# MODULE 3

## INTRODUCTION: ENGINEERING AND ECONOMICS

### LESSON STRUCTURE:



### OBJECTIVES:

- Study engineering and Economics, basic laws of Economics, simple and compound interest.
- This chapter discusses the elements of economics and the interaction between its various components. This is followed by an analysis of the need and scope of engineering economics.

This chapter discusses the elements of economics and the interaction between its various components. This is followed by an analysis of the need and scope of engineering economics. Later, elements of cost and break-even analysis are presented.

### 1.1. Introduction To Economics

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

The following are the economic goals.

1. A high level of employment
2. Price stability
3. Efficiency
4. An equitable distribution of income
5. Growth

Some of the above goals are interdependent. The economic goals are not always complementary; in many cases they are in conflict.

For example, any move to have a significant reduction in unemployment will lead to an increase in inflation.

## 1.2. Definition and Scope of Engineering Economics

As stated earlier, efficient functioning of any business organization would enable it to provide goods/services at a lower price. In the process of managing organizations, the managers at different levels should take appropriate economic decisions which will help in minimizing investment, operating and maintenance expenditures besides increasing the revenue, savings and other related gains of the organization.

**Definition**

Engineering economics deals with the methods that enable one to take economic decisions towards minimizing costs and/or maximizing benefits to business organizations.

**Scope**

The issues that are covered in this book are elementary economic analysis, interest formulae, bases for comparing alternatives, present worth method, future worth method, annual equivalent method, rate of return method, replacement analysis, depreciation, evaluation of public alternatives, inflation adjusted investment decisions, make or buy decisions, inventory control, project management, value engineering, and linear programming.

## 1.3. 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***.

## 1.4. Factors influencing demand

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

1. Income of the people
2. Prices of related goods
3. 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, 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.

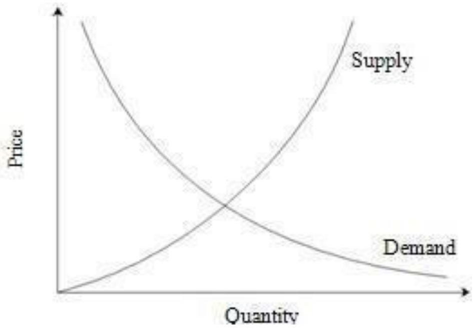


**Fig. 1.2** Demand and supply curve

## 1.5. Factors influencing supply

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

1. Cost of the inputs
2. Technology
3. Weather
4. 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 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 woolen goods will be increased in winter. So, naturally, manufacturers will supply more volume of woolen 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.

## 1.6. 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 1.1.

Table 1.1 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

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

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. 1.3. This explanation assumes that the inflation is at zero percentage.

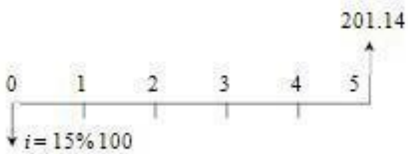


**Fig. 1.3** Time value of money.

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 at a given interest rate, say 15%? A detailed working is shown in Table 1.2.

**Table 1.2** 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 From Table 1.2, 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 $10^{th}$ 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.

3. 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.

## 1.7. Interest Formulas

While making investment decisions, computations will be done in many ways. To simplify all these computations, it is extremely important 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 can be classified into ***simple interest rate*** **and** ***compound interest rate***.

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

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

$P$ = principal amount

$n$ = No. of interest periods

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

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

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

$G$ = uniform amount which will be added/subtracted period after period to/ from the amount of deposit A1 at the end of period 1

### I. 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.1.4.

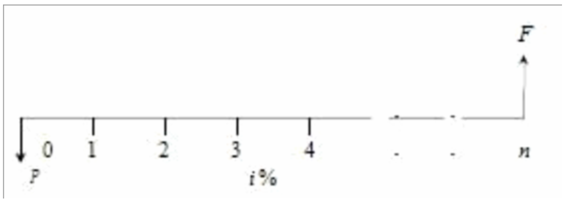


**Fig.1.4** Cash flow diagram of single-payment compound amount

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.

***EXAMPLE 1.1*** 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 10 years.

***Solution***

$P$ = Rs. 20,000

i = 18% compounded annually

$n$ = 10 years

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

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

### II. 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. 1.5

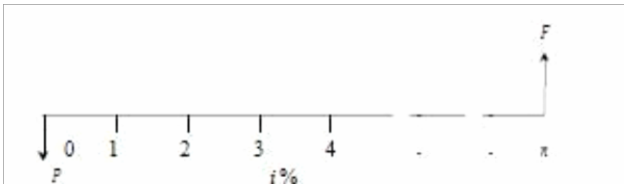


**Fig.1.5** Cash flow diagram of single-payment present worth amount.

where

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

***EXAMPLE 1.2*** A person wishes to have a future sum of Rs. 1,00,000 for 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.

***Solution***

$F$ = Rs. 1,00,000

$i$ = 15%, compounded annually

$n$ = 10 years

$$P = F/(1 + i)^n$$
$$= F(P/F, i, n)$$
$$=1,00,000\ (P/F,\ 15\%,\ 10)$$
$$=1,00,000*0.2472$$
$$= \text{Rs. } 24,720$$

The person has to invest Rs. 24,720 now so that he will get a sum of Rs. 1,00,000 after 10 years at 15% interest rate compounded annually.

### III. 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.1.6

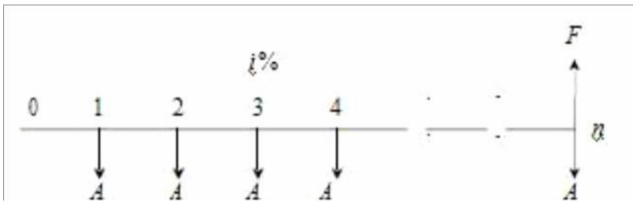


**Fig.1.6** Cash flow diagram of equal-payment series compound amount.

In Fig. 1.6,

$A$ = 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

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

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

where

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

***EXAMPLE 1.3*** A person who is now 35 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 the next 25 years starting from the end of the next year. The bank gives 20% interest rate, compounded annually. Find the maturity value of his account when he is 60 years old.

***Solution***

$A$ = Rs. 10,000

$n$ = 25 years

$i$ = 20%

$F$ = ?

The corresponding cash flow diagram is shown in Fig.1.7

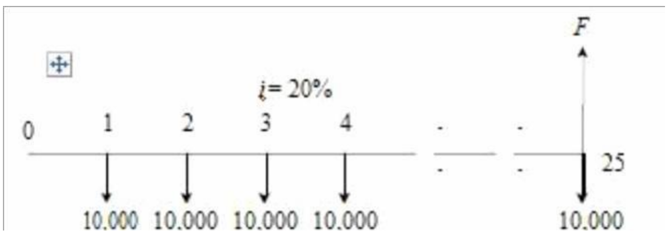


Fig.1.7 Cash flow diagram of equal-payment series compound amount.

$$
\begin{aligned}
F &= A\,\frac{(1+i)^n - 1}{i} \\
&= A(F/A, i, n) \\
&= 10{,}000(F/A, 20\%, 25) \\
&= 10{,}000 \times 471.981 \\
&= \text{Rs. } 47{,}19{,}810
\end{aligned}
$$

The future sum of the annual equal payments after 25 years is equal to Rs. 47, 19,810.

### IV. 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.1.8

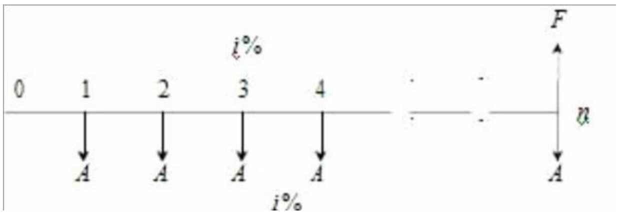


**Fig.1.8** Cash flow diagram of equal-payment series sinking fund.

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

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

where

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

***EXAMPLE 1.4*** 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 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.

***Solution***

$F$ = Rs. 5,00,000

$n$ = 15

years

$i$ = 18%

$A$ = ?

The corresponding cash flow diagram is shown in Fig.1.9

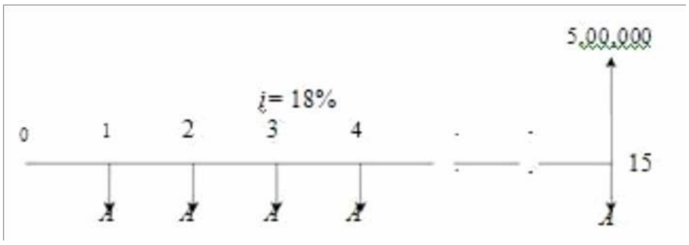


**Fig. 1.9** Cash flow diagram of equal-payment series sinking fund.

$$\text{i}$$

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

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

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

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

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

## V. 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.1.10 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.*

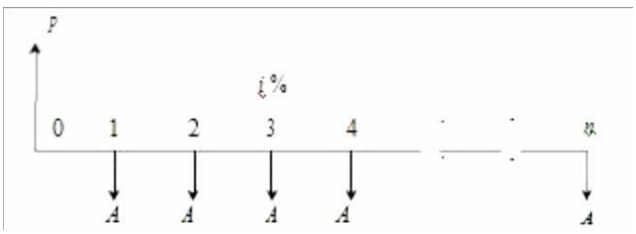

**Fig.1.10** Cash flow diagram of equal-payment series present worth amount

***EXAMPLE 1.5*** A company wants to set up a reserve which will help the company to have an annual equivalent amount of Rs. 10,00,000 for the next 20 years towards its employees welfare measures. The reserve is assumed to grow at the rate of 15% annually. Find the single-payment that must be made now as the reserve amount.

***Solution***

$A$ = Rs. 10,00,000

$i$ = 15%

$n$ = 20 years

$P$ = ?

The corresponding cash flow diagram is illustrated in Fig.1.11

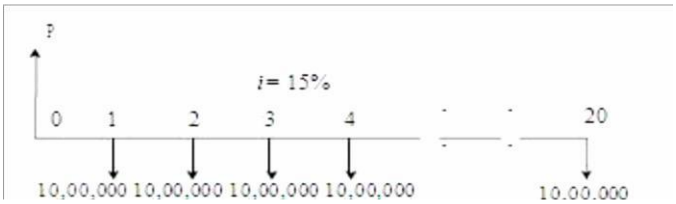


**Fig.1.11** Cash flow diagram of equal-payment series present worth amount

=10, 00,000 * ($P$/$A$, 15%, 20)

= 10, 00,000 * 6.2593

=Rs. 62, 59,300

The amount of reserve which must be set-up now is equal to Rs. 62, 59,300.

## VI. 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.1.12).

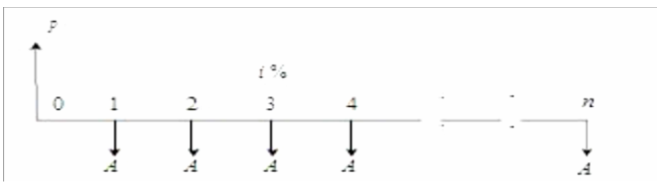


**Fig.1.12** Cash flow diagram of equal-payment series capital recovery amount.

In Fig.1.12,

$P$ = 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*.

***EXAMPLE 1.6*** A bank gives a loan to a company to purchase equipment worth Rs.10, 00,000 at an interest rate of 18% 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* = Rs. 10, 00,000

*i* = 18%

*n* = 15 years

*A* = ?

The corresponding cash flow diagram is shown in Fig.1.13

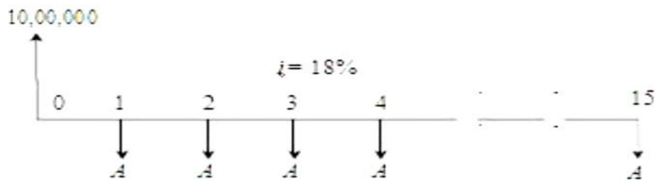


**Fig.1.13** Cash flow diagram of equal-payment series capital recovery amount

= 10, 00,000 * (*A*/*P*, 18%, 15)

= 10, 00,000 * (0.1964)

=Rs. 1, 96,400

The annual equivalent installment to be paid by the company to the bank is Rs. 1, 96,400

## VII. 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 *A*1 at the end of the first year and wth 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.1.14

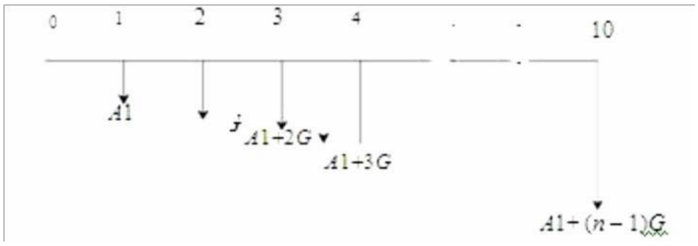


**Fig.1.14** Cash flow diagram of uniform gradient series annual equivalent amount The formula to compute $A$ under this situation is

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

where

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

***EXAMPLE 1.7*** A person is planning for his retired life. He has 10 more years of service. He would like to deposit 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 9 years with an interest rate of 15%. Find the total amount at the end of the 10th year of the above series.

***Solution*** Here,

$A1$ = Rs. 4,000

$G$ = Rs. 500

$i$ = 15%

$n$ = 10 years

$A$ = ?& $F$ = ?

The cash flow diagram is shown in Fig.1.15

**Fig.1.15** Cash flow diagram of uniform gradient series annual equivalent amount

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

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

$= 4{,}000 + 500 * 3.3832$

=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)

=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.

**OUTCOMES:**

At the end of the unit, the students are able to:

- Define engineering, economics and identify their relation between them.
- Analyze basic laws of economics.
- Define and derive simple and compound interest.
- Solve numerical problems.

**SELF-TEST QUESTIONS:**

1. Define engineering economics.
2. Brief about 'Problem solving technique' used in engineering economics.
3. Define law of demand.
4. Define law of supply.
5. Derive interest formula for Single-Payment Compound Amount factor
6. Derive interest formula for Single-Payment Present Worth Amount factor
7. Derive interest formula for Equal-Payment Series Compound Amount factor
8. Derive interest formula for Equal-Payment Series Present Worth Amount factor
9. Derive interest formula for Equal-Payment Series Capital Recovery Amount factor
10. An engineer has his last 10 years of service. Determine the amount to be deposited at the end of every year, if he wishes to withdraw Rs 15,000/- every year for 8 years after his requirement. The amount deposited earns an interest of 10% compounded annually. Also calculate the savings of his depositions if interest is compounded half yearly.
11. 'Mr. X' deposits Rs 1,000/- at the end of each year which pays an interest 6% compounded annually. How long does it take to accumulate Rs 20,000/-. What is the actual amount accumulated?

**FURTHER READING:**


1. **Engineering Economy,** Tarachand, 2000.
2. **Industrial Engineering and Management**, OP Khanna, Dhanpat Rai & Sons. 2000
3. **Financial Mangement,** Prasanna Chandra, 7th Ed., TMH, 2004
4. **Finacial Management,** IM PANDEY, Vikas Pub. House, 2002