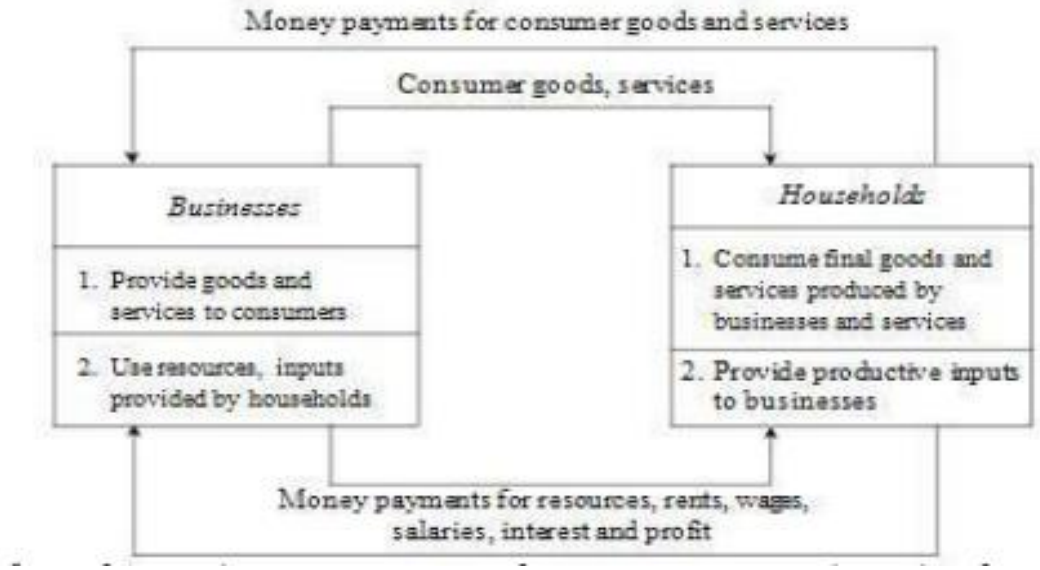
INTRODUCTION TO ENGINEERING ECONOMY:

The word Economics has been derived from 2 Greek words, namely. Oikus and Nemein. Oikus means 'household' and Nemein means 'Management'. Economics as a science deals with the problem of allocation resources among competing ends and giving maximum satisfaction at minimum cost.

ECONOMICS is the science that deals with the production and consumption of goods and services and the distribution and rendering of these for human welfare. The following are the economic goals.

· A high level of employment · Price stability · Efficiency · an equitable distribution of income · Growth.

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. Flow in an Economy The flow of goods, services, resources and money payments in a simple economy are shown in Fig. 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. Business organizations make payment of money to the households for receiving various resources. The households in turn make payment of money to business organizations for receiving consumer goods and services. This cycle shows the interdependence between the two major entities in a simple economy.



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.

Engineering Economy is the application of economic factors and criteria to evaluate alternatives by computing a specific measure of worth of estimated cash flows over a specific period of time.

Engineering economic analysis can play a role in many types of situations:

- Choosing the best design for a high-efficiency gas furnace.
- Selecting the most suitable robot for a welding operation on an automotive assembly line.
- Overnight delivery service should be purchased or leased.
- Determining the optimal staffing plan for a computer help desk.

PRINCIPLES OF ENGINEERING ECONOMY

1. Develop the Alternatives: The final choice (decision) is among alternatives. The alternatives need to be identified and then defined for subsequent analysis.

2. **Focus on the Differences:** Only the differences in expected future outcomes among the alternatives are relevant to their comparison and should be considered in the decision.

3**. Use a Consistent Viewpoint**: The prospective outcomes of the alternatives, economic and other, should be consistently developed from a defined viewpoint (perspective).

4. **Use a Common Unit of Measure**: Using a common unit of measurement to enumerate as many of the prospective outcomes as possible will make easier the analysis and comparison of alternatives.

5. **Consider All Relevant Criteria** Selection of a preferred alternative (decision making) requires the use of a criterion (or several criteria).

6. **Make Uncertainty Explicit** Uncertainty is inherent in projecting (or estimating) the future outcomes of the

alternatives and should be recognized in their analysis and comparison.

7. **Revisit Your Decisions** Improved decision making results from an adaptive process; to the extent practicable, the initial projected outcomes of the selected alternative should be subsequently compared with actual results achieved.

MICROECONOMICS VS. MACROECONOMICS

Micro economics: It is the study of markets, and segments of the economy. It looks at issues such as consumer behavior, individual labour markets, and the theory of firms.

Micro economics is concerned with:

- Supply and demand in individual markets
- Individual consumer behavior .e.g. consumer choice theory
- Individual labour markets-e.g. demand for labour, wage determination
- Externalities arising from production and consumption .e.g. Externalities

Micro economics: It is the study of the whole economy. It looks at 'aggregate' variables, such as aggregate demand, national output and inflation.

Macroeconomics is concerned with:

- Monetary/ fiscal policy
- Reasons for inflation and unemployment
- Economic growth
- International trade and globalization
- Reasons for differences in living standards and economic growth between countries.
- Government borrowing.

Micro economics	**Macro Economics**
Micro economics is the study of economics at an individual, group or company level	Macroeconomics is the study of a national economy as a whole
It focuses on issues that affect individuals and companies. This could mean studying the supply and demand for a specific product, the production that an	Macroeconomics focuses on issues that affect the economy as a whole. Some of the most common focuses of macroeconomics include unemployment

individual or business is capable of the effects of regulations on a business	rates, the gross domestic product of an economy, and the effects of exports and imports.
Micro means very small or millionth part	Macro means large o whole
The subject or example of micro economics is about person, an investor, a producer	The subject of macroeconomics is about national production, national income, income level
As it analyzes individually, it provides a partial concept or partial figure of a country	As it analyzes overall, it provides full figures or complete refection of a country
It is concerned with the individual entities	It is concerned with overall performance of the country

PROBLEMS SOLVING AND DECISION MAKING

The fundamental approach to problem solving is scientific methods used both theoretical and practical knowledge to solve the same. It takes real world facts and figure and symbolic world of theories and hypothesis to solve problems through an iterative process.

- Problems in engineering and managerial economy originate in real world of economic planning, management and control.
- Problem is defined and clarified by date from the real world.
- This information is subjected to analysis based on scientific principles to formulae hypothesis in symbolic terms.
- By manipulating and experimenting, an analyst can stimulate and project reality in multiple configurations to understand outcomes.

The seven-step process is an excellent tool that can guide you in solving problems and making those sound and timely decisions. The seven steps are:

1. Identify (recognize/define) the problem.

2. Gather information (facts/assumptions).

3. Develop courses of action (solutions).

4. Analyze and compare courses of action (alternatives/solutions).

5. Make a decision; select the best course of action (solution).

6. Make a plan.

7. Implement the plan (assess the results).

- Define the problem.

The problem needs to be assessed and understood. Ask yourself the following questions:

■ In what area is the problem (e.g., school, work, relationships, finances, etc.)?

■ Who are the people involved in the problem?

■ How did this problem come about?

■ What would I like to change?

■ What is realistic to expect in this situation?

PROBLEM SOLVING TIPS

If you have multiple stressors (e.g., increased responsibilities at work, upcoming exams), prioritize your time. Focus on the most important issues first.

■ Time management is a positive way to reduce stress and anxiety. In addition, it will ensure you have the time you need to work on resolving problems (instead of simply meeting your basic needs and important deadlines).

■ Break large demands into small, manageable parts. Work through one task at a time.

■ Be clear about your goals and what you need to do to work toward them.

■ Take action when stress first arises. Don't wait for the situation to worsen.

■ When a problem arises, identify your needs and articulate them to people who can help.

■ Acknowledge your thoughts and feelings concerning the stressors in your life.

■ Develop a support network to rely on in times of need.

■ Don't dwell on "should." Instead, remain focused on what you think you need to do to solve your problem.

■ Be willing to take an honest look at your coping style and the effectiveness of the strategies you are trying.

■ Be flexible. If something isn't working, it's time to try something new.

■ Remember to be kind to yourself.

Tips on Making Good Decisions

■ Avoid the temptation to make an impulsive decision in order to get out of the work of decision-making. While there is a time and place for quick decisions, generally good decisions have been given some thought.

■ Take the time you need to think things over, but don't use this as an excuse to avoid. Not making a decision is, in and of itself, a decision.

■ Over-focusing on making the "right" decision can leave you stuck. And sometimes, there isn't a "right" decision. Remember, you are looking for a good decision. And you can always continue to decision-make in response to your initial decision.

■ Use your head. If you make a particular decision, can you explain it to others? Is it reasonable? Does it make sense?

■ Listen to yourself. Your gut reaction/intuition is important. If a particular course of action doesn't feel right, don't pursue it.

■ Take some time to consider what you think will happen if you choose one decision over another. Where will the different

decisions take you? Where do you want to go?

■ Consider how each of your possible decisions might impact the people involved. Will a particular decision harm you orsomeone else?

■ Pay attention to how you will you feel about yourself if you make one decision instead of another. Will you be proud ofyourself? Can you live with yourself?

■ Ask yourself if your decision is ethical.

■ Talk it out. Reviewing your options with a trusted friend can help you sort out what to do.

■ Make it your own. Resist the temptation to allow others to make difficult decisions for you. This only serves to reduce your confidence and ability to set your own course.

■ Learn from your experience. Pay attention to what you have done to make good decisions and poor decisions. When situations and problems repeat themselves, take the opportunity to improve your decision-making.

■ Give yourself a break. We all have times when we make decisions we later wish we hadn't. Forgive yourself and move on.

INTREST AND TIME VALUE OF MONEY:

TIME VALUE OF MONEY

The time value of money is the greater benefit of receiving money now rather than an identical sum later. It is founded on time preference. The time value of money explains why interest is paid or earned. Interest, whether it is on bank deposit or debt , compensates the depositor or lender for the time value of money. It also underlies investment.

Investors are willing to spend their money now, only if they expect a favorable return on their investment in the future, such as the increased value to be available later in sufficiently high to offset the preference to have money now.

INTEREST FORMULAS:

Interest can be classified into simple interest and compound interest. 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 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, semi-annually, annualy]

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.

Unless otherwise indicated, all such cashflows are considered to occur at the end of their respective periods.

SIMPLE INTEREST

Simple interest is the interest that is completed only on the original sum and not on accrued interest.

Thus, if you were to loan a present sum of money (P), to someone at a simple annual rate 'i' for a period of 'n' years, the amount of interest you would receive from the loan would be,

$$\text{Total Interest Earned} = P*i*n$$

At the of 'n' years, the amount of money due you (F), would equal the amount of the loan. P plus the total interest earned. That is, the amount of money due at the end of the loan would be ,

$$F = P(1+in)$$

Where,

P = Present sum of Money (Rs)

F = Future sum of money (Rs)

n = No of Interest Periods

i =Interest rate per period (%)

PROBLEM:

1. Assuming a company has a loan of Rs. 800 is made for a period of 2 months at a simple interest of 10 % . What future amount is due at the end of loan period?

Solution:

Given Data-

P = Rs. 800

i= 10% = 0.10

n = 2months = 2//12 years

Ordinary Simple interest F = P+PiN

The total amount repaid after 2 months is F = 800+ 800* 10(2/12)

F= 813.34

Using exact simple interest

The future value is (considering not a leap year)

F= P+PiN Or P (1+In)

= 8000+800*10(31+28/365)

= 812.93

Nominal Effective interest rate

Let it be the nominal interest rate annually. But, in practice, the compounding may occur less than a year. For example, compounding may be monthly, quarterly or semiannually.

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 t compute the effective interest rate, which is compounded annually.

Effective interest rate,

$$ieff = \left(1 + \frac{r}{m}\right)^m - 1$$

Where,

i= the nominal interest rate

m= the number of interest periods in a year

2. Determine the effective interest rate for a nominal annual rate of 8% that is compounded.
   i. Daily
   ii. Monthly
   iii. Quarterly
   iv. Semi annually

Solution: DATA:

r= 8%

ieff=$\left(1 + \frac{r}{m}\right)^m - 1$

1. Daily

Here, m= 365 days (Assuming not a leap year)

$$ieff=\left(1+\frac{0.08}{365}\right)^{365}-1$$

$$=0.0832 = 8.32\%$$

2. Monthly
   Here, m =12

$$ieff=\left(1+\frac{0.08}{12}\right)^{12}-1$$

$$=0.0829 = 8.29\%$$

3. Quarterly
   Here, m= 4

$$ieff=\left(1+\frac{0.08}{4}\right)^{4}-1$$

$$=0.0824 = 8.24\%$$

4. Semi annually
   Here, m= 2

$$ieff=\left(1+\frac{0.08}{2}\right)^{2}-1$$

$$=0.0816 = 8.16\%$$

COMPOUND INTEREST

With simple interest, the amount earned (for investment money) or due (for borrowed money) in one period does not affect the principal for interest calculations in later periods.

However, this is not how interest is normally calculated. In practice, interest is completed using the compound interest method. For a loan, any interest owed but not paid at the end of the year is added to the balance due. Thus, next years interest is calculated based on the unpaid balance due, which includes the unpaid interest from the preceding period. In this way, compound interest can be thought of as interest on top of interest. This distinguishes compound interest from simple interest.

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

Where,

P = Present sum of Money (Rs)

F = Future sum of money (Rs)

n = No of Interest Periods

i =Interest rate per period (%)

CASH FLOW DIAGRAMS

It is difficult to solve a problem if you cannot see it. The easiest way to approach problems in economic analysis is to draw a picture.

The picture should show 3 things

1. A time interval divided into an appropriate number of equal periods.
2. All cash outflows (deposits, expenditures, etc.) in each period.
3. All cash inflows (withdrawals, income) for each period.

Unless otherwise indicated, all cash flows are considered to occur at the end of their respective periods.

TYPES OF COMPOUND INTEREST PROBLEMS

1. Single payment compound interest
2. Single payment present worth amount
3. Equal payment series compound amount
4. Equal payment series sinking fund
5. Equal payment series present worth amount
6. Equal payment series capital recovery amount
7. Uniform gradient series annual equivalent amount

Notations:

P =principal amount

n= no of interest periods

i=interest rate

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 I.

1) SINGLE PAYMENT COMPOUND INTEREST

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 formula to obtain single payment compound interest is

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

= P(F/P, i,n)

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

PROBLEM

1. Find the amount of Rs. 200 for 5 years at 8% compound annually

Solution: P=200, n= 5 years, i= 8%

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

$$F = 200(1+0.08)^5$$

$$= 293.87$$

2) SINGLE PAYMENT PRESENT WORTH AMOUNT

Here, the objective is to find the present worth (P) of a single future sum (F) which will be received after n periods at an interest rate I compounded at every end of year interest period.

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

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

PROBLEM

Mr. X wishes to have a future sum of Rs. 50 lakh for his daughters tuition fees for 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 12% interest compound annually

Solution:

Data: F= 50 lakhs

i= 12 %(compounded annually)

n=10 years

P=?

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

$$P = 50{,}00{,}000/(1+0.12)^{10}$$

P= 1609866.188

Sum of Rs.1609866.18/- has o be deposited now to realize 50 laks 10 years from now at a rate of interest of 12% compounded annually.

3) EQUAL PAYMENT SERIES COMPOUND AMOUNT/ FUTURE VALUE OF DEFFERED ANNUITY

In this type of investment mode, the objective is to f ind the future worth of n equal payments which are made at the end of every interest period till the end of the nth interest period at an interest rate of i compounded at the end of each interest period.

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

Here (F/A, i, n) is termed as equal payment series compound factor

A= Equal amount deposited at the end of each investment period

n= no of interest periods

i=rate of interest

F= Single future amount

PROBLEM

A man is planning to build his own house. He plans to divert his bonus of Rs. 40,000/- as investment every year for next 10 years. The bank gives 12% interest rate compounded annually. Find the maturity value of his account after 10 years.

Solution:

Data: A=40,000, n=10 years, i=12% F=?

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

$$F = 40{,}000\frac{(1+0.12)^{10}-1}{0.12}$$

= Rs. 701.949

Thus, the person will receive the above amount after 10 years if he invests Rs40,000 every year for next 10 years

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 very interest period for n interest periods to realize a future sum(F) at the end of nth interest period of i

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

Here, (A/F, i,n) is called equal payment series sinking fund factor

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 nth period

PROBLEM:

A person estimates an expenditure of Rs 10 lakh for her daughter's medical college from now. He plans to deposit at the end of every year for next 10 years at a rate of interest of 8% compounded annually. Find the equivalent amount that must be deposited at end of every year for next 8 years?

Solution: F=10 Lakhs, n=10years, i-=8%, A=?

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

$$A = 10{,}00{,}000\frac{0.8}{(1+0.8)^{10}-1}$$

$$=22466.896$$

Therefore, 2246.896 is amount paid

5) EQUAL PAYMENT SERIES PRESENT WORTH AMOUNT/ CAPITSLIZED COST

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.

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

Where (P/A,I,n) is called equal payment series present worth factor.

P=Present worth

A= Annual equivalent payment

n= no of interest periods

i=rate of interest

PROBLEM:

A certain piece of equipment in a computer CPU saves Rs 8,000 per year in material 6 years. If a sales organization has to earn 18% rate return, how must could it be justified now for the purchase of this piece of equipment?

Solution:

A=8000, n=6years, i=18%, P=?

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

$$P=8000\frac{(1+0.18)^n-1}{0.18(1+0.18)^6}$$

$$=27980.82$$

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.

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

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

P=Present worth (loan amount)

A= Annual equivalent payment (recovery amount)

i= interest rate

n=number of interest periods

PROBLEM:

If Rs 28,500/- is deposited into a saving account that earns 14% per year, what uniform annual amount could be withdrawn at the end of each year for 15 years so that nothing would be left in the account after 15th withdraw?

Solution

P=28,500, i= 14%, n=15, A=?

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

$$A=28500\frac{0.14(1+0.14)^{15}}{(1+0.14)^{15}-1}$$

$$=4639.\mathbf{8}$$

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.

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

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

PROBLEM:

A person is planning for retirement. He has 8 more years of service. He would deposit 18% of his salary, which is Rs15,000 at the end of first year and there after he wishes to deposit the same amount with an annual increase at Rs 2000 for 7 years with an interest rate of 18%. Find the total amount at the end of 8th year.

Soluttion: A=15,000 ,n=8year, G=2000, i=18%

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

$$A=15{,}000+2000\frac{(1+0.18)^8-0.18*8-1}{0.18(1+0.18)^8-0.18}$$

$$=20311.612$$

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

$$=20311.612\left(\frac{(1.18)^8-1}{0.18}\right)$$

$$=311315.99$$

DEFERRED ANNUITIES:

Deferred annuity would better be defined as a category of annuities rather than a type of annuity. All annuities can be categorized as either deferred or immediate. When income payments are scheduled to begin is the determining factor as to which category an annuity belongs. There are many different types of annuities that fall underneath the broader deferred annuity category.

A deferred annuity has two phases: the accumulation phase, where you let your money grow for a period of time, and the payout phase. During accumulation, your money grows tax-deferred until you withdraw it, either as a lump sum or as a series of payments. You decide when to take income from your annuity and therefore, when to pay any taxes owed. Gaining increased control over your taxes is one of the key benefits of deferred annuities.

The longer you can defer paying income tax on your compounded interest earnings, the greater your gain will be as compared to the gain you would make with a fully taxable account, such as a bank certificate of deposit (CD) or money market account.

INFINITE ANALYIS PERIOD: CAPITALIZED COST

Another difficulty in present worth analysis aries when we encounter an infinite analysis period ($n=\infty$).

In government analyses, a service or condition sometimes must be maintained for an infinite period. The needs for roads, dams, pipelines and other components of national, state or local infrastructure is sometimes considered to be permanent.in this situation, a present worth of cost analysis would have an infinite analysis period. We call this particular analysis capitalized cost.

To accomplish this, money set aside for future expenditures must not decline.

COMPARISON OF ALTERNATIES

In all Engineering problems, the engineers encounter one important question i.e., which project to select. To select among the different alternatives different methods have been evolved

i. Present worth method
ii. Future worth method
iii. Annual equivalent method
iv. Rate of return method
v. Pay back method

CONDITIONS FOR PRESENT WORTH METHOD

- Estimate the interest rate that the firm wishes to earn on its investment
- Determine the service life of the project
- Determine the cash inflows over each service life
- Determine the cash outflows over each service period
- Estimate the net cash flows (inflows- outflows)

If there is single investment period, whether a project will be selected or rejected that can be made accordingly.

- If PW >0, select the proposal. A positive NPW means equivalent worth of the inflows is greater than the equivalent worth of outflows. So, the project makes profit.
- If PW<0, reject the investment project. A negative NPW means the equivalent worth of inflows is less than the equivalent worth of outflows.

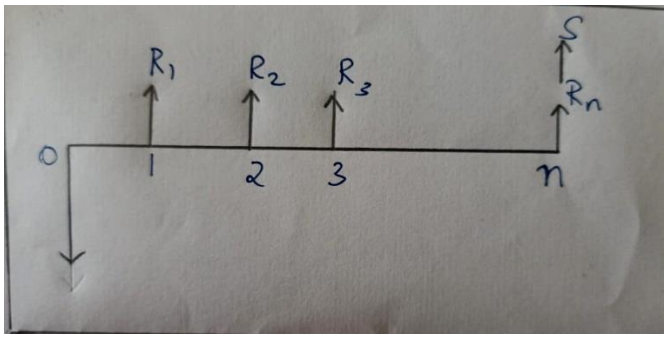
- If PW=0, remain indifferent to the investment

Two prominent methods of present worth

1. Revenue based present worth
2. Cost based present worth

1. <u>Revenue based present worth</u>

In revenue/ profit dominated cash flow diagram, the profit, revenue, salvage value (al inflows to an organization) will be assigned with positive sign. The cost (outflows) will be assigned with negative sign.



Where 'P' is the initial investment

'Rn' is the net revenue at the end of nth year.

'i' is the interest rate compounded annually

'S' is the salvage value at the end of the nth year

To find the present worth of the cash flow from the above diagram for a given interest rate, the formula is

$$PW(i) = -\frac{R1}{(1+i)^1} + \frac{R2}{(1+i)^2} + \ldots\ldots + \frac{Rn}{(1+i)^n} + \frac{S}{(1+i)^n}$$

Or

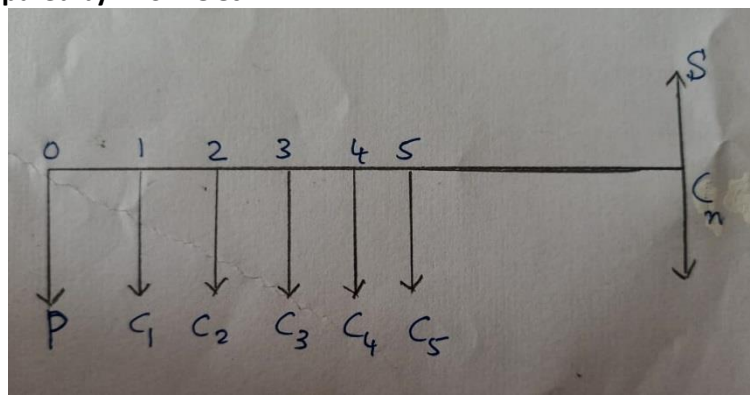
$$PW(i) = -P + R1\ (P/F,i,1) + R2\ (P/F,\ i,\ 2) + \ldots + Rn\ (P/F,i,n) + S\ (P/F,i,n)$$

If it is a uniform series or equal payment series then the formula will be

$$PW(i) = -P + R\ (P/F,\ i\ ,n) + S\ (P/F\ ,i\ ,n)$$

2. Cost based present worth

In a cost dominated cash flow diagram the costs (outflows) will be assigned with positive sign and the profit, revenue, salvage value (all inflows) will be assigned with negative sign.



Where 'P' is the initial investment

'Cn' is the net cost of operation and maintenance at the end of nth year

'S' is the salvage value at the end of nth year

'Ci' is the discounted rate of interest

The present worth expression is given by the formula,

$$PW(i)= P + \frac{C1}{(1+i)^1} + \frac{C2}{(1+i)^2} + \ldots + \frac{Cn}{(1+i)^n} - \frac{S}{(1+i)^n}$$

Or

$$PW(i)= -P + C1\,(P/F, i, 1) + C2\,(P/F, i, 2) + \ldots\ldots + Cn\,(P/F, i, n) - S\,(P/F, i, n)$$

If it is uniform series or equal payment series , then the formula will be

$$PW(i)= P + C\,(P/F, i, n) + S\,(P/F, i, n)$$

In case the decision is to select the alternative with the maximum profit, then the alternative with the maximum present worth will be selected.

If the decision is to select the alternative with the minimum cost, then the alternative with the least present worth amount will be selected.

EQUIVALENT ANNUAL WORTH COMPARISON

There are various alternatives for comparing the worthiness of a project, Equivalent annual worth (EAW) is one important method for comparing engineering alternatives. In an annual worth method, all the receipts and disbursements occurring over a period are converted to an equivalent uniform yearly amount.

EAW is a popular method because of a years profit and loses are taken into account. A large number of engineering economics decisions are based on annual comparison and so the term equivalent uniform yearly amount often used. For example, cost accounting procedures, depreciation charges, tax calculations etc. these early cost tabulations generally make the annual worth method easier.

The annual equivalent worth can be computed by using the general formula:

$$\text{i.e EAW} = \text{PW(i)}\frac{i(1+i)^n}{(1+i)^{n-1}}$$

RATE OF RETURNS METHOD

The rate of return technique is one of the method used in selecting an alternative for a project. In this method, the interest rate per period is determined ,which equates the equivalent worth of cash outflows to that of cash inflows of an alternative.

3 rates of return in engineering economy:

1) The minimum acceptable rate of return (MARRR)
2) The internal rate of return (IRR)
3) The external rate of return (ERR)

Minimum acceptable rate of return (MARR) – It is the rate set by an organization to designate the lowest level of return that makes an investment acceptable.

Internal rate of return (IRR) –It is the rate of the uncovered balance of the investment in the situation where the terminal balance is zero. It is the discount rate at which NPV= 0

External rate of return Method- It is rate of return that is possible to obtain for an investment under current economic considerations.

PROBLEMS:

1) **Alternative1: Initial purchase cost =Rs 3,00,000 , Annual operating and maintenance cost = Rs.20,000 Expected salvage value = Rs 1,25,000, Useful life = 5Years**
   Alternative 2: Initial purchase cost=Rs 2,00,000 , Annual operating and maintenance cost = Rs 35,000
   Expected salvage value =Rs 70,000 , Useful life= 5 years

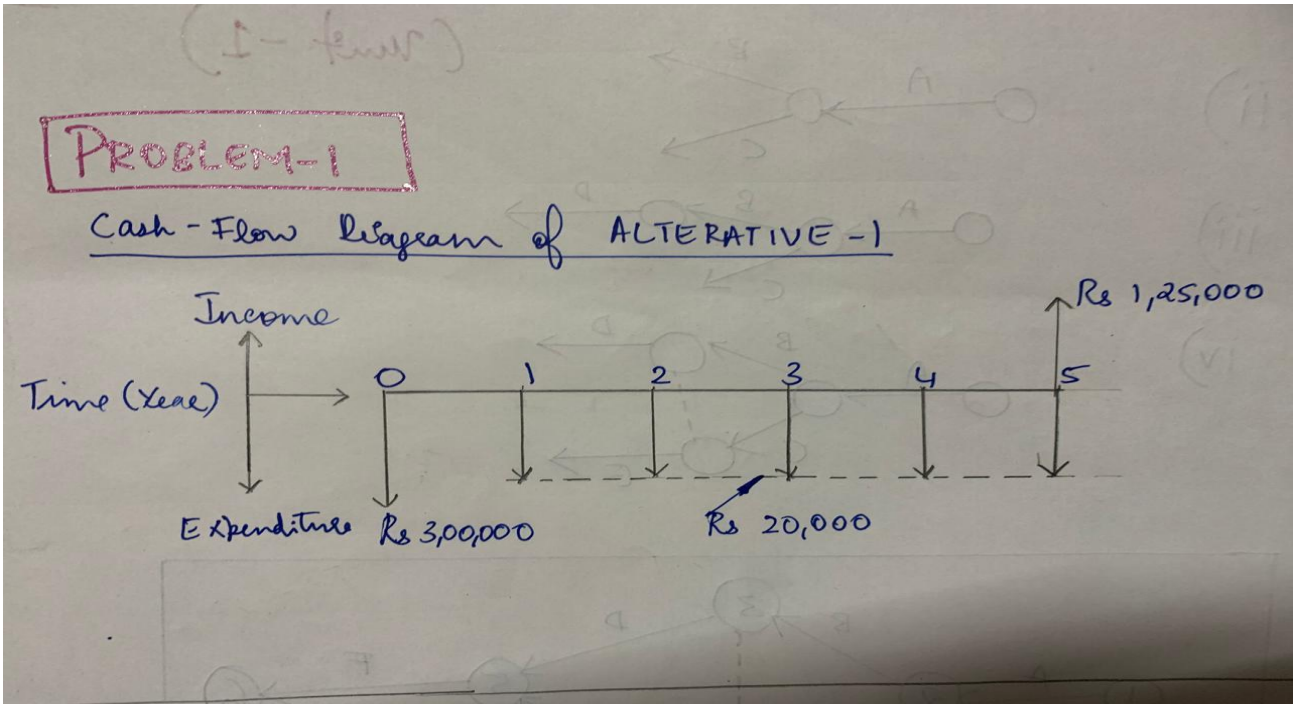
Using present worth method, find out which alternative should be selected, if the rate of interest is 10% per year.

Solution:

- Since both alternatives have same lifespan i.e. 5 years, the present worth of the alternative will be compared over a period of 5 years.
- The cash outflows i.e costs and expenditures are represented by vertically downward arrows whereas cash inflows i.e revenue or income are represented by vertically upward arrows.

  The equivalent present worth of alternative -1 i.e PW1 is calculated as follows:

  - Initial cost P= Rs 3,00,000 (Cash outflow)
  - Annual operating and maintenance cost, A= Rs 20,000 (Cash outflow)
  - Salvage value, F= 1,25,000 (Cash Inflow)



PW1= -3,00,000 -20,000 (P//A , i , n) + 1,25,000 (P/F, i , n)

PW1 = - 3,00,000 -20,000 (P//A , 10% , 5) + 1,25,000 (P/F, 10% , 5)

Now, putting the mathematical expressions of different compound interest factors in the above expression of PW1 (in Rs) results in the following.

$$PW1 = -3,00,000 - 20,000 \frac{(1+i)^n - 1}{i(1+i)^n} + 1,25,000 \frac{1}{(1+i)^n}$$

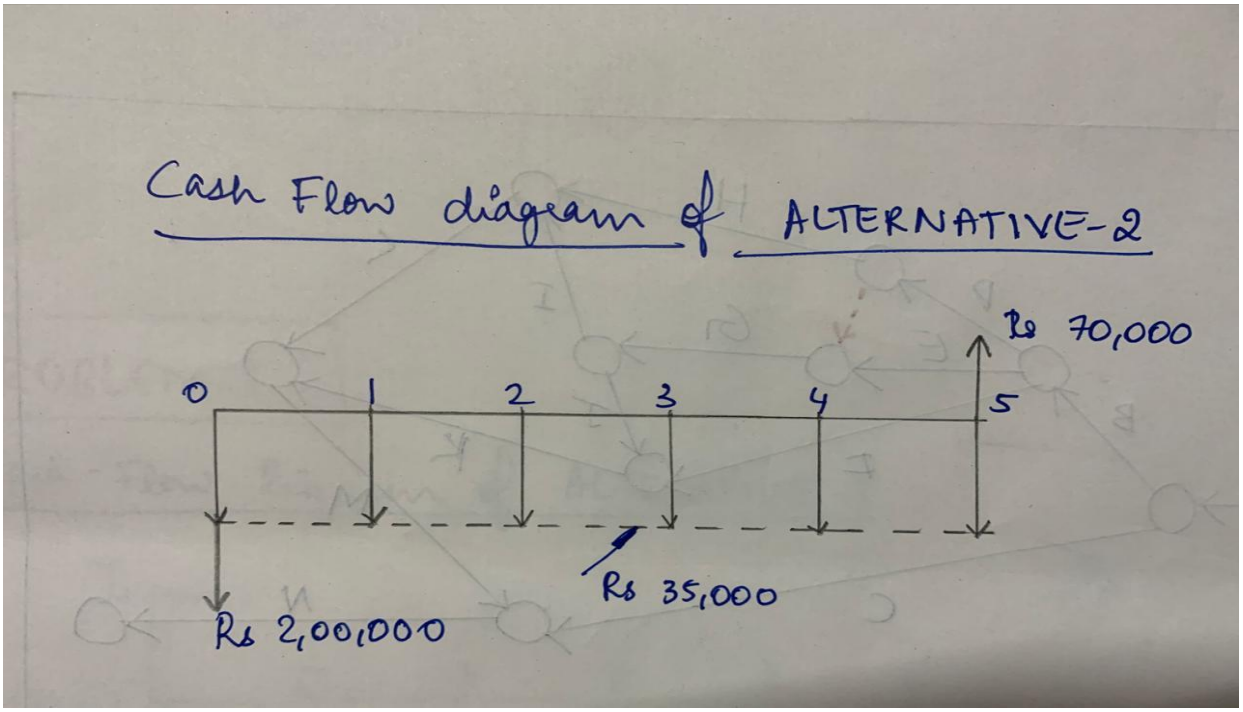
$$PW1 = -3,00,000 - 20,000 \frac{(1+0.1)^5 - 1}{0.1(1+0.1)^5} + 1,25,000 \frac{1}{(1+0.1)^5}$$

PW1= -3,00,000 -20,000*3.7908 + 1,25,000*0.6209

PW1= - Rs 2, 98, 203

Now, the equivalent present worth of alternative-2 .e PW2 (in Rs) is calculated as follows:

- Initial cost P= Rs 2,00,000 (Cash outflow)
- Annual operating and maintenance cost, A= Rs 35,000 (Cash outflow)
- Salvage value, F= 70,000(Cash Inflow)



PW2= -2,00,000 -35,000 (P//A , i , n) + 70,000 (P/F, i , n)

PW2 = - 2,00,000 -35,000 (P//A , 10% , 5) + 70,000 (P/F, 10% , 5)

$$PW2 = -2,00,000 - 35,000 \frac{(1+i)^n - 1}{i(1+i)^n} + 70,000 \frac{1}{(1+i)^n}$$

$$PW2 = -2,00,000 - 35,000 \frac{(1+0.1)^5-1}{0.1(1+0.1)^5} + 70,000 \frac{1}{(1+0.1)^5}$$

PW2= -2,00,000 -35,000*3.7908 + 70,000*0.6209

PW2= - Rs 2, 98, 215

Comparing the equivalent present worth of both the alternatives, it is observed that Alternatice-2 will be selected as it shows lower negative equivalent present worth compared to Alternative-1 at the interest rate of 10% per year.

2) **A construction firm is planning to invest Rs 8,00,000 for the purchase of a construction equipment which will generate a net profit of Rs 1,40,000 per year after deducting the annual operating and maintenance cost. The useful life of the equipment is 10 years and the expected salvage value of the equipment at the end of 10 years is Rs 2,00,000.**
Compute the rate of return using trial and error method on present worth, if the construction firms minimum attractive rate (MARR) is 10% per year.

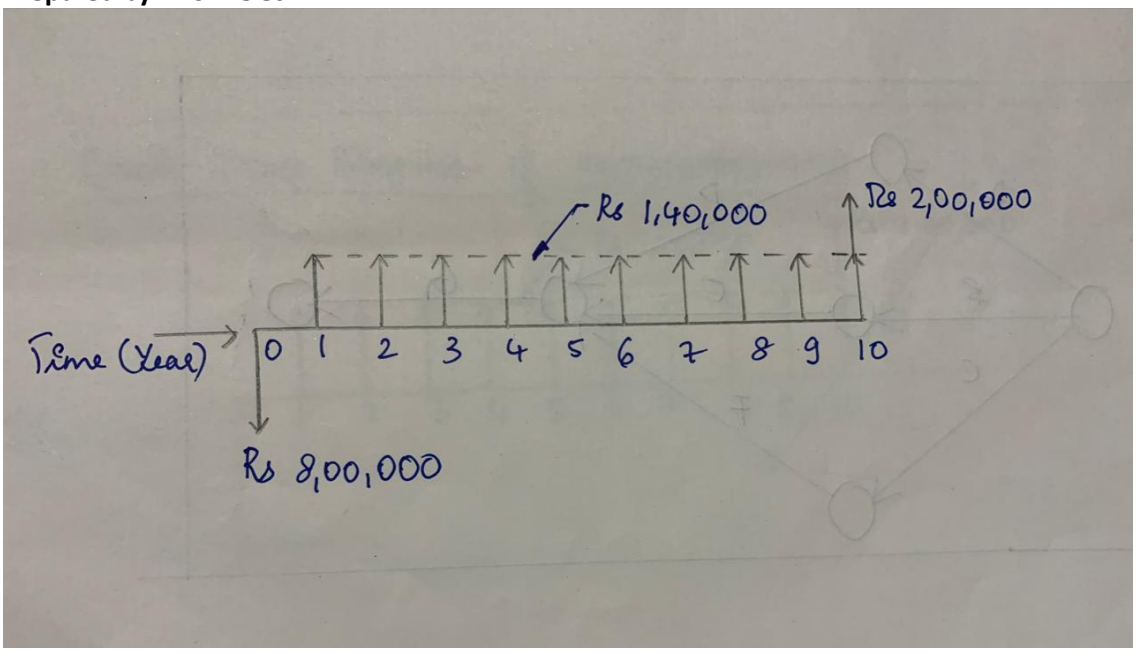
Solution: Given:

Initial outlay = Rs 8,00,000 (Outflow)

No of year = 10 years

Annual revenue =Rs 1,40,000 (Inflow)

Salvage value = Rs 2,00,000 (Inflow)



METHOD-1 USING PRESENT WORTH

- For determination of rate of return 'ir' of the construction equipment, first the equation for net present worth of cash inflows and cash outflows is equated to zero.
- Then using the trial and error method, the value of 'ir' is determined.
- The net present worth of cash inflows and cash outflows of the construction equipment is given by the following expression.

  PW= NPW (outflow) - NPW (inflow)

  PW = -8,00,000 -1,40,000 (P/A , iy , 10) + 2,00,000 (P/F, iy , 10)

For determining the values of 'ir' the net present value is equated to zero.

0 = -8,00,000 -1,40,000 (P/A , iy , 10) + 2,00,000 (P/F, iy , 10)

Now the above equation will be solved through trial and error process to find out the values of 'ir'

TRIAL NO 1:

Let i= 8% and compute the net present value.

Now putting the values of different compound interest factors in the expression for net present worth at ir equal to 8% results in following.

PW = -8,00,000 -1,40,000 (P/A , 8% , 10) + 2,00,000 (P/F, 8% , 10)

$$\textbf{PW = -8,00,000 -1,40,000 } \frac{(1+i)^n-1}{i(1+i)^n} \textbf{ + 2,00,000 } \frac{1}{(1+i)^n}$$

$$\text{PW = -8,00,000 -1,40,000 } \frac{(1+0.08)^{10}-1}{0.08(1+0.08)^{10}} \text{ + 2,00,000 } \frac{1}{(1+0.08)^{10}}$$

PW = -8,00,000+ 1,40,000 * 6.7101 + 2,00,000 *0.4632

PW = Rs 232054

The above calculated net present worth at ir is equal to 8% and is greater than zero.

TRIAL NO 2:

Let i= 12% and compute the net present value.

PW = -8,00,000 -1,40,000 (P/A , 12% , 10) + 2,00,000 (P/F, 12% , 10)

PW = -8,00,000+ 1,40,000 * 5.6502 + 2,00,000 *0.3220

PW = Rs 55428

TRIAL NO 3:

Let i= 14% and compute the net present value.

PW = -8,00,000 -1,40,000 (P/A , 14% , 10) + 2,00,000 (P/F, 14% , 10)

PW = -8,00,000+ 1,40,000 * 5.2161+ 2,00,000 *0.2697

PW = Rs -15806

- Since a negative value of net present worth at ir is equal to 14% obtained (as above) , the actual rate of return is obtained by doing linear interpolation either between 12% and 14%.
- However, for obtaining a more accurate value of rate of return, the linear interpolation is carried out between 12% and 14% .

PW = Rs 55428 at ir =12%

PW = Rs 15806 at ir = 14%

555428-(-15806)/14%-12% = 55428 – 0 / ir -12%

- On solving the above expression, the value of ir is found to be 13.55 % per year.
- The net present value of the construction equipment at MARR i.e 10% is given by

PW= -8,00,000 -1,40,000 (P/A , 10% , 10) + 2,00,000 (P/F, 10% , 10)

PW= -8,00,000 -1,40,000 *6.1446 + 2,00,000 *0.3855

PW= Rs 137344 at MARR (10 %)

- The net present worth of the construction equipment at MARR is greater than zero and the rate of return is greater than MARR.
- Thus, the purchase of the construction equipment is economically justified.

METHOD-2 USING ANNUAL WORTH METHOD

- It may be noted here that when the equivalent worth of an investment is greater than zero at interest rate equal to MARR, then the rate of return of the investment is greater than MARR.
- The rate of return ‘ir’ can also be determined by equating the net annual worth to zero.
- For the above construction equipment, the net equivalent annual worth at different values of ir are calculated as follows:

TRIAL NO 1:

At i= 12%

AW = -8,00,000 -1,40,000 (A/P , 12% , 10) + 2,00,000 (A/F, 12% , 10)

AW= -8,00,000* 0.1770 + 1,40,000 + 2,00,000* 0.0570

AW= Rs 9800

TRIAL NO 2:

At i= 14%

AW = -8,00,000 -1,40,000 (A/P , 14% , 10) + 2,00,000 (A/F, 14% , 10)

AW= -8,00,000* 0.1917 + 1,40,000 + 2,00,000* 0.0517

AW= Rs -3020

Trying out linear interpolation between 12% and 14%

PW = Rs 9800 at ir =12%

PW = Rs 3020 at ir = 14%

9800-(-3020)/14%-12% = 9800 – 0 / ir -12%

- On solving the above expression, the value of ir is found to be 13.525l%
- The minor difference in the values of ir from present worth and annual worth method is due to the effect of decimal points in the calculations.
- Similar to present worth and annual worth method, the rate of return'ir' can also be determined by equating the net present value to zero.

CAPITALIZED COST ANALYSIS

Capitalized cost represents the present worth of an alternative for a project that is going to serve for a longer period of time i.e. for an infinite period of time. As the name indicates, it refers to the present worth of mainly cost or expenditures (cash outflows) of the alternative over infinite period of time. Capitalized worth refers to present worth of expenditures and revenues of an alternative over infinite period of time.

The capitalized cost method is used for comparison of mutually exclusive alternatives which have perpetual service life (assumed to serve forever). The examples of this kind of projects are bridges, dams, irrigation projects, water supply systems for cities, pipeline projects etc. This method an also be used for finding out the capitalized cost of permanent fellowship/scholarship endowment in educational institutes and other organizations.

Benefit-cost analysis:-

The benefit-cost analysis method is mainly used for economic evaluation of public projects which are mostly funded by government organizations. In addition this method can also use for economic evaluation of alternatives for private projects. The main objective of this method is used to find out desirability of public projects as far as the expected benefits on the capital investment are concerned. As the name indicates, this method involves the calculation of ratio of benefits to the costs involved in a project.

In benefit-cost analysis method, a project is considered to be desirable, when the net benefit (total benefit less disbenefits) associated with it exceeds its cost. Thus it becomes imperative to list out separately the costs, benefits and disbenefits associated with a public project. Costs are the expenditures namely initial capital investment, annual operating cost, annual maintenance cost etc. to be incurred by the owner of the project and salvage value if any is subtracted from the costs. Benefits are the gains or advantages whereas disbenefits are the losses, both of which are experienced by the owner in the project. In case of public projects which are funded by the government organizations, owner is the government. However this fund is generally taxpayers' money i.e. tax collected by government from general public, thereby the actual owners of public projects are the general public. Thus in case of public projects, the cost is incurred by the government whereas the benefits and disbenefits are mostly experienced by the general public.

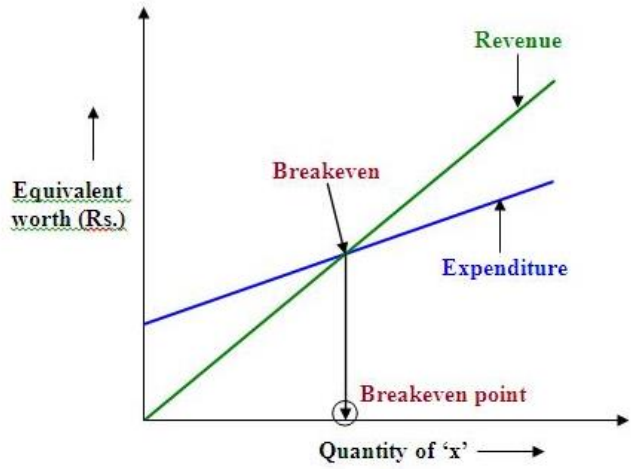
In order to know the costs, benefits and disbenefits associated with a public project, consider that a public sector organization is planning to set up a thermal power plant at a particular location. The costs to be incurred by the public sector organization are cost of purchasing the land required for the thermal power plant, cost of construction of various facilities, cost of purchase and installation of various equipment's, annual operating and maintenance cost, and other recurring costs etc. The benefits associated with the project are generation of electric power that will cater to the need of the public, generation of revenue by supplying the electricity to the customers, job opportunity for local residents, development other infrastructure in the nearby areas etc. The disbenefits associated with project are loss of land of the local residents on which the thermal power plant will come up. If it is agricultural land, then the framers will lose their valuable land along with the annual revenue generated from farming, even though they get money for their land from the public sector organization at the beginning. The other disbenefits to the local residents are greater likelihood of air pollution in the region because of the thermal power plant, chances of contamination of water in the nearby water-bodies etc.

In benefit-cost analysis method, the time value of money is taken in to account for calculating the equivalent worth of the costs and benefits associated with a project. The benefit-cost ratio of a project is calculated by taking the ratio of the equivalent worth of benefits to that of the costs associated with that project. Either of present worth, annual worth or future worth methods can be used to find out the equivalent worth of costs and benefits associated with the project.

The benefit-cost ratio of projects is determined in different forms namely conventional benefit-cost ratio and modified benefit-cost ratio. The benefit-cost ratio is generally designated as B/C ratio.

BREAK EVEN ANALYSIS

The breakeven analysis is used to calculate the value of a factor (or variable) at which the expenditures and revenues of a project or alternative are equal. This value of the variable is known as the breakeven point. Corresponding to the breakeven point, profit or loss can be determined if the expected value of the variable is higher or lower than the breakeven value. In this regard the breakeven point governs the economic acceptability of the project or the alternative. The breakeven analysis is also used for comparing two alternatives by determining the breakeven point i.e. the quantity of a factor (common to both the alternatives) at which the total equivalent worth of both alternatives are equal. The examples of some of the factors which are used in the breakeven analysis are quantities produced per year, hours of operation per year, rate of return per year and useful life etc. and the breakeven value of these factors are calculated to find out the economical acceptability of a single alternative or to select the best one between the alternatives. The breakeven point between expenditure and revenue for a single alternative is shown. Here 'x' is the factor that mainly affects the expenditure and revenue of the alternative.



Breakeven analysis between two alternatives:

The breakeven analysis between two alternatives is carried out by equating the equivalent worth of cash flows of both the alternatives. For determining the breakeven point between the alternatives, a factor or variable (as required) must be common to both the alternatives and the corresponding cost or revenue element is expressed in terms of this common variable. As already stated, the total equivalent worth of alternatives can be calculated either by present worth method, future worth method or annual worth method by considering the time value of money.

MODULE-4

COURSE TITLE: CONSTRUCTION MANAGEMENT AND ENTERPRENEURSHIP-21CV61

Prepared by: MS. POOJA D

EXPECTED QUESTIONS:

1. Discuss concept and principles of engineering economy.
2. Explain the seven steps n problem solving.
3. What are the difference between micro and macro analysis
4. Define interest and time value of money.
5. Bring the comparison between capitalized and rate of return methods, minimum cost analysis and break even analysis.
6. Define the term single payment, equal payment and uniform gradient series.
7. Explain the concept of simple and compound interest.
8. Differentiate between problem solving and decision making.

MODULE-4

COURSE TITLE: CONSTRUCTION MANAGEMENT AND ENTERPRENEURSHIP-21CV61

Prepared by: MS. POOJA D