

Actual capacity

After having decided a specific equipment, the exact number in that category is determined as follows.

When the actual output requirements from a system are known, the amount or size of equipment required to deliver that output can be determined by "working backward" to allow for normal system inefficiencies. Capacity limitations are often stated in terms of equipment efficiencies or amount of scrap loss.

For example, if the ordinary scrap loss is 3%, then the system efficiency is only 97%. The required system capacity can be determined by dividing 0.97 into the actual output required in this system capacity by the individual machine capacity yields the number of machines required in each machine type.

Example 3.1. A product line manufacturing shoes has five stations in series whose individual capacities per shift are stated in the following table. The actual output of the line is 500 pairs per shift. Find:

- the system capacity, and
- the system efficiency.

Station No.	1	2	3	4	5
Individual capacity/Shift	600	650	650	550	600

Solution. (a) The capacity of the bottleneck operation is 550 pairs per shift (i.e. at the station 4).

Therefore, the system capacity = 550 pairs per shift.

(b) The actual output of the line = 500 pairs per shift.

Therefore, the system efficiency = $\frac{\text{Actual output}}{\text{System capacity}} \times 100$

$$= (500/550) \times 100 = 90.91\%$$

Example 3.2. An automobile component manufacturer has the plan of buying a moulding machine which can manufacture 170,000 good parts per year. The moulding machine is a part of a product line. The system efficiency of the product line is 85%.

(a) What is the required systems capacity?

(b) Assume that it takes 100 seconds to mould each part and the plant operates 2000 hours per year. If the moulding machines are used only 60% of the time and are 90% efficient, what is the actual output of the moulding machine per hour?

(c) How many moulding machines would be required?

Solution.

$$(a) \text{System capacity} = \frac{\text{Actual output/year}}{\text{System efficiency}}$$

$$= 170,000/0.85 = 200,000 \text{ moulds per year.}$$

$$= 200,000/(2000 \times 0.9) = 100 \text{ moulds per hour.}$$

(b)

Output per hour = Unit capacity \times % utilization \times efficiency, where unit capacity = 3600 sec/100 sec per mould = 36 moulds per hour.

Output per hour = $36 \times 0.6 \times 0.9 = 19.44$ moulds = 20 moulds (Approx.)

(c) Number of moulding machines needed = System capacity/output per hour = $100/20 = 5$ machines.

3.2 INVESTMENT DECISIONS

3.2.1 Interest Formulas

In the area of investment decision making, computations will be done in many ways. To simplify these computations, it is highly necessary to know how to use interest formulas more effectively. Before discussing the effective application of the interest formulas for investment decision making, the various interest formulas are presented first.

Interest rate is the rental value of money. This represents the growth of capital per unit period.

The period may be a month, quarter, semiannual or year. Interest rate can be classified into simple interest rate and compound interest rate.

In simple interest, the interest is computed based on the initial deposit for every interest period.

In this case, calculation of interest on interest earned per unit period is not applied.

In compound interest, the interest for the current period is computed based on the amount

(Principle Plus interest up to the previous period) at the beginning of the current period.

The notations which are used in various interest formulas are summarized below.

P – Principle amount

n – Number of interest periods

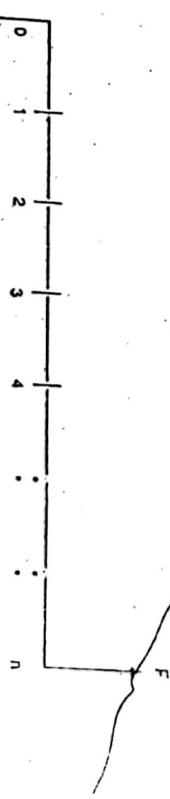
i – Interest rate (It may be compounded monthly, quarterly, semiannually or annually.)

F – Future amount at the end of the year, n.

A – Equal amount deposited at the end of every interest period.

G – Uniform amount which will be added/subtracted period after period to/from the amount of deposit A_t at the end of period t.

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. 3.1.



- 50) Production and Operations Management
The formula to obtain the single payment compound amount is given below.

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

$$= P (F/F, i, n)$$

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

Example 3.3: A person deposits a sum of Rs. 15,000 at the interest rate of 18% compounded

annually for 5 years. Find the maturity value after 5 years.

Solution.

$$P = \text{Rs. } 15,000$$

$$i = 18\% \text{ compounded annually}$$

$$n = 5 \text{ years}$$

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

$$= P (F/F, i, n)$$

$$= 15,000 (F/F, 18\%, 5)$$

$$= 15,000 \times 2.2878 = \text{Rs. } 34,317$$

The maturity value of Rs. 15,000 invested now at 18% compounded yearly is equal to Rs. 34,317 after 5 years.

Single payment present worth amount. Here, the objective is to find the present worth amount (P) of a single future sum 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. 3.2.

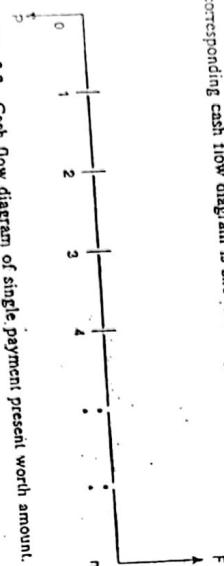


Fig. 3.2 Cash flow diagram of single payment present worth amount.

- The formula to obtain the present worth is given below.

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

$$= F (P/F, i, n)$$

where, $(P/F, i, n)$ is called as single payment present worth factor.

Example 3.4: A person wishes to have a future sum of Rs. 50,000 for his son's education 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.

- 51) Solution.

F = Rs. 50,000
i = 15% compounded annually
n = 10 years

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

$$= F(F/F, i, n)$$

$$= 50,000 (P/F, 15\%, 10)$$

$$= 50,000 \times 0.2472$$

$$= \text{Rs. } 12,360$$

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

$$= A(F/A, i, n)$$



The person has to invest Rs. 12,360 now, so that he will get a sum of Rs. 50,000 after 10 years at 15% interest rate compounded annually.

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 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. 3.3.

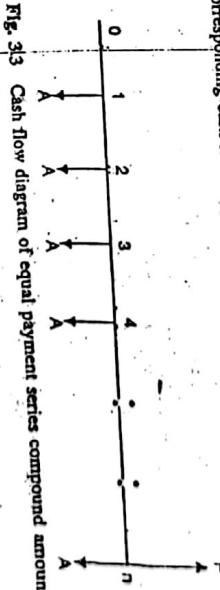


Fig. 3.3 Cash flow diagram of equal payment series compound amount.

Hence,
A = Equal amount deposited at the end of each interest period.

n = Number of interest periods.

i = Rate of interest.

F = Single future amount.

The formula to get F is shown below.

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

where $(F/A, i, n)$ is called as equal payment series compound amount factor.

Example 3.5: A person who is just 40 years old is planning for his retired life. He plans to invest an equal sum of Rs. 10,000 at the end of every year for next 20 years starting from the end of next year. This bank gives 18% interest rate, compounded annually. Find the maturity value of his account when he is 60 years old.

Solution.

$$A = \text{Rs. } 10,000$$

$$n = 20 \text{ years}$$

$$i = 18\%$$

$$F = ?$$

The corresponding cash flow diagram is shown in Fig. 3.4.

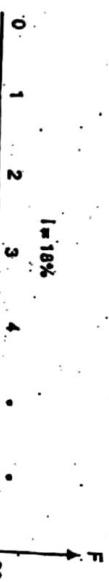


Fig. 3.4 Cash flow diagram of equal payment series compound amount.

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

$$= A (VF, i, n)$$

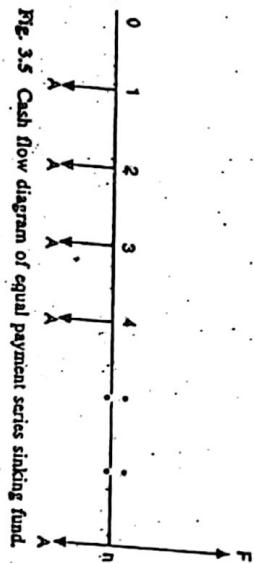
$$= 10,000 (VF, 18\%, 20)$$

$$= 10,000 \times 146.6280$$

$$= \text{Rs. } 1,466,280$$

The future sum after 20 years is equal to Rs. 1,466,280.

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. 3.5.



Here,

A – Equal amount deposited at the end of each interest period.

n – Number of interest periods.

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

where (VF, i, n) is called as equal payment series sinking fund factor.

Example 3.6. A company has to replace a present facility after 10 years at an outlay of Rs. 500,000. It plans to deposit an equal fixed amount at the end of every year for the next 10 years at an interest rate of 18% compounded annually. Find the amount that must be deposited at the end of every year for the next 10 years.

Solution.

$$F = \text{Rs. } 500,000$$

$$n = 10 \text{ years}$$

$$i = 18\%$$

$$A = ?$$

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

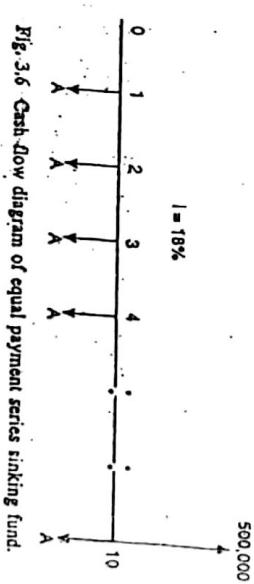


Fig. 3.6 Cash flow diagram of equal payment series sinking fund.

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

$$= F (VF, i, n)$$

$$= 500,000 (VF, 18\%, 10)$$

$$= 500,000 \times 0.0425$$

$$= \text{Rs. } 21,250$$

The annual equal amount which must be deposited is Rs. 21,250.

Production and Operations Management

5.4 Equal payment series present worth amount. The objective of this mode of investment is to find the present worth of an equal payments made at the end of every interest period for n interest periods at an interest rate of i compounded periodically at the end of every interest period. The cash flow diagram is as shown in Fig. 3.7.

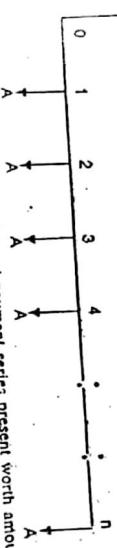


Fig. 3.7 Cash flow diagram of equal payment series present worth amount.

Here,

P = Present worth

A = Annual equivalent payment

i = Interest rate

n = number of periods of deposit

The formula to compute P is as given below:

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

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

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

Example 3.7. A company wants to set up a reserve which will help the company to have an amount of Rs. 1,000,000 for the next 25 years towards welfare measures of its employees. The reserve is assumed to grow at the rate of 18% annually. Find the single payment that must be made as the reserve amount.

Solution.

$$A = \text{Rs. } 1,000,000$$

$$i = 18\%$$

$$n = 25 \text{ years}$$

$$P = ?$$

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

$$= A (P/A, i, n) = 1,000,000 \times (P/A, 18\%, 25)$$

$$= 1,000,000 \times (5.467)$$

$$= \text{Rs. } 5,467,000$$

The amount of reserve which must be set up is equal to Rs. 5,467,000.

5.5 Equal payment series capital recovery amount. The objective of this mode of investment is to find the equal annual 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 periodically at the end of every interest period. The cash flow diagram is as shown in Fig. 3.8.

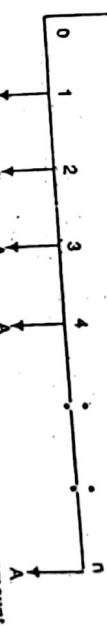


Fig. 3.8 Cash flow diagram of equal payment series capital recovery amount.

Here,

P = Present worth (Loan amount)

A = Annual equivalent payment (Recovery amount)

i = Interest rate

n = Number of periods of deposit

The formula to compute A is as given below.

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

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

Example 3.8. A bank gives a loan to a company to purchase an equipment which is worth of Rs. 1,000,000 at an interest rate, 15% compounded annually. This amount should be repaid in 15 yearly equal installments. Find the installment amount that the company has to pay to the bank.

Solution.

$$P = \text{Rs. } 1,000,000$$

$$i = 15\%$$

$$n = 15 \text{ years}$$

$$A = ?$$

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

$$= P (A/P, i, n) = 1,000,000 \times (A/P, 15\%, 15)$$

$$= 1,000,000 \times (0.1710)$$

The annual equivalent installment to be paid by the company to the bank is Rs. 171,000.

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

The corresponding cash flow diagram is shown in Fig. 3.9.

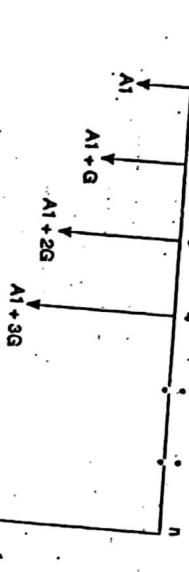


Fig. 3.9 Cash flow diagram of uniform gradient series annual equivalent amount.

Here, the formula for this situation is given below.

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

where $(A/G, i, n)$ is called as Uniform gradient series factor.

Example 3.9. A person is planning for his retired life. He has 10 more years of service. He would like to deposit 10% of his salary which is Rs. 2000 at the end of the first year and thereafter he wishes to deposit the same amount (Rs. 2000) with an annual increase of Rs. 500 for the next 9 years with an interest rate of 15%. Find the total amount at the end of the 10th year of the above series.

Solution. The cash flow diagram is shown in Fig. 3.10.

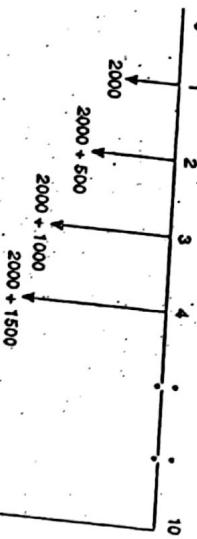


Fig. 3.10 Cash flow diagram of uniform gradient series annual equivalent amount.

This is equivalent to paying an equal amount of Rs. 3691.60 to be invested at the end of every year for the next 10 years. The future worth of this revised series at the end of the 10th year is obtained as follows:

$$\begin{aligned} F &= A (F/A, i, n) \\ &= A (F/A, 15\%, 10) \\ &= 3691.60 (20.304) \\ &= \text{Rs. } 74,954.25 \end{aligned}$$

The compounded amount at the end of the 10th year is Rs. 74,954.25.

3.2.2 Bases for Comparison of Alternatives

In most of the practical decision environments, executives will be forced to select the best alternative from a set of competing alternatives. Let us assume that an organization has huge sum of money for potential investment. There are three different projects whose initial outlay and annual revenues during their life are known. The executive has to select the best alternative among these three competing projects.

There are several bases for comparing the worthiness of the projects which are mentioned below.

- Present Worth Method
- Annual Equivalent Method
- Future Worth Method
- Rate of Return Method

Present worth method. In this method of comparison, the cash flows of each alternative will be reduced to time zero by assuming an interest rate. Then, depending on the type of decision, the best alternative will be selected by comparing the present worth amounts of the alternatives. In case the decision is to select the alternative which will result in 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. Here, 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.

Production and Operations Management

58. Alpha Industry is planning for expanding 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 the following table. Suggest the best technology which is to be implemented based on present worth method of comparison assuming 20% interest rate compounded annually.

	Initial Outlay (Rs.)	Annual Revenue (Rs.)	Life (Yrs.)
Technology 1	1,200,000	400,000	15
Technology 2	2,000,000	600,000	15
Technology 3	1,800,000	500,000	15

The present worth expression for this technology is shown below.

$$\text{Technology 1: The present worth expression } = -1,200,000 + 400,000 \times (P/A, 20\%, 15)$$

$$PW(20\%)_1 = -1,200,000 + 400,000 \times (4.6755)$$

$$= -1,200,000 + 1,870,200$$

$$= 670,200$$

The present worth expression is as follows.

$$\text{Technology 2: The present worth expression } = -2,000,000 + 600,000 \times (P/A, 20\%, 15)$$

$$PW(20\%)_2 = -2,000,000 + 600,000 \times (4.6755)$$

$$= -2,000,000 + 2,805,300$$

$$= 805,300$$

The present worth expression for this technology

Technology 3: The following is the present worth expression $(P/A, 20\%, 15)$

$$PW(20\%)_3 = -1,800,000 + 500,000 \times (4.6755)$$

$$= -1,800,000 + 2,337,750$$

$$= 537,750$$

From the above calculations, it is clear that the present worth of the Technology 2 is the highest among all the technologies. Hence, it is recommended for implementation to expand the production.

Example 3.11. An engineer has two bids for an elevator to be installed in a new building. The bids and his evaluation of the elevators are as follows.

	Engineer's Estimates
Bids	Annual Operation and Maintenance Cost (Rs.)
Initial Cost (Rs.)	Life (Yrs.)

	Service Cost (Rs.)
Alternative	450,000
Alpha Elevator Inc.	540,000

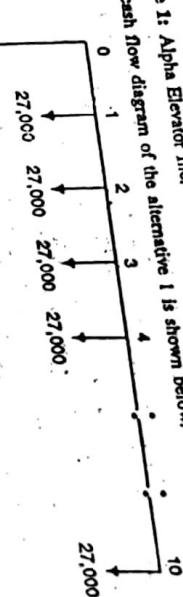
Beta Elevator Inc.

The engineer will make a present worth analysis using a 15% interest rate. Prepare the analysis and determine which bid should be accepted.

Solution.

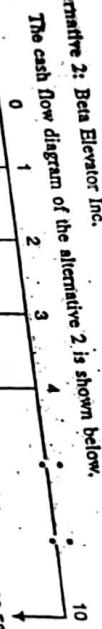
Alternative 1: Alpha Elevator Inc.

The cash flow diagram of the alternative 1 is shown below.



$$\begin{aligned} PW(15\%) &= 450,000 + 27,000 \times (P/A, 15\%, 10) \\ &= 450,000 + 27,000 \times 5.019 \\ &= 450,000 + 135,513 \\ &= \text{Rs. } 585,513 \end{aligned}$$

Alternative 2: Beta Elevator Inc.



$$\begin{aligned} PW(15\%) &= 540,000 + 28,500 \times (P/A, 15\%, 10) \\ &= 540,000 + 28,500 \times 5.019 \\ &= 540,000 + 143,042 \\ &= \text{Rs. } 683,042 \end{aligned}$$

$$\begin{aligned} \text{The total present worth of the alternative 1 is less than that of the alternative 2. Hence, the} \\ \text{alternative 1 is to be selected and installed in the new building. That means, the elevator from Alpha Elevator} \\ \text{Limited is to be purchased and installed in the new building.} \end{aligned}$$

Example 3.12. Investment proposals A and B have the net cash flows as shown below.

Investment proposals A and B have the net cash flows as shown below.

	End of Years
Proposal	0 1 2 3 4
A (Rs.)	-10,000 3000 3000 3000

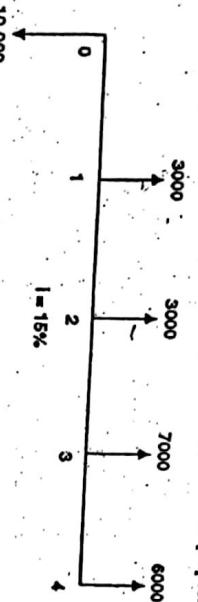
B (Rs.)

6000

3000

value? Compare the present worth of A with the present worth of B for $i = 15\%$. Which has the higher solution.

Solution. The present worth of A at $i = 15\%$. The cash flow diagram of the proposal A is shown below.



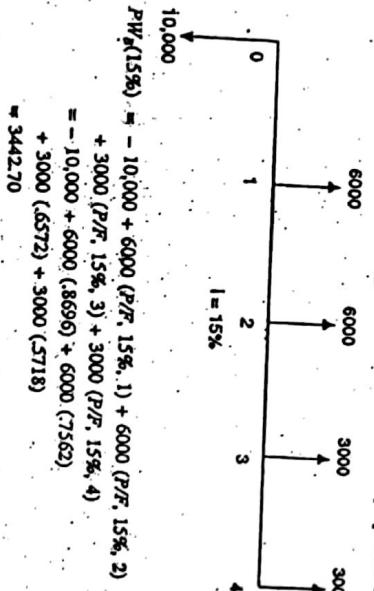
$$PW_A(15\%) = -10,000 + 3000(P/F, 15\%, 1) + 3000(P/F, 15\%, 2)$$

$$= -10,000 + 3000(.8696) + 6000(.7562)$$

$$+ 7,000(.6572) + 6,000(.5718)$$

$$= 2908.60$$

The present worth of B at $i = 15\%$. The cash flow diagram of the proposal B is shown below.



$$PW_B(15\%) = -10,000 + 6000(P/F, 15\%, 1) + 6000(P/F, 15\%, 2)$$

$$+ 3000(P/F, 15\%, 3) + 3000(P/F, 15\%, 4)$$

$$= -10,000 + 3000(.8696) + 3000(.7562)$$

$$+ 7,000(.6572) + 6,000(.5718)$$

$$= 2908.60$$

The present worth of this option is Rs. 1,238,500, which is less than the first option of complete down payment of Rs. 1,600,000. Hence, the company should select the second alternative.

Annual equivalent method: In this method of comparison, first, the annual equivalent net cost or net revenue of each alternative will be evaluated. Then, the alternative with the minimum annual equivalent net cost in the case of cost based comparison or with the maximum annual equivalent net revenue in the case of revenue based comparison will be selected as the best alternative.

Example 3.14. A company provides car to its chief executive. The owner of the company is concerned about the increasing cost of petrol. He feels that the cost of petrol will be increasing by Re. 1 every year. His experience with his company car indicates that it averages 9 kilometres per litre of petrol. The executive expects to drive an average of 20,000 kilometres each year for the next four years. What is the annual equivalent cost of fuel over this period of time? If he is offered similar service with the same quality on rental basis at Rs. 60,000 per year, whether the owner should continue to provide his own car for his executive or alternatively provide a rental car to his executive?

*Assume $i = 15\%$. If the rental car is preferred, then the company car will find some other alternate use within the company.

Solution. The average number of kilometre run/year = 20,000 km

Number of kilometre/litre of petrol = 9 km

Therefore, petrol consumption/year = $20,000/9 = 2222.2$ litre

The cost/litre of petrol for the first year = Rs. 20.

The cost/litre of petrol for the second year = Rs. $20.00/0.9 = 22.22$

The cost/litre of petrol for the third year = Rs. $22.22/0.9 = 24.69$

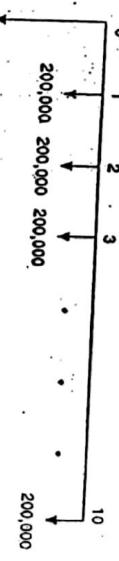
The cost/litre of petrol for the fourth year = Rs. $24.69/0.9 = 27.44$

The fuel expenditure for 1st year = $2222.2 \times 20 = \text{Rs. } 44,444.00$

The fuel expenditure for 2nd year = $2222.2 \times 21 = \text{Rs. } 46,666.20$

1. Down payment of Rs. 1,600,000
2. Down payment of Rs. 400,000 and 10 annual equal installments of Rs. 200,000 each.

The present worth calculation of the second alternative:



$$PW(20\%) = 400,000 + 200,000(P/A, 20\%, 10)$$

$$= 400,000 + 200,000 \times 4.1925$$

$$= \text{Rs. } 1,238,500$$

The present worth of this option is Rs. 1,238,500, which is less than the first option of complete down payment of Rs. 1,600,000. Hence, the company should select the second alternative.

The cash flow diagram of the second alternative is shown below.



$$PW_A(15\%) = -10,000 + 3000(P/F, 15\%, 1) + 3000(P/F, 15\%, 2)$$

$$+ 7,000(P/F, 15\%, 3) + 6,000(P/F, 15\%, 4)$$

$$= -10,000 + 3000(.8696) + 3000(.7562)$$

$$+ 7,000(.6572) + 6,000(.5718)$$

$$= 2908.60$$

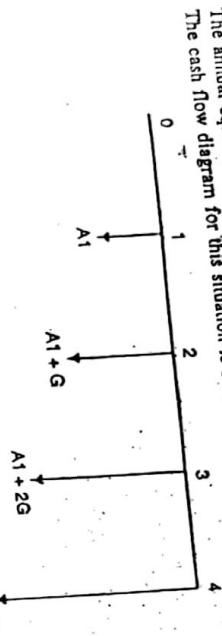
The present worth of the proposal B is higher than that of the proposal A. Hence select the proposal B.

Example 3.13. A granite company is planning to buy fully automated granite cutting machine. If it is purchased under down payment, the cost of the machine is Rs. 1,600,000. If it is purchased on installment basis, the company has to pay 25% of the cost at the time of purchase and the remaining amount in 10 annual equal installments of Rs. 200,000 each. Suggest the best alternative for the company using present worth basis of $i = 20\%$.

Capacity Planning and Investment Decisions

62 Production and Operations Management

The fuel expenditure for 3rd year = $2222.2 \times 22 = \text{Rs. } 48,888.40$
 The fuel expenditure for 4th year = $2222.2 \times 23 = \text{Rs. } 51,110.60$
 The annual equal increment of the above expenditures is $\text{Rs. } 2222.20$ (G).
 The cash flow diagram for this situation is shown below.



$$A_1 = \text{Rs. } 44,444$$

$$G = \text{Rs. } 2222.20$$

$$\begin{aligned} A &= A_1 + G (A/G, 15\%, 4) \\ &= 44,444 + 2222.2 (1.3263) \end{aligned}$$

$$= \text{Rs. } 47,391.30$$

The proposal of using the company car by spending for petrol by the company will cost an annual equivalent amount of $\text{Rs. } 47,391.30$ for four years. This amount is lesser than the annual rental value of $\text{Rs. } 60,000$. Hence, the company should continue to provide its own car to the executive.

Example 3.15. A company is planning to purchase advanced machine centre. Three original manufacturers have responded to its tender whose particulars are shown below:

Yearly Equal Installment (Rs.)	Number of Installments
500,000	200,000
400,000	300,000
600,000	150,000

The annual equivalent cost of the alternative 3 (machine centre from manufacturer 3) is lesser than that of the alternative 1 and the alternative 2. Hence, the company should buy the advanced machine centre from the manufacturer 3.

Example 3.16. A company invests in one of the two mutually exclusive alternatives. The life of both alternatives is estimated to be 5 years with the following investments, annual returns and salvage values.

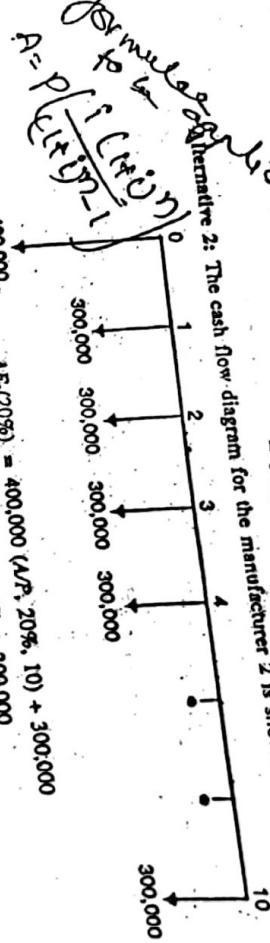
Determine the best alternative based on the annual equivalent method by assuming $i = 20\%$.

Alternative 1: The cash flow diagram for the manufacturer 1 is shown below.



$$\begin{aligned} \Delta E_1(20\%) &= 500,000 (A/P, 20\%, 10) + 200,000 \\ &= 500,000 (2.335) + 200,000 \\ &= 319,250 \end{aligned}$$

The cash flow diagram for the manufacturer 2 is shown below.



$$\begin{aligned} \Delta E_2(20\%) &= 400,000 (A/P, 20\%, 10) + 300,000 \\ &= 400,000 (2.335) + 300,000 \\ &= \text{Rs. } 395,400. \end{aligned}$$

Alternative 3: The cash flow diagram for the manufacturer 3 is shown below.



$$\begin{aligned} \Delta E_3(20\%) &= 600,000 (A/P, 20\%, 10) + 150,000 \\ &= 600,000 (2.335) + 150,000 \\ &= \text{Rs. } 293,100. \end{aligned}$$

Determine the best alternative based on the annual equivalent method by assuming $i = 20\%$.

Alternative 1: The cash flow diagram for the manufacturer 1 is shown below.

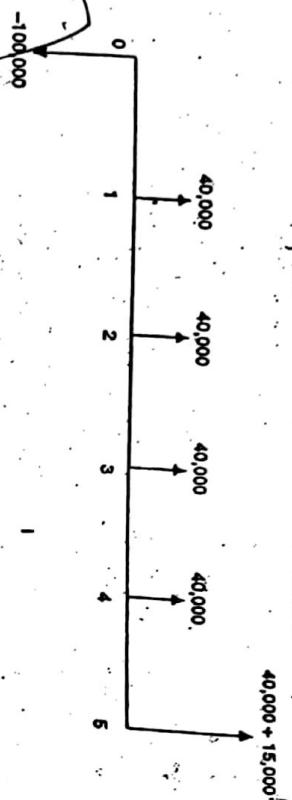
Alternative 2: The cash flow diagram for the manufacturer 2 is shown below.

Alternative 3: The cash flow diagram for the manufacturer 3 is shown below.

Determine the best alternative based on the annual equivalent method by assuming $i = 25\%$.

Solution.

Alternative A: The cash flow diagram for the alternative A is shown below.

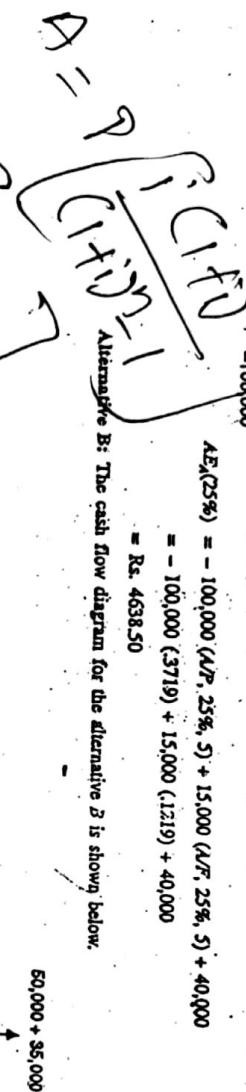


$$\Delta E_A(25\%) = -100,000 (AP, 25\%, 5) + 15,000 (AF, 25\%, 5) + 40,000$$

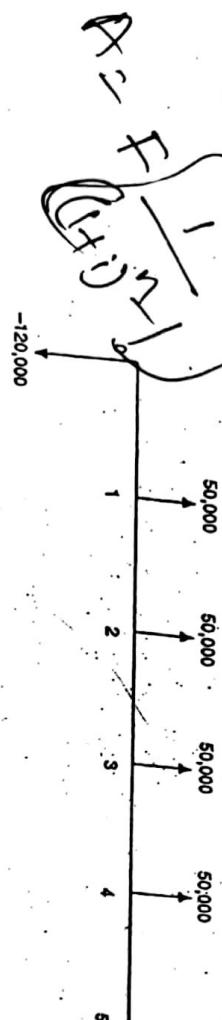
$$= -100,000 (3.719) + 15,000 (1.219) + 40,000$$

$$= \text{Rs. } 4638.50$$

Alternative B: The cash flow diagram for the alternative B is shown below.



$$50,000 + 35,000$$



$$\Delta E_B(25\%) = -120,000 (AP, 25\%, 5) + 35,000 (AF, 25\%, 5) + 50,000$$

$$= -120,000 (3.719) + 35,000 (1.219) + 50,000$$

$$= \text{Rs. } 9638.50$$

The annual equivalent net return of the alternative B is more than that of the alternative A.

Hence, the company should select the alternative B.

Example 3.17. A certain individual firm desires an economic analysis to determine which of the two machines is attractive in a given amount of time. The minimum attractive rate of return for the firm is 12%. The following data are to be used in the analysis.

Capacity Planning and Investment Decisions

Alternative	0	1	2	3	4
1	-5,00,000	1,700,000	1,700,000	1,700,000	1,700,000
2	-5,30,000	1,800,000	1,800,000	1,800,000	1,800,000

Production and Operations Management

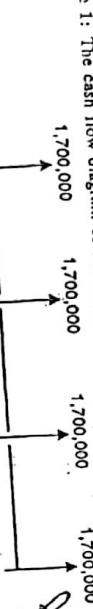
Example 3.18. Consider the following mutually exclusive alternatives.

End of Year	0	1	2	3	4
Alternative	0	1,700,000	1,700,000	1,700,000	1,700,000
1	-5,00,000	1,800,000	1,800,000	1,800,000	1,800,000

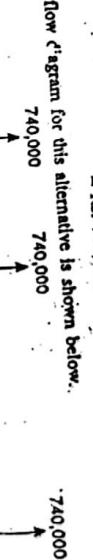
$i = 12\%$, select the best alternative based on future worth method.

Solution.

Alternative 1: The cash flow diagram of the alternative 1 is shown below.



The cash flow diagram for this alternative is shown below.



Evaluate the alternatives based on future worth method at $i = 12\%$.

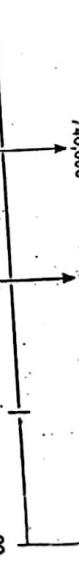
Alternative 1: Build Gas Station.

$$\text{Net annual income} = \text{Annual income} - \text{Annual property tax}$$

$$= \text{Rs. } 830,000 - \text{Rs. } 90,000$$

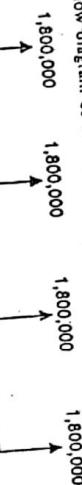
$$= \text{Rs. } 740,000$$

The cash flow diagram for this alternative is shown below.



$$\begin{aligned} FW_A(12\%) &= -5,00,000 (F/P, 12\%, 4) + 1,700,000 (F/A, 12\%, 4) \\ &= -5,00,000 (1.574) + 1,700,000 (4.779) \\ &= 254,300 \end{aligned}$$

Alternative 2: The cash flow diagram of the alternative 2 is shown below.



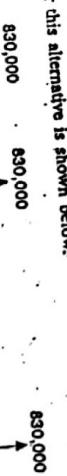
Alternative 2: Build Soft Ice-Cream Stand.

$$\text{Net annual income} = \text{Annual income} - \text{Annual property tax}$$

$$= \text{Rs. } 980,000 - \text{Rs. } 150,000$$

$$= \text{Rs. } 830,000$$

The cash flow diagram for this alternative is shown below.



$$\begin{aligned} FW_A(12\%) &= -5,30,000 (F/P, 12\%, 4) + 1,800,000 (F/A, 12\%, 4) \\ &= -5,30,000 (1.574) + 1,800,000 (4.779) \\ &= 260,000 \end{aligned}$$

The future worth of the net revenue of the alternative 2 is greater than that of the alternative 1.

Hence, the alternative 2 should be selected. Hence, the alternative 2 should be selected.

Example 3.19. A man owns a corner plot. He must decide which of the several alternatives he decides in trying to obtain a desirable return on his investment. After much study and calculation, he decides that the two best alternatives are as shown in the following table.

$$PW_2(12\%) = -3,600,000 (P/F, 12\%, 20) + 830,000 (P/A, 12\%, 20)$$

$$= -3,600,000 (0.064) + 830,000 (7.2052)$$

$$\Rightarrow \text{Rs. } -23,077,560$$

The future worth net revenue of the alternative 1 is greater than that of the alternative 2. Hence, building the gas station is the best alternative.

Example 3.20. Mr. Krishna Castlers Ltd. is planning to replace its annealing furnace. It has received tenders from three different official manufacturers of annealing furnaces. The details are as follows. Which is the best alternative based on future worth method at $i = 20\%$?

	Manufacturer		
Initial cost (Rs.)	1,000,000	7,000,000	9,000,000
Life (years)	10	10	10
Annual operation and maintenance cost (Rs.)	800,000	900,000	850,000
Salvage value after 10 years	500,000	400,000	700,000

Solution:

Alternative 1: Manufacturer 1

The cash flow diagram for this alternative is shown below.



$$PW_1(20\%) = 1,000,000 (P/F, 20\%, 10) + 800,000 (P/A, 20\%, 10) - 500,000$$

$$= 1,000,000 (0.192) + 800,000 (7.5939) - 500,000$$

$$\Rightarrow \text{Rs. } 69,803,200$$

Alternative 2: Manufacturer 2

The cash flow diagram for this alternative is shown below.



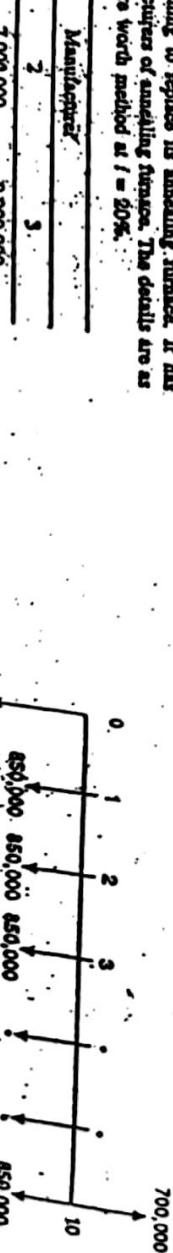
$$PW_2(20\%) = 7,000,000 (P/F, 20\%, 10) + 900,000 (P/A, 20\%, 10) - 400,000$$

$$= 7,000,000 (0.192) + 900,000 (7.5939) - 400,000$$

$$\Rightarrow \text{Rs. } 66,307,100$$

Alternative 3: Manufacturer 3

The cash flow diagram for this alternative is shown below.



$$PW_3(20\%) = 9,000,000 (P/F, 20\%, 10) + 850,000 (P/A, 20\%, 10) - 700,000$$

$$= 9,000,000 (0.192) + 850,000 (7.5939) - 700,000$$

$$\Rightarrow \text{Rs. } 77,093,150$$

The future worth cost of the alternative 2 is lesser than that of the other two alternatives. Hence, Mr. Krishna castles should buy the annealing furnace from the manufacturer 2.

Rate of return method. Rate of return of a cash flow is the interest rate at which the present worth of that cash flow reduces to zero. In this method of comparison, the rate of return of alternative is computed. Then the alternative which has the highest rate of return is selected as best alternative.

Example 3.21. A company is planning to expand its present business activity. It has two alternative for the expansion programme and corresponding cash flows are given in the following table. Evaluate alternative has a life of 5 years and a negligible salvage value. Evaluate them based on the rate of return method and suggest the best alternative to the company.

	Initial Investment (Rs.)	Yearly Revenue (Rs.)
Alternative 1	500,000	150,000
Alternative 2	800,000	250,000

Solution:

Alternative 1: The present worth function of the alternative 1 is given as:

$$PW_1 = -500,000 + 150,000 (P/A, i, 5) \quad P = A \left[\frac{(1+i)^5 - 1}{i} \right]$$

The above function approximately reduces to zero at 15.24% interest rate. Hence, the

return of the expansion programme as per the alternative 1 is 15.24%.

Alternative 2: The present worth function of the alternative 2 is as follows:

$$PW_2 = -800,000 + 250,000 (P/A, i, 5)$$

Production and Operations Management

The above function approximately reduces to zero at 17% interest rate. Hence, the rate of return of the expansion programme as per the alternative 2 is more than that of the alternative 1, the alternative 2 is more than that of the alternative 1.

Since, the rate of return of the alternative 2 is more than that of the alternative 1, the alternative 2 is more than that of the alternative 1.

QUESTIONS

Distinguish between design capacity and system capacity.
A company has seven stations. The individual capacity of the stations is 800 units per week. If the actual output of the product line is 800 units per week, find
the system capacity.

The system efficiency of the system manufacturing electric motors has seven stations. The individual capacity of the stations is 800 units per week. If the actual output of the product line is 800 units per week, find
the system capacity.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Company has to select the best alternative among the following three alternatives based on present.

Capacity Planning and Investment Decisions

7. A suburban taxi company is considering buying taxis with diesel engines instead of petrol engines. The car averages 60,000 km a year with a useful life of three years for taxi with the petrol engines, and four years for the diesel taxi. Other comparative data are as follows:

Vehicle cost (Rs.)	Diesel.	Petrol
Initial cost (Rs.)	390,000	360,000
Annual repairs (Rs.)	9,000	15,000
Mileage in km/km	15,000	60,000
Annual insurance premium (Rs.)	60,000	45,000
Resale value at the end of life (Rs.)	90,000	30,000

8. A company must decide whether to buy Machine A or Machine B. Determine the more economical choice if interest rate is 20%.

	Machine A	Machine B
Initial cost (Rs.)	200,000	300,000
Useful life (Yrs.)	30,000	30,000

9. A trucking company has been looking for a new tire for its vehicle and has located the following alternatives.

Brand	Tire Warranty	Price per Tire
A	12 Months	Rs. 1200
B	24 Months	Rs. 1800
C	36 Months	Rs. 2100
D	48 Months	Rs. 2700

At 15% interest rate, which machine should be purchased?

At 15% interest rate, which machine should be purchased?

At 15% interest rate, which machine should be purchased?

At 15% interest rate, which machine should be purchased?

At 15% interest rate, which machine should be purchased?

At 15% interest rate, which machine should be purchased?

At 15% interest rate, which machine should be purchased?

At 15% interest rate, which machine should be purchased?

At 15% interest rate, which machine should be purchased?

At 15% interest rate, which machine should be purchased?

At 15% interest rate, which machine should be purchased?

At 15% interest rate, which machine should be purchased?

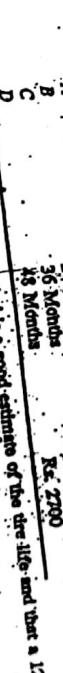
At 15% interest rate, which machine should be purchased?

At 15% interest rate, which machine should be purchased?

At 15% interest rate, which machine should be purchased?



10. The cash flow diagram of two different mutually exclusive alternatives are given below.



Aims and Functions of Finance

and discretely used) Investment decisions allocate and ration the resources among the competing investment alternatives or opportunities. The effort is to find out the projects, which are acceptable.

(Investment decisions relate to the total amount of assets to be held and their composition in the form of fixed and current assets) Both the factors influence the risk the organisation is exposed to. The more important aspect is how the investors perceive the risk.

(The investment decisions result in purchase of assets. Assets can be classified under two broad categories:)

- (i) Long-term investment decisions – Long-term assets
- (ii) Short-term investment decisions – Short-term assets)

Long-term Investment Decisions: (The long-term capital decisions are referred to as capital budgeting decisions, which relate to fixed assets) (The fixed assets are long term, in nature) (Basically, fixed assets create earnings to the firm) (They give benefit in future) (It is difficult to measure the benefits as future is uncertain.)

(The investment decision is important not only for setting up new units but also for expansion of existing units) (Decisions related to them are, generally, irreversible. Often, reversal of decisions results in substantial loss) (When a brand new car is sold, even after a day of its purchase, still, buyer treats the vehicle as a second-hand car. The transaction, invariably, results in heavy loss for a short period of owning. So, the finance manager has to evaluate profitability of every investment proposal, carefully, before funds are committed to them.)

Short-term Investment Decisions: (The short-term investment decisions are, generally, referred as working capital management) (The finance manager has to allocate among cash and cash equivalents, receivables and inventories) (Though these current assets do not, directly, contribute to the earnings, their existence is necessary for proper, efficient and optimum utilisation of fixed assets)

(B) Finance Decision

Once investment decision is made, the next step is how to raise finance for the concerned investment) (Finance decision is concerned with the mix or composition of the sources of raising the funds required by the firm) (In other words, it is related to the pattern of financing) In finance decision, (the finance manager is required to determine the proportion of equity and debt, which is known as capital structure) There are two main sources of funds, shareholders' funds (variable in the form of dividend) and borrowed funds (fixed interest-bearing). These sources have their own peculiar characteristics. The key distinction lies in the fixed commitment. (Borrowed funds are to be paid interest, irrespective of the profitability of the firm) Interest has to be paid, even if the firm incurs loss and this permanent obligation is not there with the funds raised from the shareholders. The borrowed funds are relatively cheaper compared to shareholders' funds, however they carry risk. This risk is known as financial risk i.e. Risk of insolvency due to non-payment of interest or non-repayment of borrowed capital.

On the other hand, the shareholders' funds are permanent source to the firm. The shareholders' funds could be from equity shareholders or preference shareholders. Equity share capital is not repayable and does not have fixed commitment in the form of dividend. However, preference share

3rd Meek

~~and risk profile of the organisation. When the nature of business is such that the production does not commence immediately, and requires long gestation period, it is necessary to have the long-term sources like share capital, debentures and long term loan etc. A concern with longer gestation period does not have profits for some years. So, the firm should rely more on the permanent capital like share capital to avoid interest burden on the borrowing component.~~

- ~~2. Proper Utilisation of Funds: Raising funds is important, more than that is its proper utilisation. If proper utilisation of funds were not made, there would be no revenue generation. Benefits should always exceed cost of funds so that the organisation can be profitable. Beneficial projects only are to be undertaken. So, it is all the more necessary that careful planning and cost-benefit analysis should be made before the actual commencement of projects.~~
- ~~3. Increasing Profitability: Profitability is necessary for every organisation. The planning and control functions of finance aim at increasing profitability of the firm. To achieve profitability, the cost of funds should be low. Idle funds do not yield any return, but incur cost. So, the organisation should avoid idle funds. Finance function also requires matching of cost and returns of funds. If funds are used efficiently, profitability gets a boost.~~
- ~~4. Maximising Firm's Value: The ultimate aim of finance function is maximising the value of the firm, which is reflected in wealth maximisation of shareholders. The market value of the equity shares is an indicator of the wealth maximisation.~~

1.7 FUNCTIONS OF FINANCE

Finance function is the most important function of a business. Finance is closely connected with production, marketing and other activities. In the absence of finance, all these activities come to a halt. In fact, only with finance, a business activity can be commenced, continued and expanded. Finance exists everywhere, be it production, marketing, human resource development or undertaking research activity. Understanding the universality and importance of finance, finance manager is associated, in modern business, in all activities as no activity can exist without funds.

Financial Decisions or Finance Functions are closely inter-connected. All decisions mostly involve finance. When a decision involves finance, it is a financial decision in a business firm. In all the following financial areas of decision-making, the role of finance manager is vital. We can classify the finance functions or financial decisions into four major groups:

- (A) Investment Decision or Long-term Asset mix decision
- (B) Finance Decision or Capital mix decision
- (C) Liquidity Decision or Short-term asset mix decision
- (D) Dividend Decision or Profit allocation decision

(A) Investment Decision

Investment decisions relate to selection of assets in which funds are to be invested by the firm.
Investment alternatives are numerous. Resources are scarce and limited. They have to be rationed

L(IV)

(3)

capital has a fixed commitment, in the form of dividend and is redeemable, if they are redeemable preference shares.

Barring a few exceptions, every firm tries to employ both borrowed funds and shareholders' funds to finance its activities. The employment of these funds, in combination, is known as financial leverage. Financial leverage provides profitability, but carries risk. Without risk, there is no return. This is the case in every walk of life!

When the return on capital employed (equity and borrowed funds) is greater than the rate of interest paid on the debt, shareholders' return get magnified or increased. In period of inflation, this would be advantageous while it is a disadvantage or curse in times of recession.

Example:

<i>Total investment:</i>	Rs.	1,00,000
Return		15%.
<i>Composition of Investment:</i>		
Equity	Rs.	60,000
Debt @ 7% Interest	Rs.	40,000
<i>Return on Investment</i>		
@ 15%	Rs.	15,000
Interest on Debt	Rs.	2,800
7% on Rs.40,000		
Earnings available to Equity shareholders	Rs.	12,200

Return on equity (ignoring tax) is 20%, which is at the expense of debt as they get 7% interest only.

In the normal course, equity would get a return of 15%. But they are enjoying 20% due to financing by a combination of debt and equity.

This area would be discussed in detail while dealing with Leverages, in the later chapter.

The finance manager follows that combination of raising funds which is optimal mix of debt and equity. The optimal mix minimises the risk and maximises the wealth of shareholders.

(C) Liquidity Decision

Liquidity decision is concerned with the management of current assets. (Basically, this is Working Capital Management.) Working Capital Management is concerned with the management of current assets. (It is concerned with short-term survival.) Short term-survival is a prerequisite for long-term survival.)

When more funds are tied up in current assets, the firm would enjoy greater liquidity. In consequence, the firm would not experience any difficulty in making payment of debts, as and when they fall due. (With excess liquidity, there would be no default in payments.) So, there would be no threat of insolvency for failure of payments. However, funds have economic cost. Idle

current assets do not earn anything) Higher liquidity is at the cost of profitability. Profitability would suffer with more idle funds. Investment in current assets affects the profitability, liquidity and risk. A proper balance must be maintained between liquidity and profitability of the firm. This is the key area where finance manager has to play significant role. The strategy is in ensuring a trade-off between liquidity and profitability. This is, indeed, a balancing act and continuous process. It is a continuous process as the conditions and requirements of business change, time to time. In accordance with the requirements of the firm, the liquidity has to vary and in consequence, the profitability changes. This is the major dimension of liquidity decision-working capital management. Working capital management is day to day problem to the finance manager. His skills of financial management are put to test, daily.

(D) Dividend Decision

(Dividend decision is concerned with the amount of profits to be distributed and retained in the firm.)

Dividend: The term 'dividend' relates to the portion of profit, which is distributed to shareholders of the company. It is a reward or compensation to them for their investment made in the firm. The dividend can be declared from the current profits or accumulated profits.

Which course should be followed – dividend or retention? Normally, companies distribute certain amount in the form of dividend, in a stable manner, to meet the expectations of shareholders and balance is retained within the organisation for expansion. If dividend is not distributed, there would be great dissatisfaction to the shareholders. Non-declaration of dividend affects the market price of equity shares, severely. One significant element in the dividend decision is, therefore, the dividend payout ratio i.e. what proportion of dividend is to be paid to the shareholders. The dividend decision depends on the preference of the equity shareholders and investment opportunities, available within the firm. (A higher rate of dividend, beyond the market expectations, increases the market price of shares) However, it leaves a small amount in the form of retained earnings for expansion. The business that reinvests less will tend to grow slower. The other alternative is to raise funds in the market for expansion. It is not a desirable decision to retain all the profits for expansion, without distributing any amount in the form of dividend.

There is no ready-made answer, how much is to be distributed and what portion is to be retained. Retention of profit is related to

- Reinvestment opportunities available to the firm.
- Alternative rate of return available to equity shareholders, if they invest themselves.

1.8 INTER-RELATIONSHIP OF FINANCE FUNCTIONS OR DECISIONS

All the major functions or decisions – Investment function, Finance function, Liquidity function and Dividend function, are inter-related and inter-connected. They are inter-related because the goal of all the functions is one and the same. Their ultimate objective is only one – achievement of maximisation of shareholders' wealth or maximising the market value of the shares.