. The productivity of any organization is a function of many factors. It is largely affected by efficient and effective use of machinery and equipment. So, operations and maintenance of these equipment are very important to the organization.

A machine which is purchased today cannot be used forever. It has a definite economic lifetime. After the economic life, the machine should be replaced with a substitute machine with similar operational capabilities. This kind of analysis is called *replacement analysis*.

The elements of costs involved in the replacement analysis are as follows:

1. Purchase cost (initial cost)
2. Annual operation and maintenance cost
3. Salvage value at the end of every year, if it is significant

The trade-off between different cost elements is shown in Fig. 11.3.

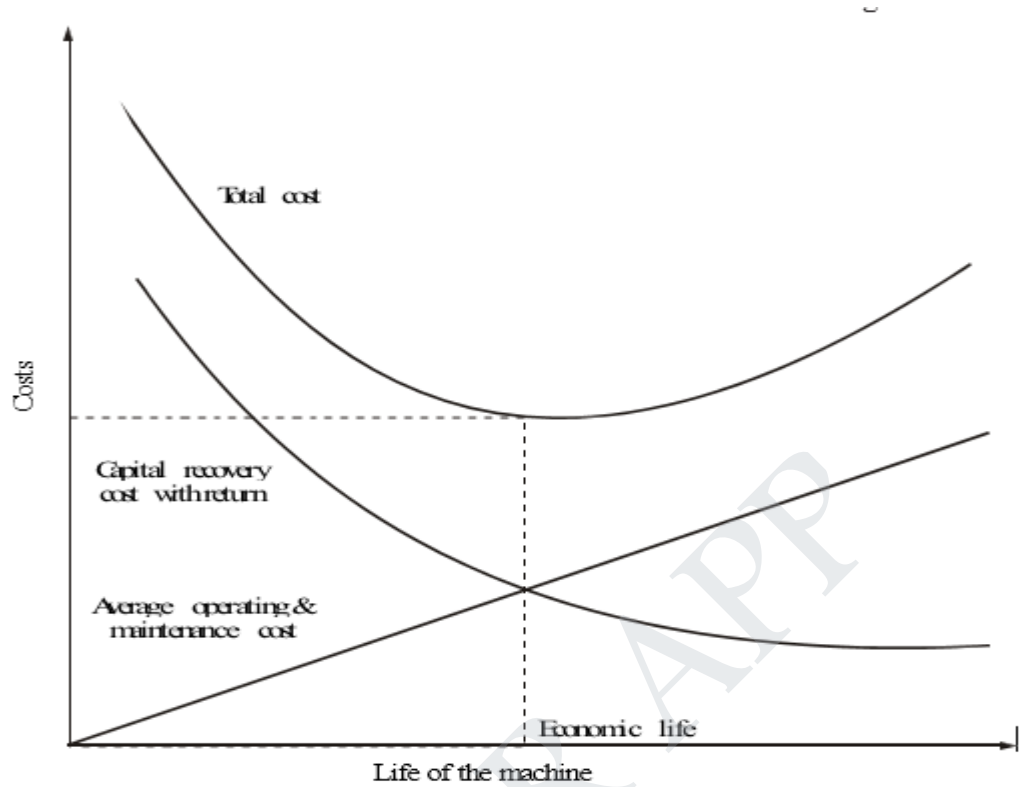


**Fig. 11.3** Chart showing economic life.

### 11.3.1 Limitation of Existing Model

In the case where the machine is replaced due to wear and tear, the following costs are considered (refer Chapter 8):

1. Initial cost
2. Operation and maintenance cost
3. Salvage value

In the existing model to deal with this type of replacement analysis, the different cost elements are estimated without taking the effect of inflation into account.

The annual cost of operation and maintenance of the machine will increase with the age of the machine due to decline in efficiency of the machine. In the existing model, this increase in the operation and maintenance cost is taken into account. But the increase in the operation and maintenance cost due to inflation is not considered. Similarly, in the existing model, the salvage value is estimated without taking into account the effect of inflation.

To highlight this particular fact on salvage value, an example is now given.

The internal combustion engines (R.A. Lister) which were made in England during pre-independence of India are still functioning well. Their resale value is

going up year after year. This may be partly due to inflation and partly due to good quality of the engine parts. So, consideration of the effect of the inflation on the economic life of the machine is a realistic approach.

In replacement analysis, a discount rate is usually assumed to reflect the time value of money. First the concept of replacement analysis is demonstrated without taking the inflation into account. Then, the same is demonstrated by taking the effect of inflation into account. At the end, a comparison between the two models is presented.

### 11.3.2 Economic Life Determination without Inflationary Effect

The determination of economic life of a machine without considering the effect of inflation is demonstrated using the following example.

***EXAMPLE 11.2*** A machine costs Rs. 5,00,000. Its annual operation cost during the first year is Rs. 40,000 and it increases by Rs. 5,000 every year thereafter. The maintenance cost during the first year is Rs. 60,000 and it increases by Rs. 6,000 every year thereafter. The resale value of the machine is Rs. 4,00,000 at the end of the first year and it decreases by Rs. 50,000 every year thereafter. Assume an interest rate (discounting factor) of 20%.

The method of finding the economic life of the machine with a discounting factor of 20% at zero inflation rate is summarized in Table 11.2. From the table it is clear that the total annual equivalent cost is minimum if the machine is used for 14 years. Hence, the economic life of the machine is 14 years.

### 11.3.3 Economic Life Determination with Inflationary Effect

The illustration in Section 11.3.2 is reconsidered for analyzing the effect of inflation on the economic life of the machine. An average annual inflation rate of 6% is assumed for discussion. The corresponding steps are explained in Table 11.3.

From the Table 11.3, it is clear that the total annual equivalent cost is minimum if the machine is used for three years. Thus, the economic life of the machine is three years.

(ii)

***To find:*** $D_t$ for 5 years

☺ ***Solution:*** Sum $= n(n+1)/2$

$= 5 \times 6/2$

$= 15$

The rates for year 1–5 are 5/15, 4/15, 3/15, 2/15 and 1/15 respectively.

The calculation of $D_t$ for different values of $t$ are summarized below:

| End of year $n$ | Depreciation $D_t$ | Book value $B_t$ |
|---|---|---|
| 0 | – | 1,60,000.00 |
| 1 | 39,999.99 | 1,20,000.01 |
| 2 | 31,999.99 | 88,000.02 |
| 3 | 24,000.00 | 64,000.02 |
| 4 | 15,999.99 | 48,000.03 |
| 5 | 7,999.99 | 40,000.03 |

The above data's are the computation of depreciation ($D_t$) and book value ($B_t$) for the corresponding 8 years.

 

***19. (i) State the object behind the provision of depreciation. 6***

***(ii) The Alpha Druge company has just purchased a capsulation machine for Rs 2000000. The plant Engineer estimate that the machine has a useful life of five year and a salvage of R.s 25000at the end of its useful life. Compute the deprecation schedule for the machine by each of the following deprecation methods:***

***1. Straight line method of depreciation.***

***2. Sum- of- Years digit method of depreciation. (May 2012)***

***Given:*** Cost of the machine (P) = Rs. 20,00,000

Salvage value (F) = Rs. 25,000

Useful life ($n$) = 5 years

☺ ***Solution:***

***1. Calculation of depreciation under straight line method***

$$= \frac{20,00,000 - 25,000}{5}$$

$$= \frac{19,75,000}{5}$$

$$= 3,95,000$$

***Result:*** ***Depreciation Schedule***

| End of year ($t$) | Depreciation |
|---|---|
| 0 | – |
| 1 | 3,95,000 |
| 2 | 3,95,000 |
| 3 | 3,95,000 |
| 4 | 3,95,000 |
| 5 | 3,95,000 |

2. ***Calculation of depreciation under sum-of-the years digit method:***

$$\text{Sum-of-the years digit} = \frac{n(n+1)}{2}$$

$$= \frac{5 \times (5+1)}{2}$$

$$= \frac{5(6)}{2}$$

$$= 15$$

The rate for year 1 – 5, are respectively $\frac{5}{15}, \frac{4}{15}, \frac{3}{15}, \frac{2}{15}$ and $\frac{1}{15}$.

The formula to find depreciation under sum-of-the years digit method is

$$D_t = \text{Rate} \times (P - F)$$

1st year: $\frac{5}{15} \times 20,00,000 - 25,000 = 6,58,333.33$

2nd year: $\frac{4}{15} \times 20,00,000 - 25,000 = 5,26,666.67$

3rd year: $\frac{3}{15} \times 20,00,000 - 25,000 = 3,95,000$

4th year: $\frac{2}{15} \times 20,00,000 - 25,000 = 2,63,333.33$

5th year: $\frac{1}{15} \times 20,00,000 - 25,000 = 1,31,666.67$

***Result:*** ***Depreciation Schedule***

| End of year ($n$) | Depreciation ($D_t$) |
|---|---|
| 0 | – |
| 1 | 6,58,333.33 |
| 2 | 5,26,666.67 |
| 3 | 3,95,000 |
| 4 | 2,63,333.33 |
| 5 | 1,31,666.67 |

(ii)

### 5.1.3. Reasons for Providing Depreciation

1. To know the correct profits
2. To show correct financial position
3. To make provision for replacement of assets
4. To compute tax liability
5. To decide how much to buy or sell the assets in second hand market.
6. To decide what part of the gross profit to distribute the owners of the business.
7. To decide how much to charge the consumers of product.

***20. (i) what is service output method of deprecition? (May 2012)***

### 9.2.5 Service Output Method of Depreciation

In some situations, it may not be realistic to compute depreciation based on time period. In such cases, the depreciation is computed based on service rendered by an asset. Let

$P$ = first cost of the asset

$F$ = salvage value of the asset

$X$ = maximum capacity of service of the asset during its lifetime

$x$ = quantity of service rendered in a period.

Then, the depreciation is defined per unit of service rendered:

Depreciation/unit of service = $(P - F)/X$

Depreciation for $x$ units of service in a period = $\frac{P-F}{X}(x)$

***(ii) The cost of road laying machine is R.s 800000. Its Salvage value after 5 year is Rs 50,000.The length of the road that can be laid by the machine during its life time 75000 Km. Find the depreciation of the equipment for that year (10)***

***Given:*** P = Rs. 80,00,000

F = Rs. 50,000

X = 75,000 km

$x$ = 2000 km

***To find:*** Depreciation for year 3 = $D_3$

☺ ***Solution:*** Depreciation for $x$ unit of service in year 3

$$= \frac{(P-F)}{X}x$$

$$D_3 = \frac{80,00,000 - 50,000}{75,000} \times 2,000$$

$$= \text{Rs. } 2,12,000$$

***Result:*** The depreciation for year 3 is Rs. 2,12,000.

***21. Original cost of the machine: Rs.20000***
***Life time: 5 years***
***Scrap or residual value: R.s 2500***
***Find out the of depreciation for the machine using double declining balance method. (May 2011)***

***Given Data:***

Cost of the machine (P) = Rs. 20,000
Scrap or residual value (F) = Rs. 2,500
Life time ($n$) = 5 years

***To find:*** Rate of depreciation using double declining balance method.

***(May 2011)***

☺ ***Solution:***

Formula to find depreciation is

$$D_t = K \times B_{t-1}$$

$$\left.\begin{array}{r}\text{Double declining balance}\\ \text{depreciation rate}\end{array}\right\} = \left(\frac{1}{\text{useful life}}\right) \times 200\%$$

$$= \frac{1}{5} \times 200\%$$

$$= 40\%$$

| End of year $n$ | $B_{t-1}$ | Percentage K | Depreciation $D_t$ | Book value $B_t$ |
|---|---|---|---|---|
| 1 | 20000 | 40% | 8000 | 12000 |
| 2 | 12000 | 40% | 4800 | 7200 |
| 3 | 7200 | 40% | 2880 | 4320 |
| 4 | 4320 | 40% | 1728 | 2592 |
| 5 | 2592 | 3.55% | 92* | 2500 |

**Note:* The double declining balance calculation does not consider the salvage value in the depreciation of each period however, if the book value will fall below the salvage value, the last period might be adjusted so that it ends at the salvage value.

***22. (i) Explain sinking fund method of calculating depreciating (May 2012)***

In this method of depreciation, the book value decreases at increasing rates with respect to the life of the asset. Let

$P$ = first cost of the asset,

$F$ = salvage value of the asset,

$n$ = life of the asset,

$i$ = rate of return compounded annually,

$A$ = the annual equivalent amount,

$B_t$ = the book value of the asset at the end of the period $t$, and

$D_t$ = the depreciation amount at the end of the period $t$.

The loss in value of the asset $(P - F)$ is made available an the form of cumulative depreciation amount at the end of the life of the asset by setting up an equal depreciation amount $(A)$ at the end of each period during the lifetime of the asset.

$$A = (P - F) \times [A/F, i, n]$$

The fixed sum depreciated at the end of every time period earns an interest at the rate of $i$% compounded annually, and hence the actual depreciation amount will be in the increasing manner with respect to the time period. A generalized formula for $D_t$ is

$$D_t = (P - F) \times (A/F, i, n) \times (F/P, i, t - 1)$$

The formula to calculate the book value at the end of period $t$ is

$$B_t = P - (P - F)\ (A/F, i, n)\ (F/A, i, t)$$

The above two formulae are very useful if we have to calculate $D_t$ and $B_t$ for any specific period. If we calculate $D_t$ and $B_t$ for all the periods, then the tabular approach would be better.

(ii) Write short notes on inflation adjusted decisions.

A general inflationary trend in the cost of goods is common everywhere due to various interacting factors. If the rate of inflation is very high, it will produce extremely serious consequences for both individuals and institutions.

Inflation is the rate of increase in the prices of goods per period. So, it has a compounding effect. Thus, prices that are inflated at a rate of 7% per year will increase 7% in the first year, and for the next year the expected increase will be 7% of these new prices. The same is true for succeeding years and hence the rate of inflation is compounded in the same manner that an interest rate is compounded. If the average inflation over six years period is 7%, then the prices at the beginning of the seventh year would be 150% that of the first year by assuming 100% for the prices at the beginning of the first year of the six-year period.

If economic decisions are taken without considering the effect of inflation into account, most of them would become meaningless and as a result the organizations would end up with unpredictable return.

But there is always difficulty in determining the rate of inflation. The world-wide trend/wish is to curtail inflation. But due to various reasons, it is very difficult to have zero inflation. For practical decision making, an average estimate may be assumed depending on the period of the proposals under consideration. Hence, we need a procedure which will combine the effects of inflation rate and interest rate to take realistic economic decision.

***23. Discuss in detail about:***
***(1) Declining balance method of depreciation.***
***(2) Sinking fund method of depreciation. (May2009)***
***Answer is present in Question No: 4***
***24 (1) How will you evaluate the public alternative? Explain in detail.***
***(2) Discuss on inflation adjusted decisions, (May 2009)***
***Answer is present in Question No: 4***
***25 Explain the Method of Evaluation of Public alternatives with special reference to inflation adjusted decision.***

A general inflationary trend in the cost of goods is common everywhere due to various interacting factors. If the rate of inflation is very high, it will produce extremely serious consequences for both individuals and institutions.

Inflation is the rate of increase in the prices of goods per period. So, it has a compounding effect. Thus, prices that are inflated at a rate of 7% per year will increase 7% in the first year, and for the next year the expected increase will be 7% of these new prices. The same is true for succeeding years and hence the rate of inflation is compounded in the same manner that an interest rate is compounded. If the average inflation over six years period is 7%, then the prices at the beginning of the seventh year would be 150% that of the first year by assuming 100% for the prices at the beginning of the first year of the six-year period.

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## 11.2 PROCEDURE TO ADJUST INFLATION

A procedure to deal with this situation is summarized now.

1. Estimate all the costs/returns associated with an investment proposal in terms of today's rupees.
2. Modify the costs/returns estimated in step 1 using an assumed inflation rate so that at each future date they represent the costs/returns at that date in terms of the rupees that must be expended/received at that time, respectively.
3. As per our requirement, calculate either the annual equivalent amount or future amount or present amount of the cash flow resulting from step 2 by considering the time value of money.

## 11.3 INFLATION ADJUSTED ECONOMIC LIFE OF MACHINE

In any industrial/service organization, equipment/machinery forms an important element. The productivity of any organization is a function of many factors. It is largely affected by efficient and effective use of machinery and equipment. So, operations and maintenance of these equipment are very important to the organization.

A machine which is purchased today cannot be used forever. It has a definite economic lifetime. After the economic life, the machine should be replaced with a substitute machine with similar operational capabilities. This kind of analysis is called *replacement analysis*.

The elements of costs involved in the replacement analysis are as follows:

1. Purchase cost (initial cost)
2. Annual operation and maintenance cost
3. Salvage value at the end of every year, if it is significant

The trade-off between different cost elements is shown in Fig. 11.3.

The trade-off between different cost elements is shown in Fig. 11.3.

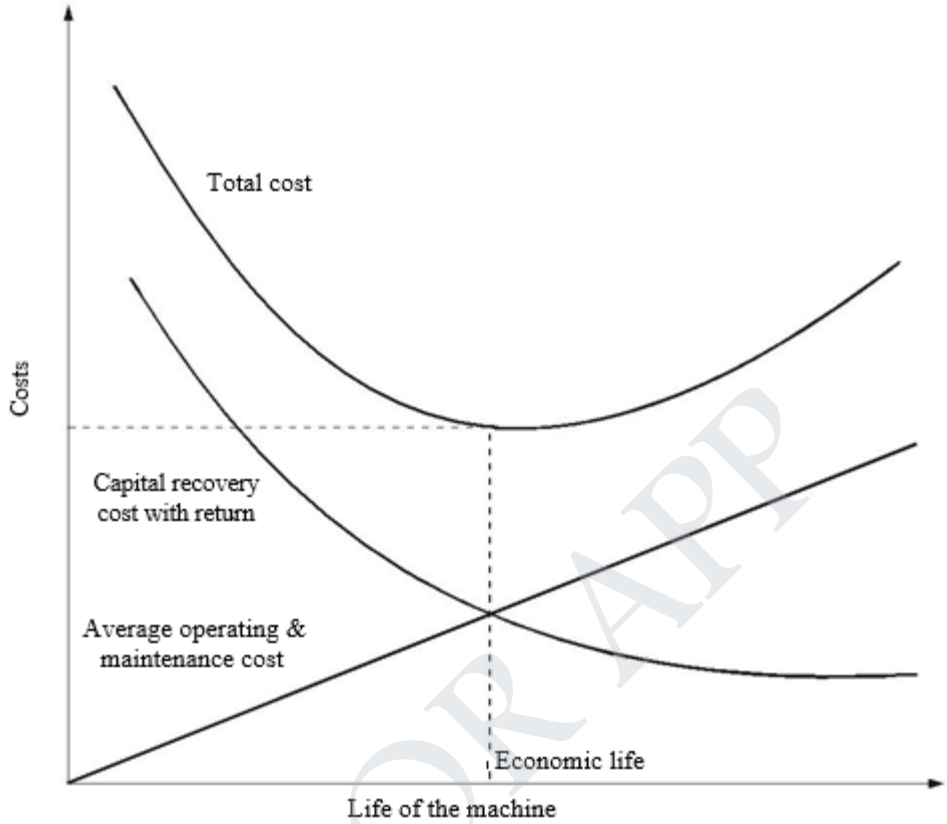


**Fig. 11.3 Chart** showing economic life.

From Fig. 11.3, it is clear that the sum of operation and maintenance cost increases with the life of the machine. But the capital recovery with return decreases with the life of the machine. The total cost of the machine goes on decreasing initially but it starts increasing after some years. The year with the minimum total cost is called as the economic life of the machine.

### 11.3.1 Limitation of Existing Model

In the case where the machine is replaced due to wear and tear, the following costs are considered (refer Chapter 8):

1. Initial cost
2. Operation and maintenance cost
3. Salvage value

In the existing model to deal with this type of replacement analysis, the different cost elements are estimated without taking the effect of inflation into account.

The annual cost of operation and maintenance of the machine will increase with the age of the machine due to decline in efficiency of the machine. In the existing model, this increase in the operation and maintenance cost is taken into account. But the increase in the operation and maintenance cost due to inflation is not considered. Similarly, in the existing model, the salvage value is estimated without taking into account the effect of inflation.

To highlight this particular fact on salvage value, an example is now given. The internal combustion engines (R.A. Lister) which were made in England during pre-independence of India are still functioning well. Their resale value is going up year after year. This may be partly due to inflation and partly due to good quality of the engine parts. So, consideration of the effect of the inflation on the economic life of the machine is a realistic approach.

In replacement analysis, a discount rate is usually assumed to reflect the time value of money. First the concept of replacement analysis is demonstrated without taking the inflation into account. Then, the same is demonstrated by taking the effect of inflation into account. At the end, a comparison between the two models is presented.

### 11.3.2 Economic Life Determination without Inflationary Effect

The determination of economic life of a machine without considering the effect of inflation is demonstrated using the following example.

***EXAMPLE 11.2*** A machine costs Rs. 5,00,000. Its annual operation cost during the first year is Rs. 40,000 and it increases by Rs. 5,000 every year thereafter. The maintenance cost during the first year is Rs. 60,000 and it increases by Rs. 6,000 every year thereafter. The resale value of the machine is Rs. 4,00,000 at the end of the first year and it decreases by Rs. 50,000 every year thereafter. Assume an interest rate (discounting factor) of 20%.

The method of finding the economic life of the machine with a discounting factor of 20% at zero inflation rate is summarized in Table 11.2. From the table it is clear that the total annual equivalent cost is minimum if the machine is used for 14 years. Hence, the economic life of the machine is 14 years.

### 11.3.3 Economic Life Determination with Inflationary Effect

The illustration in Section 11.3.2 is reconsidered for analyzing the effect of inflation on the economic life of the machine. An average annual inflation rate of 6% is assumed for discussion. The corresponding steps are explained in Table 11.3.

From the Table 11.3, it is clear that the total annual equivalent cost is minimum if the machine is used for three years. Thus, the economic life of the machine is three years.

**Comparison of results**

The results of the two approaches are summarized in Table 11.4. From the table, it is clear that the inflation has an effect on the economic life of the machine. Since it is meaningful and realistic to analyze this type of problem by considering the effect of inflation, the second approach should be used for such analysis.

***26.Two equipment are purchased each for R,s 12000. The estimated useful is 5 years for both, the estimated scrap value for each equipment is R.s 2000. For one equipment the straight-line method is used to calculated annucla depreciation the straight-line method is used to calculated annual deprecation and for the other equipment, the reducing balance method is doted. Compare the depreciation charges for both all the 5 years. (May 2017)***

***Solution***

$$P = \text{Rs. } 12000 \quad F = \text{Rs. } 20{,}00 \quad n = 5 \text{ years}$$

$$D_t = (P - F)/n$$
$$= (12000 - 20{,}00)/5$$
$$= \text{Rs. } 2000$$

In this method of depreciation, the value of $D_t$ is the same for all the years. The calculations pertaining to $B_t$ for different values of $t$ are summarized in Table 9.1.

**Table 9.1** $D_t$ and $B_t$ Values under Straight line Method of Depreciation

| *End of year* ($t$) | *Depreciation* ($D_t$) | *Book value* ($B_t = B_{t-1} - D_t$) |
|---|---|---|
| 0 | | 12000 |
| 1 | 2000 | 10000 |
| 2 | 2000 | 8000 |
| 3 | 2000 | 6000 |
| 4 | 2000 | 4000 |
| 5 | 2000 | 2000 |

If we are interested in computing $D_t$ and $B_t$ for a specific period ($t$), the formulae can be used. In this approach, it should be noted that the depreciation is the same for all the periods.

 

***27.A Machine cost Rs. 500000.Its annual oeration cost during the first year is Rs. 40,000 and it increases by R.s 5000 every year thereafter. The maintenance cost during the first year is R.s 60000 and it increases by R.s 6000 every thereafter. The resale value of the machine is R.s 400000 at the end of the first year and first year and it decreases by R.s 50000 every year thereafter. Take an interest rate of the 20%. Find the Economic life of the asset. (May 2017)***

Solution:-

Determination of Economic Life of the Machine with Inflationary Effect.

| End of year (n) 1 | operation cost 2 (Rs) | Maintenance cost 3 (Rs) | Sum of operation and Maintenance cost (2)+(3) (4) Rs | F/P, i, n (i = 6%) | Inflated operation & Maintenance cost (4) x (5) (6) Rs | P/F, i, n i = 20% | Present worth of column 6 (6) x (7) (8) Rs | Cummulative of column (8) (9) Rs | Salvage value (5) (10) Rs | Inflated Salvage value (10) x (5) (11) Rs | Present worth of column 11 (11) x (7) (12) (Rs) | Total Present worth 500,000 + column 12 (13) Rs | A/P, i, n i = 20% (14) Rs | Annual Equivalent amount of total Present worth (13) x (14) (15) Rs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 40,000 | 60,000 | 1,00,000 | 1.060 | 1,06,000 | 0.8333 | 88,327.80 | 88,327.80 | 4,00,000 | 4,24,000 | 3,53,319.20 | 2,35,010.6 | 1.20000 | 2,82,012.70 |
| 2 | 45,000 | 66,000 | 1,11,000 | 1.124 | 1,24,764 | 0.6945 | 86,648.59 | 1,74,978.30 | 3,50,000 | 3,93,400 | 2,73,216.30 | 4,01,760 | 0.6546 | 2,62,993.40 |
| 3 | 50,000 | 72,000 | 1,22,000 | 1.191 | 1,45,302 | 0.5787 | 84,086.26 | 2,59,064.60 | 3,00,000 | 3,57,300 | 2,06,767.50 | 5,52,295.1 | 0.4747 | 2,62,174.50 *** |
| 4 | 55,000 | 78,000 | 1,33,000 | 1.262 | 1,67,846 | 0.4823 | 80,952.12 | 3,40,016.70 | 2,50,000 | 3,15,500 | 1,52,165.60 | 6,87,851.1 | 0.3863 | 2,65,716.80 |

*** Total annual Equivalent cost is minimum if machine is used for three years.

Comparison of results

Results of the Two Approaches

| Approach | Minimum annual Equivalent cost (Rs) | Corresponding Life (years) |
|---|---|---|
| Replacement analysis without inflation effect | 2,50,456.00 | 14 |
| Replacement analysis with inflation effect | 2,62,174.50 | 3 |



 