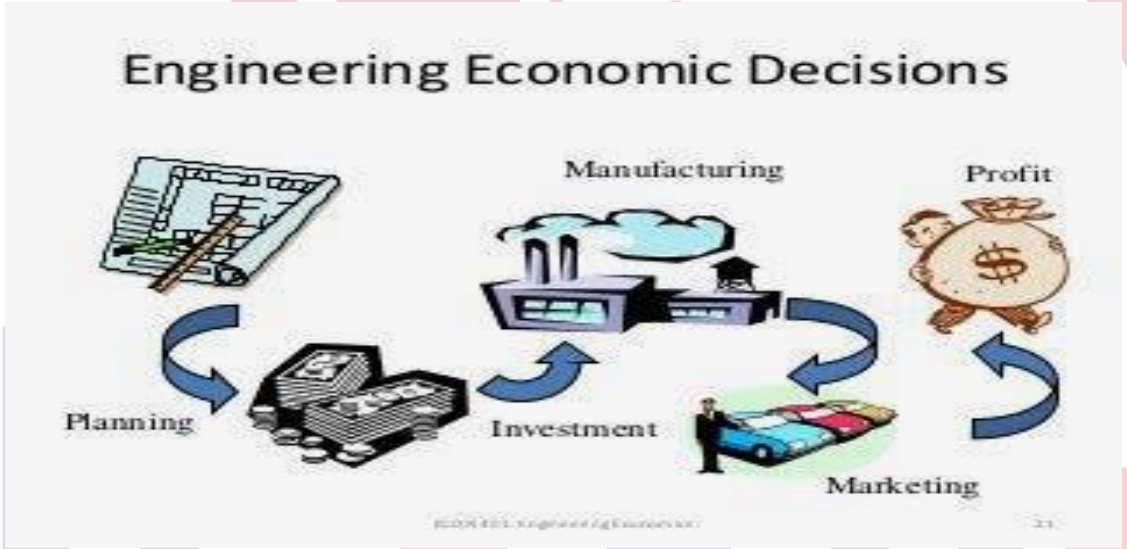
ENGINEERING ECONOMICS



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INTRODUCTION

WHAT IS ECONOMICS ???????

- Economics is the study of how society manages its scarce resources.
- Allocation of the resources to fulfill the unlimited desires of the human beings.
- Branch of social science that deals with the production and consumption of goods and services as well as the distribution for the human welfare and their management.

Engineering Economics

- Deals with the methods that enable one to take economic decision towards minimizing the cost or maximizing benefits to business organization (Project).
- The field of engineering economy is concerned with the systematic evaluation of the benefits and costs of the projects involving engineering design and analysis.
- In manufacturing or construction, engineering is involved in every detail of a product's production from conceptual design to distribution.
- 80% of cost is involved in the design and construction and other 20% is used in other Administrative expenses.

- **Engineers must decide if the benefits of a project exceed its costs and must make this comparison in a unified framework.**
- **The frame work within which to make this comparison is the field of engineering economics.**

Definition1:

- **“Engineering economics is the application of economic techniques to the evaluation of design and engineering alternatives.**
- **The role of engineering economics is to assess the appropriateness of a given project, estimate its value, and justify it from an engineering standpoint”. (Dr. John M.Watts)**

Definition 2:

"Engineering economics deals with the methods that enable one to take economics decision towards minimizing the cost or maximizing benefits to business organization".

Definition 3:

"Engineering economy involves formulating, estimating, and evaluating the economic outcomes when alternatives to accomplish a defined purpose are available. Another way to define engineering economy is as a collection of mathematical techniques that simplify economic comparison".

STRATEGIC ECONOMIC DECISIONS

- **Once project ideas are identified, they are typically classified as:**

1. **Equipment and process selection**
2. **Equipment Replacement**
3. **New product and product expansion**
4. **Cost reduction, and**
5. **Service improvement**

Essential Economics Terminology

1. Annuity

- A series of equal payments/receipts occurring at equal periods of time
- Amount paid annually/monthly/semi-annually etc, including reimbursement of borrowed capital and payment of interest

2. Assets

- An economic resource of entity (including money resources, physical resources, and intangible resources)

3. Capital

- The financial resources involved in establishing and sustaining an enterprise or project

4. Break even point

- A graphical representation of relation between total income and total costs for various levels of production and sales indicating areas of profit and loss.
- A point where the organization is in no gain and no loss state.

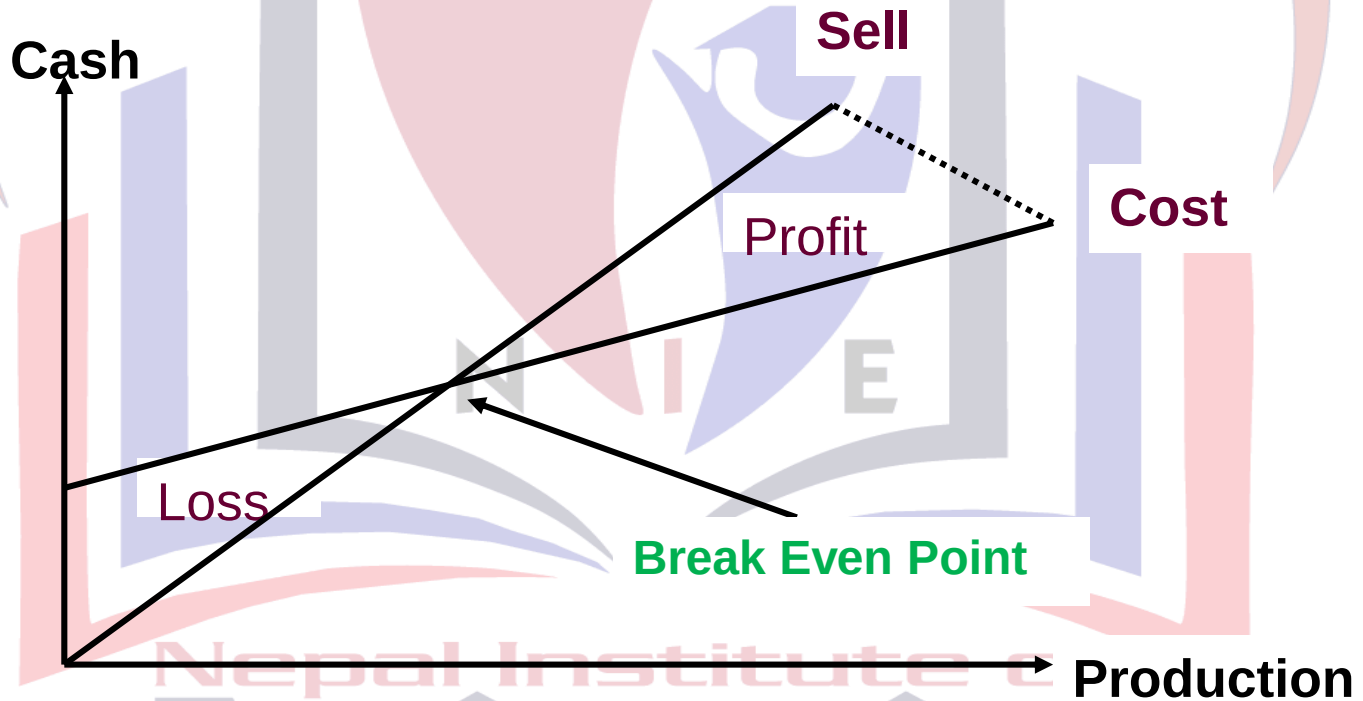


Fig: Break Even Analysis

5. Cash flow

The actual rupees coming into firm and going out of the firm

6. Simple interest

- **The interest charges under the condition that interest in any time period is charged only on the principal.**

7. Compound interest

- **The type of interest that is periodically added to the amount investment (or loan) so that subsequent interest is based on the cumulative amount**

8. Decision making

- **A program of action undertaken as a result of established policy to influence the final decision**

10. Decision making under certainty

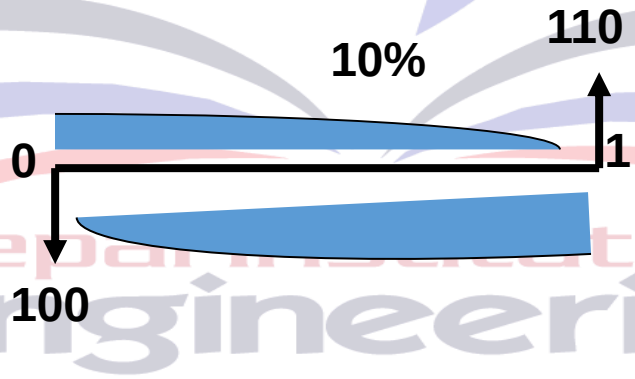
- Simple decisions that assume complete information and no uncertainty connected with the analysis of the decisions

10. Decisions under uncertainty

- A decision for which the analyst elects to consider several possible futures, the probabilities of which cannot be estimated.

12. Discount rate

- The rate used to calculate the present value of the future cash flows. It is inverse of compounding



12. Depreciation

- Decline in value of a capitalized asset.

14. Salvage Value:

- Receipt at project termination for sale or transfer of the equipment (can be a salvage cost).

14. Economic life

- The timeframe an asset will be economically useful.

14. Economic efficiency

- Ratio of output to input of a business system
- Economic efficiency (%) = Output/Input*100 = Worth/ cost *100

15. Inflation

- an increase in the average price paid for goods and services bringing about reduction in the purchasing power.
- The converse of inflation is deflation.

16. Intangibles

- conditions or economy factors that cannot be readily evaluated in quantitative terms as in money.
- In accounting, the assets that cannot be reliably evaluated (e.g., goodwill, social values).

16. Opportunity cost

- The value of benefits sacrificed in selecting a course of action among alternatives.
- The value of the next best opportunity foregone by deciding to do one thing rather than another.

19. Utility

- satisfaction that a consumer obtains from goods and services that are consumed. It is a measure of satisfaction.

20. Time value of money

- since money has the ability to earn interest, its value increases with time. Hence it is the relationship between interest and time.

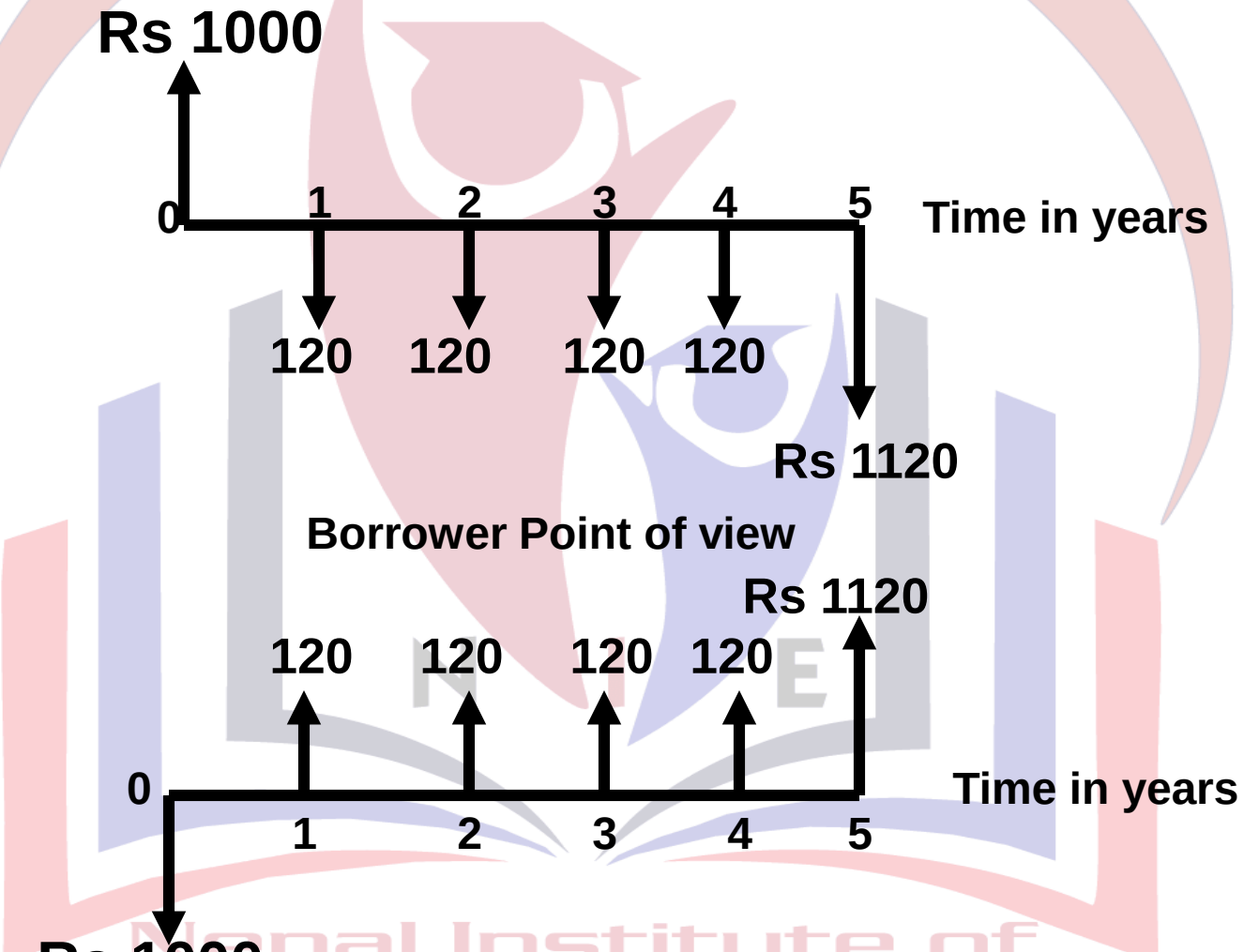
Definition of cash flow

- The analysis of events and transactions that affects the cash position of company is termed as cash flow.
- A cash flow is the difference between total receipts (inflows) and total cash disbursement (outflows) for a given period of time.
- It is the statement that shows the actual rupees coming into firm or going out of the firm.

Cash Inflows: Actual rupees coming into a firm represented by ⬆ e.g. savings, receipt, profit, revenue, income, gain etc.

Cash outflows: Actual rupees going out from the firm represented by ⬇ e.g. Investment, loss, expenses, tax, cost, payment, deposit, insurance etc.

Cash Flow Diagram



- **Cash flow diagram is the means of visualizing (and simplifying) the flow of receipts and disbursements. (payments)**
- **The diagram convention consist-**

Horizontal axis

- **denotes time which marked off in equal increment, one per period up to the duration of project.**

Revenues: represented by upward pointing arrows.

Disbursement: disbursement (payments) is represented by downward pointing arrows.

- **Arrow lengths are approximately proportional to the magnitude of the cash flow.**
- **Since there are two parties to every transaction, it is important to note that cash flow direction in cash flows diagram depend upon the point of view taken.**

Time Value of Money

- Time value of money is defined as the time-dependent value of money stemming both from changes in purchasing power of money (inflation or deflation) and from the real earning potential of alternative investments over time.
- Since money has the ability to earn interest, its value increases with time.
- Hence it is the relationship between interest and time.

Interest

- **The fee that is charged for use of someone else's money.**
- **The size of the fee will depend upon the total amount of money borrowed and the length of time over which it is borrowed.**

Simple Interest

- Interest earned on only principal amount during each interest period.
- Interest earned during each interest period doesn't earn additional interest in the remaining period.

For a deposit of P dollars at a simple interest rate of *i* for N periods, the total interest *I* would be

$$I = (iP)\ N$$

The total amount available at the end of *N* period, *F*, would be

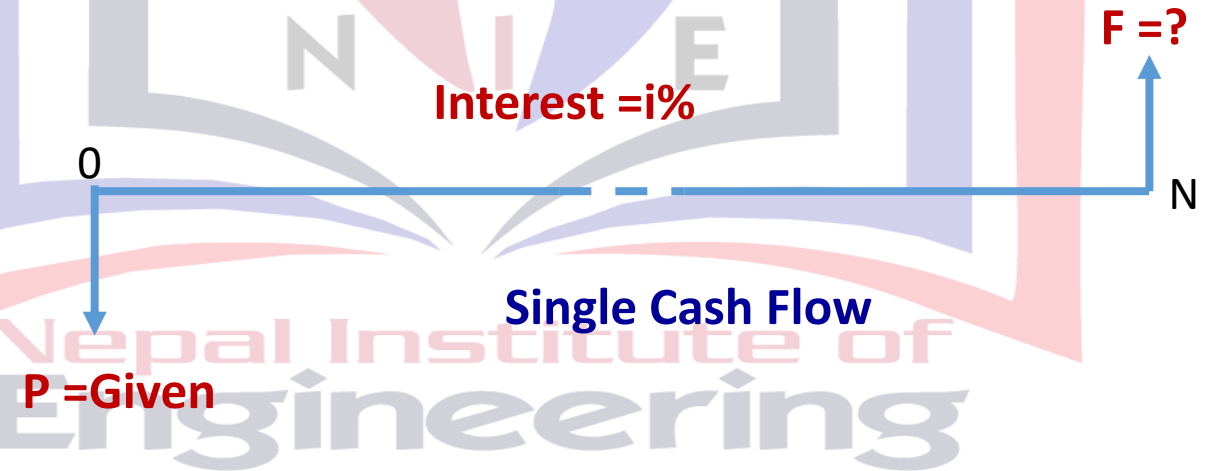
$$F = P + I = P\ (1+iN)$$

Compound Interest

- The interest earned in each period is calculated based on the total amount at the end of the previous period.
- The total amount includes the original principal plus the accumulated interest that has been left in the account.

TO FIND F WHEN P IS GIVEN

If *P* dollar is deposited (invested) at interest rate, *i*, then,



For the 1st Interest Period

$$\text{Interest } (I_1) = P * i$$

Total accumulated amount at the end of 1st year

$$F_1 = P + I_1 = P + P*i = P(1+i)$$

For the 2nd Interest Period

$$\text{Interest } (I_2) = F_1 * i$$

Total accumulated amount at the end of 2nd year

$$F_2 = F_1 + I_2 = P(1+i) + P(1+i) * i$$

$$= P(1+i)(1+i) = P(1+i)^2$$

For the 3rd Interest Period

$$\text{Interest } (I_3) = F_2 * i$$

Total accumulated amount at the end of 3rd year

$$F_3 = F_2 + I_3 = P(1+i)^2 + P(1+i)^2 * i$$

$$= P(1+i)^3$$

For the Nth Interest Period

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

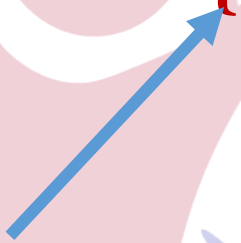
Single Payment Compound Amount Factor

Functionally,

$$F = P(F/P, i\%, N)$$

TO FIND P WHEN F IS GIVEN

$$P = F\{(1+i)^{-N}\}$$



Single Payment Present Amount Factor

Functionally,

P= F (P/F, i%, N)

Nominal and Effective interest rate

- If a financial institution uses a unit of time other than a year – a month or a quarter (e.g. when calculating interest payments), the institution usually quotes the interest rate on an annual basis known as Nominal interest rate or *annual percentage rate (APR).* Commonly this rate is stated as

r% Compounded M-ly

Where, r = the nominal interest rate per year

M = the compounding frequency or the number of interest periods per year

Example

" 18 % compounded monthly"

We say 18% is the nominal interest rate or annual percentage rate (APR) and compounding period is monthly (12) i.e. 1.5% per month.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Interest rate (%)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Fig: *The nominal interest rate is determined by summing the individual interest rates per period*

18% compounded monthly

r = 18%, M=12, & i = r/M = 18/12 = 1.5% per month

12% compounded semi annually

r = 12%, M=2, & i = r/M = 12/2 = 6% per 6 month

12% compounded quarterly

r = 12%, M=4, & i = r/M = 12/4 =3% per 3 month

15% compounded weekly

r = 15%, M=52, & i = r/M = 15/52=0.29% per week

Effective Interest Rate

- **Suppose that Rs 1,000 to be invested at a nominal rate of 12% compounded semiannually.**
- **The interest earned during first six months is 1,000* 0.12/2 = Rs 60**
- **Total principal at the end of the first six months = Rs (1,000+60) = Rs 1,060**
- **Interest earned during the second six months is Rs 1,060*0.12/2 = Rs 63.60**
- **Total interest at the end of 1 year = Rs 60+ Rs 63.60 = Rs 123.60**
- **The effective annual interest rate for the entire year**

  = 123.60/1,000 * 100 = 12.36%

- **The *exact or the actual rate* of interest earned on the principal during one year is known as the *effective interest (i)*. The effective interest rates are always expressed on an annual basis unless specifically stated otherwise.**

Numerical

What is the effective interest rate of the nominal interest rate 9% per year if the compounding is a) yearly b) quarterly c) monthly (d) daily

- **Solution**
- **For compounding yearly,**

$$i = (1+0.09/1)^{1} - 1 = 0.09 = 9\%$$

- **For compounding quarterly,**

$$i = (1+0.09/4)^{4} - 1 = 0.09308 = 9.308\%$$

- **For compounding monthly,**

$$i = (1+0.09/12)^{12} - 1 = 0.09380 = 9.380\%$$

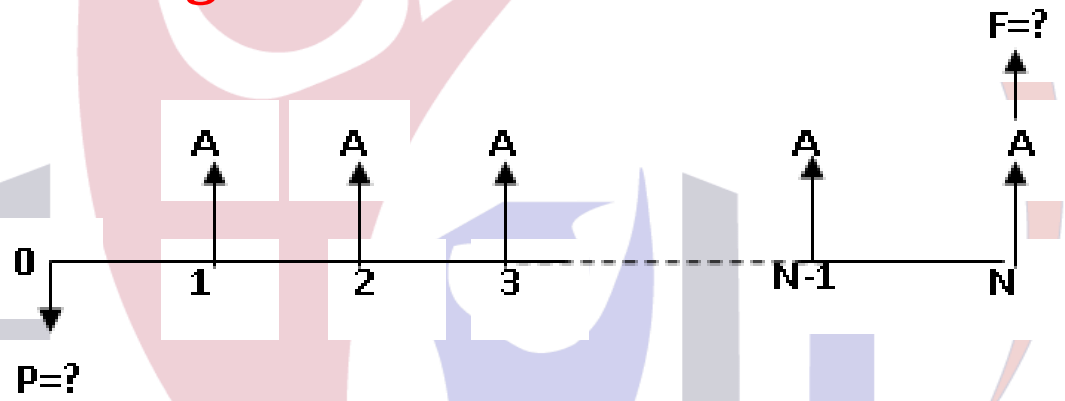
- **For compounding daily,**

$$i = (1+0.09/365)^{365} - 1 = 0.0941 = 9.41\%$$

Discrete compounding and discrete cash flow

Interest formula relating a uniform (equal) series

To Find F when A is given



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

Uniform Series Compound Amount Factor

Functionally,

F= A (F/A, i%, N)

To Find P when A is given

$$P = A\frac{[(1+i)^N - 1]}{[i * (1+i)^N]}$$

Uniform Series Present Amount Factor

Functionally,

P= A (P/A, i%, N)

To Find A when F is given

$$A = F [i / (1+i)^{N} - 1]$$

Sinking Fund Factor

Functionally,

A= F (A/F, i%, N)

Sinking fund is an interest bearing account into which a fixed sum is deposited each interest period: it is commonly established for the purpose of replacing fixed assets.

To Find A when P is given

$$A = P\,[i*(1+i)^{N}] / [(1+i)^{N} - 1]$$

Capital Recovery Factor

Functionally,

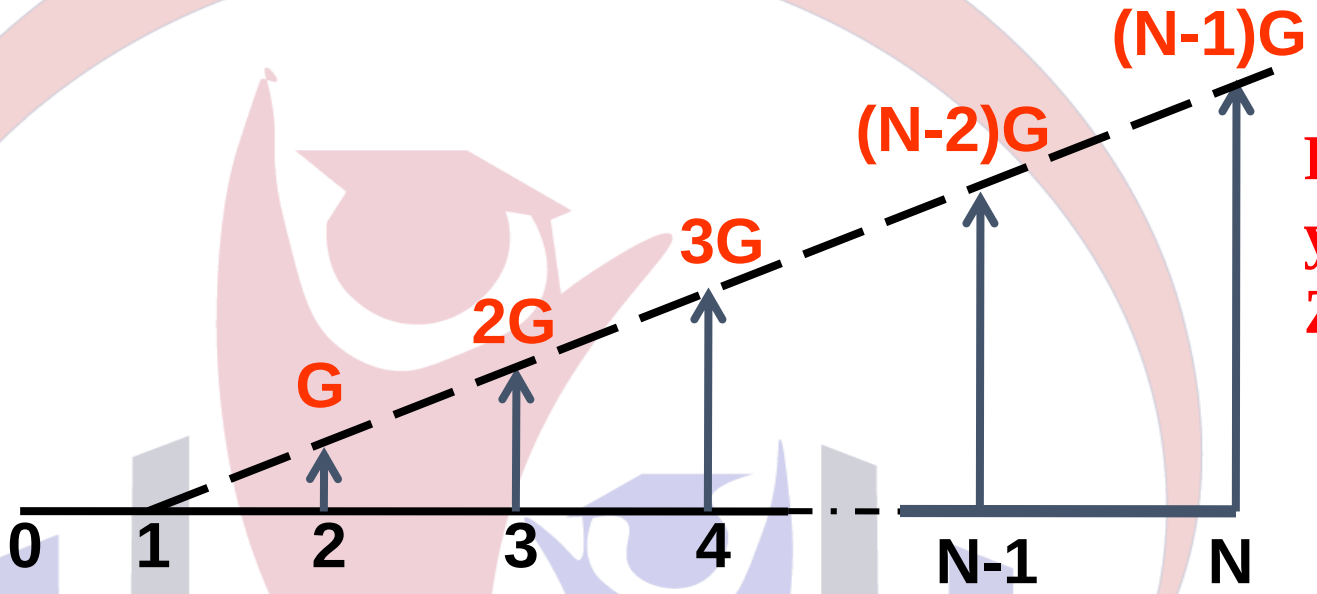
A= P (A/P, i%, N)

Capital recovery is the annual equivalent of capital cost

Linear and Geometric Gradient Series

Linear Gradient Series

- Linear gradient series involves periodic payments that increase or decrease by a constant amount (G).
- If G>o, the series is referred to as an *increasing* gradient series.
- If G<o, the series is referred to as an decreasing gradient series.
- First cash flow in the gradient series occurs at the end of period two. i.e. first cash flow is zero.



First cash flow (in year 1) is always Zero)

Fig1: Typical Cash flow diagram of the gradient series

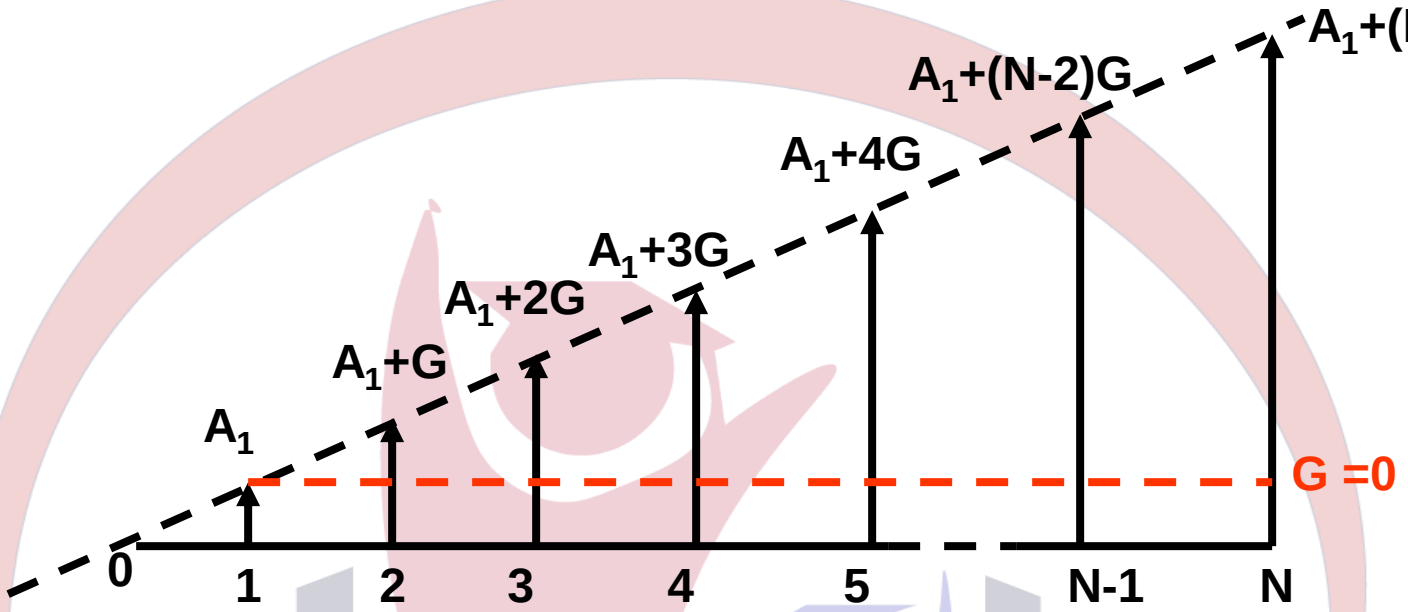


Fig: Increasing Gradient Series (G>0)

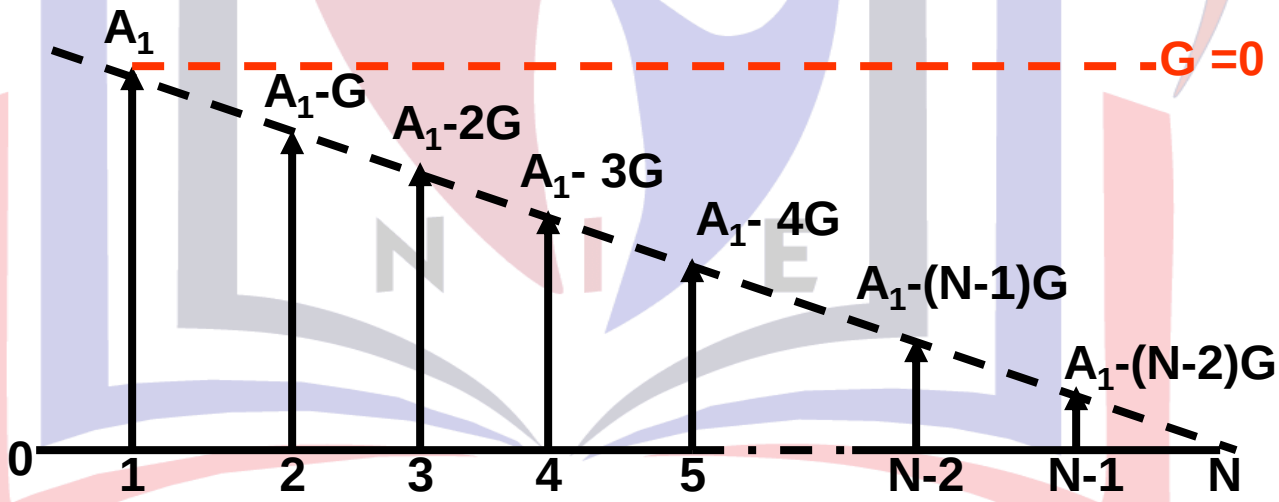


Fig: Decreasing Gradient Series (G<0)

Future worth Factor
Find F, given G, i, N

$$F = \frac{G}{i}\left\{\frac{(1+i)^N - 1}{i}\right\} - \frac{NG}{i}$$

Gradient to Future equivalent factor

Functionally,

F = G (F/G, i, N)

Equal payment series conversion factor
Find A, given G, i, N

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

Gradient to Uniform Series Factor

Functionally,

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

Present worth Factor
Find P, given G, i, N

$$P = G\left[\frac{(1+i)^N - iN - 1}{i^2(1+i)^N}\right]$$

Gradient to Present amount factor

Functionally,

$$P = G\,(P/G, i, N)$$

METHODS

- **Equivalent Worth Method**
  - Present worth method (PW)
  - Future worth method (FW)
  - Annual worth method (AW)
- **Rate of Return Method**
  - Internal rate of return (IRR)
  - External rate of return (ERR)
- **Benefit Cost Analysis (B/C ratio)**
  - Conventional B/C
  - Modified B/C
- **Payback Period Method**
  - Simple payback period
  - Discounted payback period

Equivalent worth Method

Present worth method (PW) or Net Present Value (NPV)

- **The Net Present Worth (NPW) or Present Worth or Net Present Value (NPV) of a given series of cash flow is the equivalent values of the cash flows at the end of year zero (i.e. beginning of year 1).In other words, how much money we have to set aside to provide for future cash flow.**
- ***Net present worth = Equivalent present worth of future cash flow – Initial investment***
- **Here we use NPW or NPV as PW**

Decision Rule

- *If PW (i) > 0’ accept the investment*
- *If PW (i) = 0’ remain indifferent*
- *If PW (i) < 0’ reject the investment*

Future worth Method (FW) or Net Future worth Method (NFW)

- **Net present worth measures the surplus in an investment project at time zero where as net future worth measures this surplus at time period other than zero.**
- **Net future worth analysis is particularly useful on an investment solution where we need to compute the equivalent worth of a project at the end of investment period rather than its beginning.**

Decision Rule

If FW (i) > 0'	***accept the investment***
If FW (i) = 0'	***remain indifferent***
If FW (i) < 0'	***reject the investment***

Annual worth Method (AW) or Net Annual worth Method (NAW)

- **Annual worth method provides the basis for measuring investment worth by determining equal payments on an annual basis.**
- **The AW of a project is its annual equivalent receipts (R) minus annual equivalent expenses (E) minus annual equivalent capital Recovery (CR). R, E, and CR are calculated at MARR**

$$AW(i) = R - E - CR$$

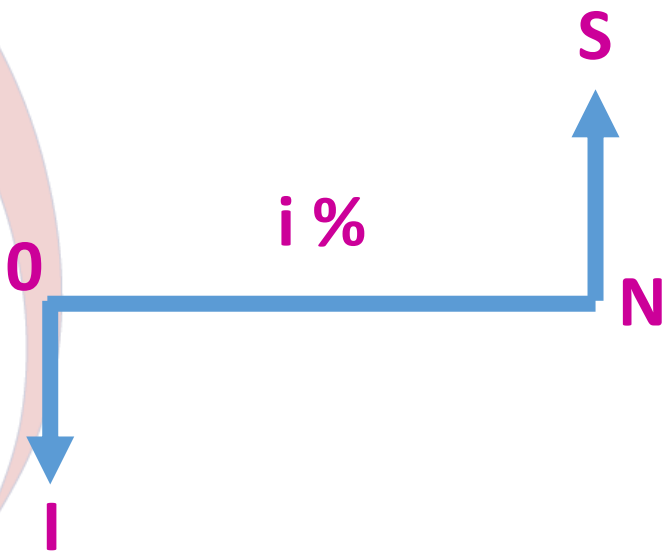
R = Annual Revenue

E = Annual Expenses

CR = Capital Recovery Cost (annual equivalent of capital cost)

Capital Recovery (CR)

- In any investment project, two types of costs are involved, i.e. Capital cost and operation cost.
- Operating cost is recurred over the life of project and they are estimated on annual basis.
- Capital costs tend to be one time cost. This one time cost must translated into its annual equivalent over the life of the project.
- This annual equivalent of capital cost is given a special name: Capital Recovery cost designated as CR (i)



$$CR\ (i\%) = I\ (A/P, i\%, N) - S\ (A/F, i\%, N)$$

Decision Rule

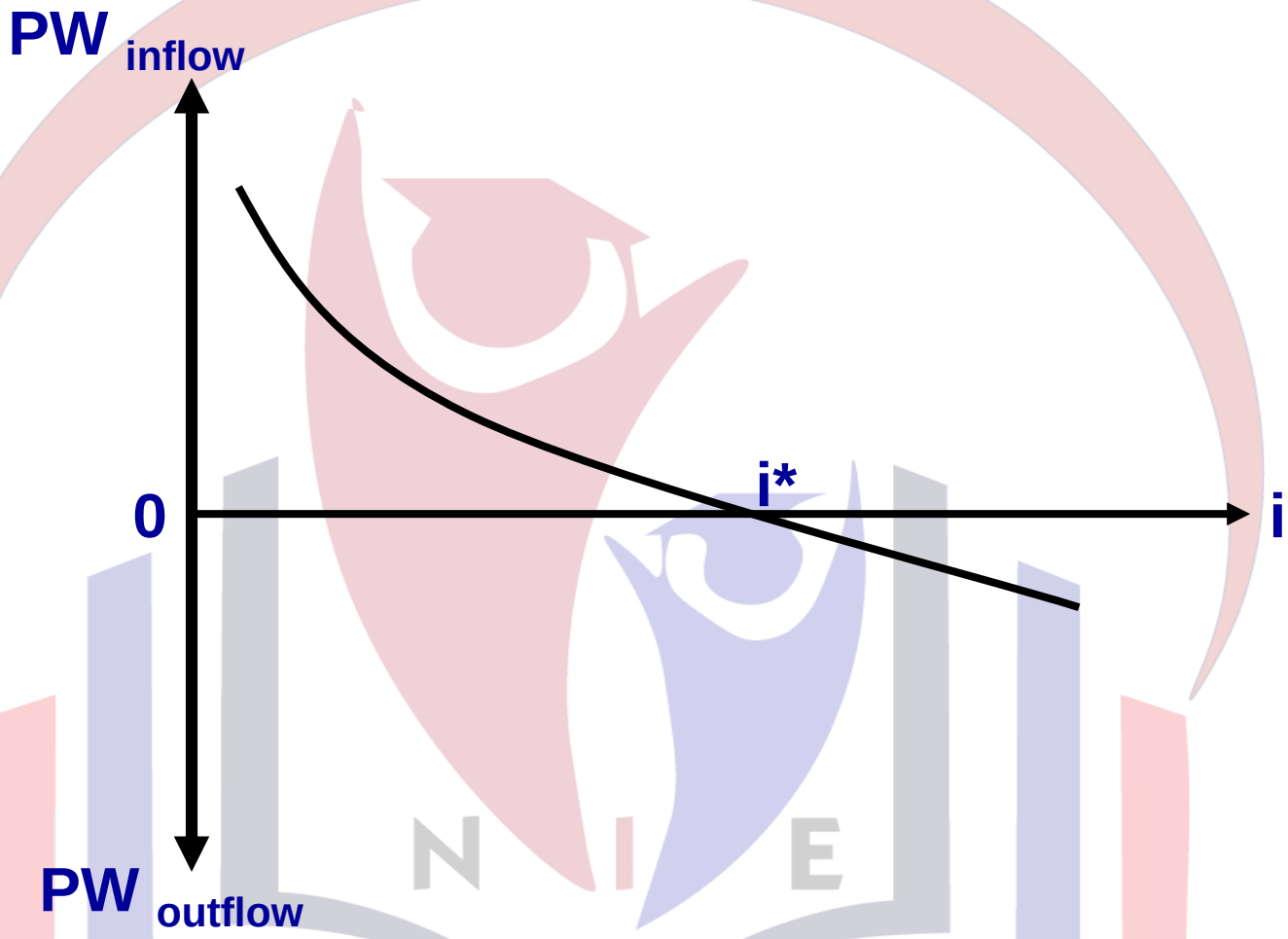
IF AW (i) > 0 , *accept* the investment.

IF AW (i) = 0 , remains indifferent.

IF AW (i) < 0, *reject* the investment.

Internal Rate of Return (IRR)

- **IRR is the interest rate that is charged on the un-recovered project balance of the investment such that, when the project terminates, the un-recovered balance will be zero.**



Accept /Reject Decision Rule

- **If** *IRR > MARR,* *accept the project*
- *IRR = MARR,* *remain indifferent*
- *IRR < MARR,* *reject the project*

DRAWBACKS OF IRR

- The recovered funds are re-invested at i*% rather than MARR, which leads to the concept of External rate of return (ERR).
- It needs trial and error approach for the calculation.
- If the algebraic sum of the cash flow changes in the middle of the project more that two times, we might obtain multiple IRR.
- When choosing between the mutually exclusive alternatives, IRR method can be misleading and does not compare the scale of investment.

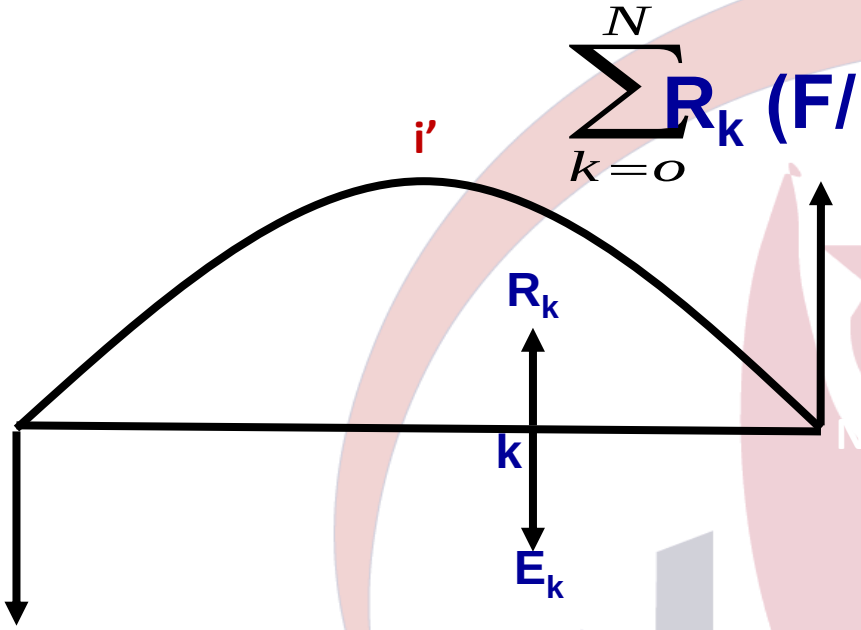
EXTERNAL RATE OF RETURN/ MODIFIED IRR

- **The drawback of the IRR method (reinvestment assumption) may not be valid in the engineering economy.**
- **For example, if a firm's MARR is 10% per year and the IRR for a project is 18%, it may not be possible for the firm to reinvest net cash proceeds from the project at much more than 10%.**
- **This situation, coupled with the computational demands and possible multiple interest rates associated with the IRR method, has given rise to other rate of return methods that can remedy this weakness which is referred as *External rate of Return* or *Modified IRR*.**

- **The External Rate of Return (i') is the unique rate of return for a project that assumes that net positive cash flows, which represent money not immediately needed by the project, are reinvested at the reinvestment rate ε%.**
- **The reinvestment rate depends upon the market rate available for investments.**

Steps of ERR Calculation

- All cash outflows are discounted to period zero (present) at Ɛ% per compounding period.
- All cash inflows are Compounded to period N at Ɛ %
- ERR is the interest rate that equivalence between the two equation.



Where,

R_k = receipts in period k

E_k = expenditures in period k

N = project life or number of study period

Ɛ % = external reinvestment rate per period.

$\sum_{k=o}^{N} E_k$ (P/F, Ɛ%, k)

$$E_k\,(P/F, Ɛ\%, k)\,(F/P, i', N) = R_k\,(F/P, Ɛ\%, N-k)$$

Accept /Reject Decision Rule

If $ERR > MARR$, *accept the project*
$ERR = MARR$, *remain indifferent*
$ERR < MARR$, *reject the project*

BENEFIT/COST ANALYSIS

- The benefit/cost ratio is defined as the ratio of the equivalent worth of benefits to the equivalent worth of costs.
- Mostly used for the Public Sector Project Analysis.
- The equivalent worth measure applied can be present worth (PW), future worth (FW), and annual worth (AW).
- Also called “savings – investment ratio”

Benefit/Cost Analysis of Single Project

Using PW formulation

Conventional B/C ratio

$$= \frac{\text{PW (benefits of proposed project)}}{\text{PW (total cost of proposed project)}}$$

$$= \frac{\text{PW (B)}}{\text{I} - \text{PW (S)} + \text{PW (O\&M)}}$$

Modified B/C ratio

$$= \frac{\text{PW (B)} - \text{PW (O\&M)}}{\text{I} - \text{PW (S)}}$$

Using FW formulation

Conventional B/C ratio

$$= \frac{\text{FW (benefits of proposed project)}}{\text{FW (total cost of proposed project)}}$$

$$= \frac{\text{FW (B)}}{\text{FW (I)} - \text{(S)} + \text{FW (O\&M)}}$$

Modified B/C ratio

$$= \frac{\text{FW (B)} - \text{FW (O\&M)}}{\text{FW (I)} - \text{(S)}}$$

Using AW formulation

Conventional B/C ratio

$$= \frac{\text{AW (benefits of proposed project)}}{\text{AW (total cost of proposed project)}}$$

$$= \frac{\text{AW (B)}}{\text{CR + AW (O\&M)}}$$

Modified B/C ratio

$$= \frac{\text{AW (B)} - \text{AW (O\&M)}}{\text{Capital recovery (CR)}}$$

DECISION RULE

The decision guideline is very simple:

- **If** $B/C \geq 1.0$ **, accept the project**
- **If** $B/C < 1.0$ **, reject the project**
- **If** $B/C = 1.0$ **, remains indifferent**

PAYBACK PERIOD METHOD

- **Simple payback period**

Simple payback period doesn't considers the time value of money (i=0).

- **Calculate the both types of payback period for the given cash flow of the project. (Assume i=20%)**

➢ **Discounted payback period**

The problem with the Simple payback period is that it ignores the time value of money. In order to correct this, we can use discounted cash flows in calculating the payback period.

Period	Net Cash flow (Rs)
0	-25,000
1	+8,000
2	+8,000
3	+8,000
4	+8,000
5	+13,000

CHAPTER 4
COMPARATIVE ANALYSIS OF ALTERNATIVES

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Useful Life

- **The useful life of an asset is the time period during which it is kept in productive use in a trade or business.**

Analysis Period (Study Period)

- **The analysis period is a time span over which the economic effects of an investment will be evaluated.**
- **The analysis period may also be called the *study period* or *planning horizon*.**
- **The length of the analysis period is determined by company policy, the service period, the useful life of the shorter lived alternative, the useful life of longer lived alternative etc.**

TWO CASES

- Case1:Useful lives are same for all alternatives and **equal** to study period.

- Case2:Study Period differs from the project lives and useful lives are **unequal** among the alternatives

Case1:Useful lives are same for all alternatives and equal to study period.

Equivalent Worth Method (PW/FW/AW)

- **Calculate PW at the MARR for each alternative.**
- **If PW/FW/AW is greater than zero for all alternatives, then the alternative having the highest PW/FW/AW or least negative PW/FW/AW is selected.**

PW_A	PW_B	Selected Alternative
- $1500	-$500	B
- $ 500	+$1000	B
+$2500	-$1000	A
+$2500	+$1000	A

Result

$$PW_3(12\%) > PW_1(12\%) > PW_2(12\%)$$

&

$$FW_3(12\%) > FW_1(12\%) > FW_2(12\%)$$

Option 3 is the most economical.

Rate of Return METHOD

Let us Consider the two mutually exclusive alternatives with 1 year of service life.

Period (n)	A_1	A_2
0	-$1,000	-$5,000
1	$ 2,000	$7,000
IRR	100%	40%
BCR	1.82	1.27
PW (10%)	$818	$1364

Here, A_2 is preferred over A_1 , by the NPW measure.

A_1 is preferred over A_2, by the IRR & BCR measure.

IRR Method for Mutually Exclusive Alternatives

- Under the equivalent worth method (PW,FW and AW), the mutually exclusive project with the highest worth figure was preferred.
- In the case of rate of return method, the same procedure cannot be applied, i.e the project with the higher IRR may not be the preferred alternative.

WHY?????

The inconsistency in ranking occurs because

- NPW,NFW,NAW are *absolute (dollars/Rs)* measures of investment worth.
- Whereas IRR/BCR/ERR is a *Relative* measure and decision cannot be applied in the same way as PW, FW and AW.

THEN WHAT SHOULD BE DONE

???????

INCREMENTAL ANALYSIS

- **Incremental Analysis evaluates difference, or the 'increment" between two or more mutually exclusive alternatives.**
- **<u>Steps:</u>**

1. **Identify all the alternatives.**
2. **Compute the IRR/BCR/ERR of each alternative. Any alternative with IRR<MARR, BCR <1, ERR < MARR should be rejected.**
3. **Order Alternative in increasing order of investment cost to ensure that the increments have cash flow corresponding to investments.**
4. **Establish a base Alternative**

   Alternative having least capital investment is established as the base alternative and should have been pre qualified i.e. IRR> MARR, ERR>MARR, BCR>1

5. **Perform an incremental IRR analysis between the base alternative and the alternative with the next higher initial cost. If the incremental IRR ≥ MARR, "reject" the base alternative and "accept" the higher cost alternative and "retain" it as base alternative.**

6. **Select the next higher cost alternative and perform the incremental analysis until all the alternatives have been evaluated.**

- ***Evaluation should always be done based on same study period for all alternatives***

Decision Rule

IF IRR_{B-A} > MARR , select B (higher first cost alternative)

IF IRR_{B-A} = MARR , select either one

IF IRR_{B-A} < MARR , select A (lower first cost alternative)

Case2:Study Period differs from the project lives and useful lives are unequal among the alternatives

Two Assumptions

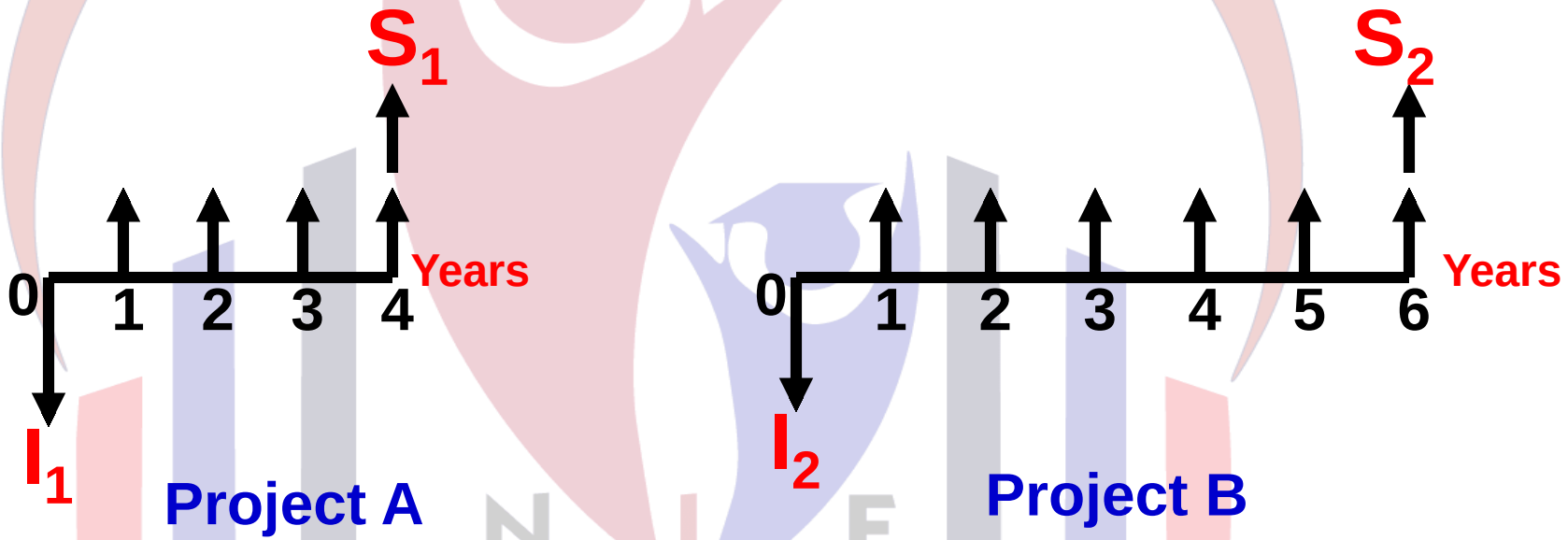
1. **Repeatability assumption**
2. **Co - terminated assumption**

Repeatability assumption

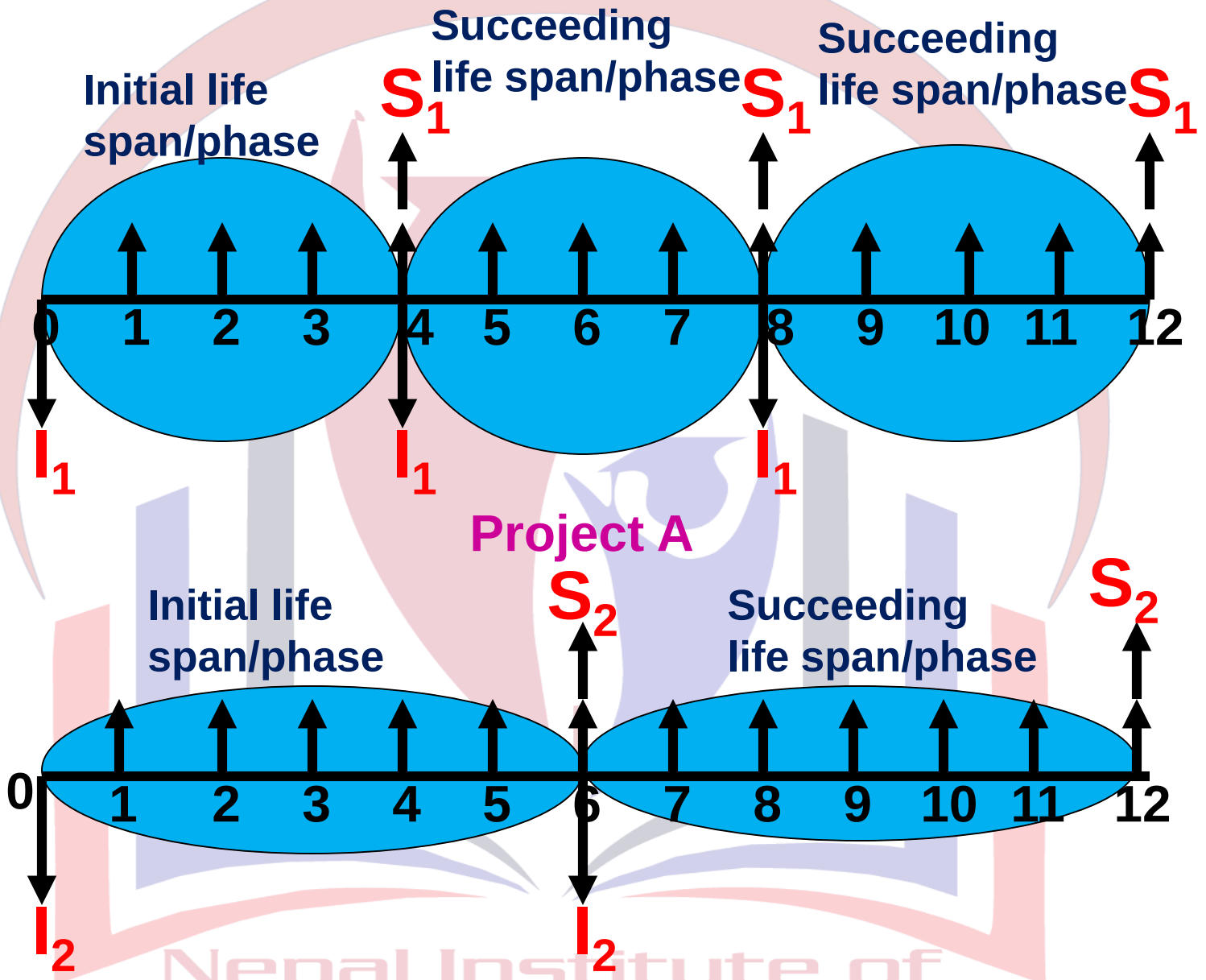
- **Two alternatives having different useful life are *changed into projects having same useful* life by expanding their life up to least common year.**
- **The *study period* is equal to the least common multiple (LCM) of the lives of alternatives.**
- **The economic consequences that are estimated to happen in an alternative's initial life span will also happen in all succeeding life spans**

Example

Lets consider the following project



LCM of 4 and 6 is 12 years, so we assume study period as 12 years


Initial life span/phase
Succeeding life span/phase
Succeeding life span/phase
S_1
S_1
S_1
0 1 2 3 4 5 6 7 8 9 10 11 12
I_1
I_1
I_1
Project A
Initial life span/phase
Succeeding life span/phase
S_2
S_2
0 1 2 3 4 5 6 7 8 9 10 11 12
I_2
I_2
Project B

Co - terminated assumption

- **This assumption uses a identical study period for all feasible alternatives and analysis is made over this period. The planning horizon, thus chosen could be:**
- **Life of shorter lived alternative**
- **Life of longer lived alternative**
- **Less than the shorter lived alternative**
- **Greater than the longer lived alternative**
- **In between the shortest and longest lived alternatives**

Two cases:

Case 1: STUDY PERIOD > USEFUL LIFE

Case 2: STUDY PERIOD < USEFUL LIFE

Capitalized WORTH METHOD (CW)

- **Special case of PW criterion is useful when the life of a proposed project is *perpetual* or study period is extremely long (40 years or more) or forever.**
- **The process of computing the PW cost for the infinite series is referred as the *capitalization* of project cost.**
- **Example: Public projects such as bridges, waterway constructions, irrigation systems, hydroelectric dams, roads etc falls into this category.**

The capitalized cost represents the amount of money that must be invested today to yield a certain return *A* at the end of each and every period forever, assuming interest rate *i*.

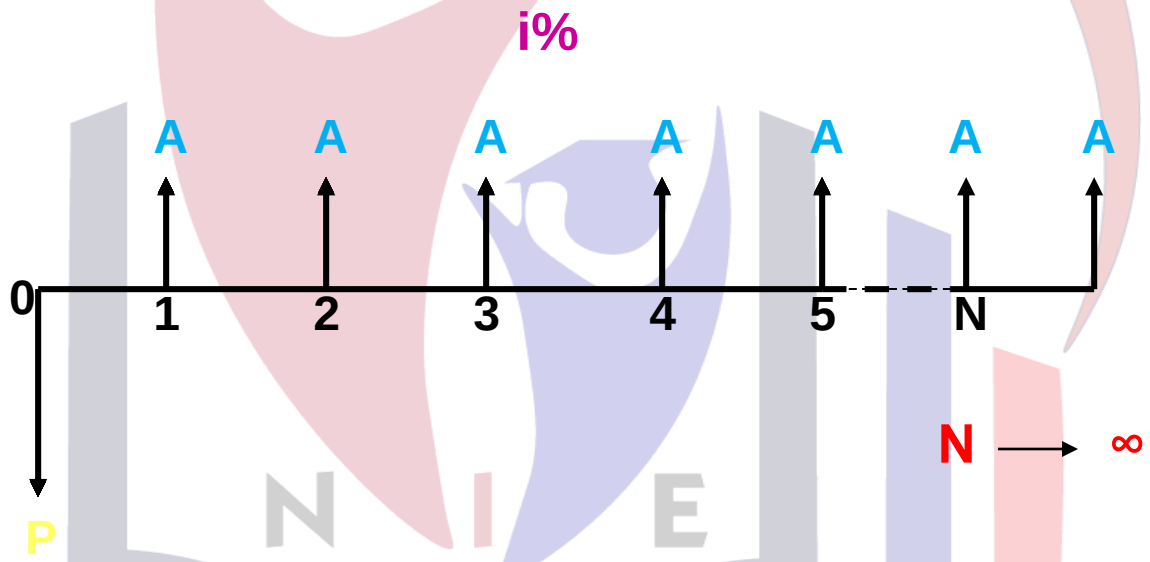


Fig: Equivalent present worth of an infinite cash flow series

As $n \rightarrow \infty$

$$CC = \frac{A}{i} = \frac{AW}{i}$$

Here CC (CW) replaces P or PW

Definition of Mutually Exclusive Alternatives In terms of Combination of Project

Before the analysis or evaluation of any alternative (project), we have to categorize the projects

Independent Project

- **It is one that may be accepted or rejected without influencing the accept-reject decision of another project.**

Dependent Project

- **It is one such that the acceptance or rejection of one influences the acceptance or rejection of another.**
- **Two types of dependencies:**
  - **Contingent**
  - **Mutually Exclusive**

Contingent

- Two or more projects are *contingent* if the acceptance of one requires the acceptance of another.
- For example: The purchase of computer printer is dependent upon the purchase of printer. Purchase of Computer printer is *contingent* on purchase of computer.

Mutually Exclusive project

- Among the several alternatives to fulfill the common objective, only one is selected and others are excluded.

Independent Projects

- **Do not compete with one another in the evaluation.**
- **Each project is evaluated separately and thus the comparison is between one project at a time and do-nothing alternative.**
- **Considering alternative A, B and C, the possible combination of alternatives can be:**

Combination	A	B	C	Remark
1	X	X	X	Do nothing
2	√	X	X	Accept A
3	X	√	X	Accept B
4	X	X	√	Accept C
5	√	√	X	Accept A&B
6	√	X	√	Accept A&C
7	X	√	√	Accept B&C
8	√	√	√	Accept all

• Mutually Exclusive Alternatives

If A , B, C are the mutually exclusive alternatives than we can make following combination

Combination	A	B	C	Remark
1	X	X	X	Do nothing
2	√	X	X	Accept A
3	X	√	X	Accept B
4	X	X	√	Accept C

Contingent Alternatives

- **Two or more projects are contingent if the acceptance of one requires the acceptance of another.**
- **If A, B, C are three alternatives where C is contingent on B and B is contingent on A, we can make following combination.**

Combination	A	B	C	Remark
1	X	X	X	Do nothing
2	√	X	X	Accept A
3	√	√	X	Accept A&B
4	√	√	√	Accept All

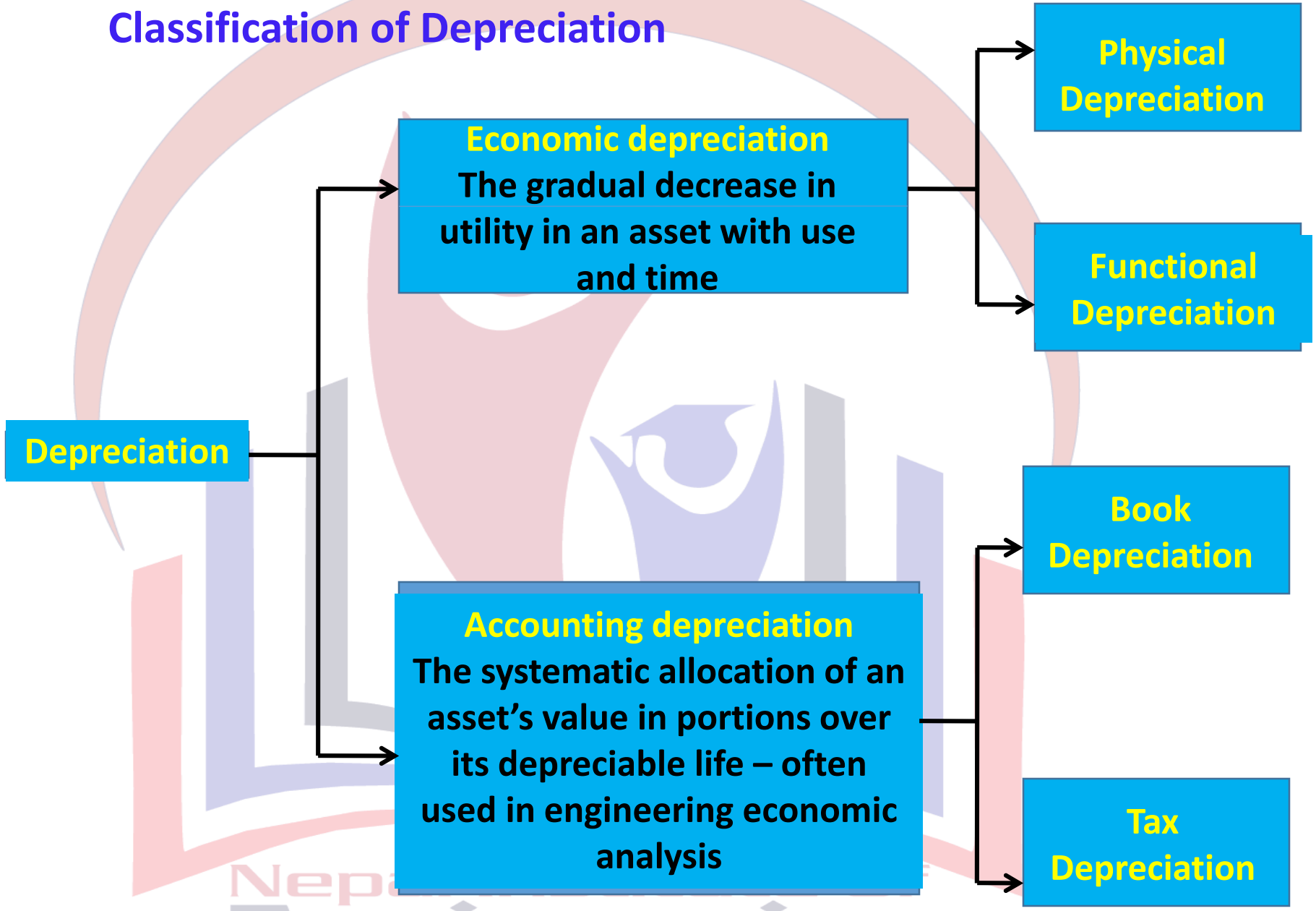
CHAPTER 7
DEPRECIATION &CORPORATE TAX

ISHWAR ADHIKARI

Introduction

- **Depreciation is the decrease in value of physical properties with the passage of time and use.**
- **Depreciation is an *accounting concept* that establishes an annual deduction against before tax income such that the effect of time and use on asset's value can be reflected in a firm's financial statements.**

Classification of Depreciation



Physical Deprecation

It can be defined as a reduction in an asset's capacity to perform its intended service due to physical impairment. It may be due to

1. deterioration from interaction with the environment like rotting, corrosion and other chemical changes.
2. wear and tear from use.

Functional depreciation

- It occurs as a result of changes in technology that decrease or eliminate the need of asset.
- It may be declining need for the services performed by the asset, or inability to meet increased quantity/quality demands.

Accounting Depreciation

The systematic allocation of the initial cost of an asset in parts over a time, known as its depreciable life and is done by the accounting depreciation.

Book Depreciation

Use by a corporation or business intended for the financial reports such as for the balance sheet or income statement.

Tax Depreciation

Use in tax calculations per government regulations.

Book Depreciation Method

1. Straight line Method
2. Accelerated Method
   (a) Declining balance Method
   (b) Sum of the Year's Digit Method.
   (c) Sinking Fund Method

Tax Depreciation Methods

1. Accelerated Cost Recovery System (ACRS)
2. Modified Accelerated Cost Recovery Systems. (MACRS)

Terminologies

1. **Cost basis or Unadjusted Cost**

- **Initial cost of the assets including purchase price, delivery and installation fees, and other depreciable direct costs incurred to prepare the asset for use.**

2. **Book Value**

- **Represents the remaining, un-depreciated capital investment on the books after the total amount of depreciation charges to date have been subtracted from the basis.**
- **The book value is usually determined at the end of each year.**

3. **Recovery period**

- **It is the depreciable life ‘n’ of the assets in years.**

4. **Salvage Value (SV)**

- **It is the estimated value of the property at the end of its useful life.**

5. **Useful life**

- **It is the estimated or expected period of time that a property will be used in a trade or business or to produce income.**

Book depreciation Method

1. Straight – Line Method (SL)

- It is the simplest and most often used depreciation method.
- It assumes that a constant amount is depreciated each year over the depreciable (useful life) of the asset

$$D_n = (I - S)/ N$$

Where,

D_n = Depreciation charge during year n

I = Cost of the assets including installation expenses

S = Salvage value at the end of useful life

N = Useful life

Book Value in a given year = Cost Basis – total depreciation charges made to date

NUMERICAL

Consider the following automobile data:

Cost of the asset , (I) = $ 10,000

Useful life ,(N) = 5 years

Estimated Salvage value (S) = $ 2,000

Compute the annual depreciation allowance and the resulting book value using the straight line depreciation method?

Solution

Given . $I = \$10,000$

$S = \$2,000$

$N = 5$ years

Find . D_n and B_n for n =1 to 5

The straight line depreciation rate is 1/5 or 20%.
Therefore the annual depreciation charge is

$$D_n = (0.20)\ (\$10,000 - \$2000) = \$\ 1600$$

The asset would have the following book value during its useful life

n	B_{n-1}	D_n	B_n
1	$ 10,000	$ 1,600	$ 8,400
2	$ 8,400	$ 1,600	$ 6, 800
3	$ 6,800	$ 1,600	$ 5,200
4	$ 5,200	$ 1,600	$ 3,600
5	$ 3,600	$ 1,600	$ 2,000

Where B_{n-1} and B_n represents the book value before depreciation and after depreciation

2. Accelerated Method

Depreciation methods that provide for a higher depreciation charge in the first year of an asset's life and gradually decreasing charges in subsequent years are called accelerated depreciation methods

(a) Declining balance Method (DB)

- Declining balance is also known as the fixed percentage or uniform percentage method.
- In this method, Book value is multiplied by the fixed rate

$\alpha = (1/N)$ multiplier

NUMERICAL

- **Consider the following accounting information for a computer system.**

  Cost Basis of the asset, I, = $ 10,000

  Useful life, N, = 5 years

  Estimated Salvage Value , S, = $778

  Compute the annual depreciation allowances and the resulting book values using the double declining deprecation method.

Solution

- The book value at the beginning of the first year is $ 10,000.
- The declining balance rate (α) is (1/5) *2 = 40%
- The depreciation deduction for the first year will be $ 4000

(40%* $10,000 = $4000)

- The book value at the beginning of the second year is $10,000 - $4000 = $6000
- The depreciation deduction for the second year will be $ 2,400 (40% * $ 6,000 = $2,400)
- The book value at the beginning of the third year is

6, 000 – 2400 = $ 3,600}

- On continuing this process, we obtain the depreciation value and book value as shown in Table:

n	B_{n-1}	D_n	B_n
1	$ 10,000	$ 4,000	$ 6,000
2	$ 6,000	$ 2,400	$ 3,600
3	$ 3,600	$ 1,440	$ 2,160
4	$ 2,160	$ 864	$ 1,296
5	$ 1,296	$ 518	$ 778

(b) Sum-of- Years' Digit (SOYD) Method

- **In this method, the number 1, 2, 3,……..N are summed, where N is the estimated years of useful life.**

$$SOYD = 1+2+3+ \ldots\ldots\ldots+N = \frac{N(N+1)}{2}$$

The depreciation each year

$$D_n = \{N - n + 1\}(I - S)$$
$$SOYD$$

NUMERICAL

Compute the SOYD depreciation schedule for the following:

Cost basis of the asset, I , = $ 10,000

Useful life , N , = 5 years

Salvage Value , S, = $ 2,000

Solution

We first compute the sum – of – years' digits

SOYD = 1+2+3+4+5 = 5 (5+1) / 2 = 15

Year	D_n	B_n
1	(5/15) ($10,000 - $2,000) = $ 2667	$ 10,000 - $ 2667 = $ 7,333
2	(4/15) ($10,000 - $2,000) = $ 2133	$ 7,333 - $ 2,133 = $ 5,200
3	(3/15) ($10,000 - $2,000) = $ 1600	$ 5,200 - $ 1,600 = $ 3,600
4	(2/15) ($10,000 - $2,000) = $ 1067	$ 3,600 - $ 1067 = $ 2,533
5	(1/15) ($10,000 - $2,000) = $ 533	$ 2,533 - $ 533 = $ 2,000

Numerical

Compute the depreciation charge and book value in each year using sinking fund method.

Cost of the asset = Rs 1, 00,000

Salvage value = Rs 20,000

Life of the asset (N) = 8 years

Interest rate (i) = 12%

- **Solution**

To find A, the annual depreciation charge

A = (P-F) (A/F, 12%, 8) = (1, 00, 000 – 20, 000) (0.0813)

= Rs 6,504

Depreciation at the end of 1st year (D1) = Rs 6,504

Depreciation at the end of 2nd year (D2)

= 6,504 + (6,504 *0.12) = Rs 7284.48

Depreciation at the end of 3rd year (D3)

= {6,504 + (6,504 + 7,284.48) *0.12} = Rs. 8,158.62

Depreciation at the end of 4th year (D4)

= {6,504 + (6,504 + 7,284.48+8,158.62) *0.12}

= Rs. 9,137.65

EOY (t)	Fixed depreciation	Net depreciation(D_t) Rs	Book value (B_t) Rs
0	6, 504		1,00,000
1	6, 504	6, 504.00	93,496.00
2	6, 504	7,284.48	86,211.52
3	6, 504	8,158.62	78,052.90
4	6, 504	9,137.65	68,915.25
5	6, 504	10,234.17	58.681.08
6	6, 504	11,462.27	47,218.81
7	6, 504	12,837.74	34,381.07
8	6, 504	14,378.27	20,002.80

Tax Depreciation Method

Modified Accelerated Cost Recovery System (MACRS)

- Historically, for the tax purposes as well as for accounting, an asset's depreciable life was determined by its estimated useful. i.e. an asset would be fully depreciated at approximately the end of its useful life.
- The MACRS scheme, totally abandon this practice and simpler guidelines were set which created several classes of assets, each with more or less arbitrary life called Recovery Period.
- The MARCS scheme includes 8 categories of assets: 3 year, 5 year, 7 year, 10 year, 15 year, 20 year, 27.5 year and 39 year.
- The salvage value of property is always treated as zero.

- **Half year Convention**

- **The MACRS scheme uses the half-year convention i.e. it is assumed that all assets are placed in service at mid-year and they have zero salvage value.**

- **Only half year depreciation is allowed for the first year of the asset placed in service.**

- **With half year's depreciation being taken in service, a full year's depreciation is allowed in each of the remaining years of the assets recovery period.**

- **Finally the remaining half year depreciation in the year following the end of the recovery period.**

QUESTIONS

- **What is the factor name for the formula $\{ (1+i)^N * i / (1+i)^N - 1 \}$**

(a) Uniform series future amount factor

(b) Uniform series present amount factor

(c) Capital recovery factor

(d) Sinking fund factor

- **What is the term for the annuity with a fixed time span?**

(a) Ordinary annuity (b) perpetuity (c) annuity certain (d) Annuity due

- **The interest which is expressed annually but the compounding is on periodic basis is called**

(a) Nominal interest (b) effective interest (c)compound interest

(d) Simple interest.

- **Time value of money is**

(a) Relation between money and time

(b) Relation between money and capital value

(c) Relation between interest and time

(d) Relation between interest and time

- **Which one among the following is the relative measurement for evaluation of project**

(a) PW (b) IRR (c) FW (d) AW

- **The fund which is established for the purpose of replacing assets in future is**

(a) Provident fund (b) dividend fund (c) investment fund (d) sinking fund

- **What type of depreciation is due to the reduction in the obsolescence in technology**

(a) Physical (b) functional (c)design (d) demand

- **The value obtained after the depreciation is each year is called**

(a) Book value (b) Scrap value (c)salvage value (d) market value

- **What is the effective interest rate of the nominal interest of 9% if compounding is annually**

(a) 9% (b) 9.308% (c)9.380% (d) 9.41%

- **if capital cost of asset is Rs 10,000 and salvage value is Rs 2000, the annual depreciation using SL method is**

(a) 1800 (b) 1700 (c)1600 (d) 1500

- **If the nominal interest rate is 12% compounded quarterly, than the calculation for monthly interest will be**

(a) $(1+0.03)^{3}-1$ (b) $(1+0.03)^{1/3}-1$ (c) $(1+0.03)^{-3}-1$ (d) $(1+0.03)^{1/2}-1$

- **If project C is contingent on B and Project B is contingent on A then**

(a) Only A and B is chosen (b) Only B and C is chosen (C) Only A and C is chosen (d) All of them are chosen.

- **For increment analysis, initial investment must be**

(a) Maximum (b) Average (c) Minimum (d) Zero

- **If the initial investment for a machine is Rs 10,000 and depreciation amount per year is Rs 1600, then calculate the book value at the end of year 5.**

(a) 1500 (b) 2000 (c) 2500 (d) 8,000

- **IRR is calculated when**

(a) NPV < 0 (b) NPV> 0 (c) NPV = 0 (d) NPV = MARR

- **The term $(1+i)^{-N}$ is called**

(a) Single payment discount amount factor

(b) Single payment compound amount factor

(c) Annual compound amount factor (d) None of these

- **The rate which is used to make the future sum of the present value is**

(a) Discount rate (b) nominal rate (c) Ordinate rate (d) Compound rate

- **What do you call the sum of principal is added to the future worth with an increasing i% interest rate?**

(a) Simple interest (b) Effective interest (c) Compound interest (d) Continuous interest.

- **The formula for the effective interest rate "I" is (r is the nominal interest rate and m is the compounding period per year)**

(a) $(1+r/m)^m +1$ (b) $(1- r/m)^m -1$ (c) $(1- r/m)^m +1$ (d) $(1+r/m)^m -1$