ARBA MINCH UNIVERSITY

Arba Minch Water Technology Institute

Faculty of Water Supply and Environmental Engineering

Course Name: Engineering Economics

Course Code: WSEE-5263

Target Group: G5WSEE

OUTLINE

◆ **Chapter-I**

- **INTRODUCTION**

- **Project Concept**

- **CLASSIFICATION OF COST**

- **TIME VALUE OF MONEY**

- **Interest Formula and Equivalence**

- **Cash Flow Diagram**

◆ **Chapter-II: Methods of comparing alternative proposals**

- **present worth method of Analysis**

- **Annual worth method of Analysis**

- **Future worth method of Analysis**

- **Rate of return method of Analysis**

- **Incremental Rate of return Method**

- **Break-even comparison method or break-even Analysis**

- **Benefit-cost Analysis**

OUTLINE

◈ **Chapter-III: Project Investment Evaluation**

- **Tax**

- **Depreciation**

- **Depreciation Methods**

  ✓ **Straight line method**

  ✓ **Sum –Of-Year Digit method**

  ✓ **Decline balance method**

  ✓ **Sinking fund method**

◈ **Chapter-IV: Economic Analysis of a Project**

- **Benefit-cost Analysis**

- **Sensitivity Analysis**

- **Effect of Inflation**

OUTLINE

◈ **Chapter-V: Project Appraisal And Case Studies**

- **Key Elements For Project Appraisal**

- **Special Issues In Project Appraisal, Making Technical Expertise Available**

◈ **Engineering economics:**

- is **Systematic evaluation** of the **economic merits** of proposed solutions to engineering problems.

- is about **determining the economic factors** and the **economic criteria** utilized when one or more alternatives are considered for selection

- is a **collection of mathematical techniques**, which simplify **economic comparisons**.

◆ **Objective-Evaluation**

- How to compare the economic value of alternative   design option?

◆ **Example**
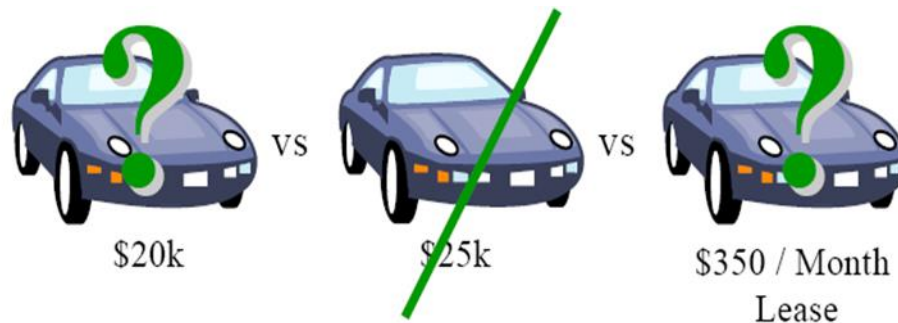
◆ **Basis-Cash Flow Analysis**

- Which project or alternative has better net cash flow?

◆ **Key issues-**

- Time value of money

- Cash flow occurring at different time

- Designs with different durations

◈ **Engineers design things and perform projects**

◈ **Therefore, engineers must be concerned with the economic aspects of designs that they recommend, and projects that they perform**

◈ **Engineering economics is needed for many kinds of decision making.**

◈ **Example: Buying a car**

- **Alternatives:**

  ✓ **Not buying**

  ✓ **Buying with $18,000 now, or**

  ✓ **Buying for $600 per month for 3 years**

- **Which is better?**

◈ **It will help you make good decisions:**

  • **In your professional life**

    ✓ **(Regardless of whether you go into the private or public sector)**

  • **And in your personal life!**

◈ **Knowledge of engineering economics will have a significant impact on you personally!**

◈ **Engineering economics involves:**

  • **Formulating**, **Estimating**, and **Evaluating** economic out comes when choices or alternatives are available.

◈ **By using specific mathematical relationships:**

- **to compare the cash flows of the different alternatives (typically using spreadsheets)**

◈ **Here is an approach to problem-solving:**

1. **Understand the Problem**

2. **Collect all relevant data/information** *(difficult!)*

3. **Define the feasible alternatives**

4. **Evaluate each alternative** ⟶

5. **Select the "best" alternative**

6. **Implement and monitor**

> This is the major role of engineering economics

◈ **Engineering economics is based mainly on estimates of future costs and benefits:**

  • **So it has to deal with risk and uncertainty**

◈ **The costs, benefits, and other parameters are typically unknown, and can vary over time:**

  • **The values of these parameters will dictate a particular numerical outcome**

  • **And therefore a particular decision!**

◈ **Sensitivity analysis can be used to explore how the decision changes as our estimates change**

◈ **Remember:**

- **"Tools" don't make decisions**

- **People make decisions, based on *values***

◈ **Engineering economics is just a set of tools:**

- **It can help in decision making**

- **But *it won't make the decision for you***

◈ **Which alternative is "best" is up to you!**

◈ **Cash Flow Comparisons!**

    ◈ **Example: Buying a car**

        • **Alternatives:**

            ✓ **Not buying**

            ✓ **Buying with $18,000 now, or**

            ✓ **Buying for 600 per month for 3 years (= $21,600 total)**

        • **Which is better?**

            ✓ **It depends!**

                ■ **Issue: how much is money now worth compared to money in the future?**

            ✓ **Leads to idea of time value of money!**

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◆ **What is project?**

- **It is an investment plan**

- **It is undertaken for a particular goal or objective to be achieved within a limited period of time and with limited resources (manpower, money, etc.)**

◆ **project characterized by:**

- **A construction period**

- **An operational period**

- **(expected) life time**

- **Specific desired output (benefits)**

- **Use of scarce and valuable resources and/or undesired outputs (costs).**

- **Sometimes a well defined target.**

◈ **Classify project period into different phases:**

- **Project identification**

- **Project formation and preparation**

- **Project appraisal**

- **Project implementation**

- **Project monitoring and evaluation**

◈ **Project appraisal or investment analysis is about the comparison of different investment alternatives or projects say: A0, A1, A2... Aj, An**

◈ **The objective of economic analysis of projects is three fold**

- **The evaluation as to whether a specific project is economically desirable.**

- **The identification of the most desirable project among several desirable alternatives.**

- **The placement of the more economically desirable projects in rank order.**

◈ **Projects classifications:**

- **Private owned:**

- **Public or state owned**

✓ **This distinction is closely related to the nature of goods and services in terms of excludability and subtractibility.**

  - **Excludability: the degree to which users can be excluded (example: Flood protection…) this implies for public owned**

  - **Subtractibility: the degree to which consumption by one user reduces the possibility of consumption by the others. (example: Fisheries…) this implies for private owned**

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◈ **Public Projects/goods:-**

- **have low subtractibility and low excludability.**

   ✓**Eg. Service of flood protection.**

◈ **Private Projects/goods:**

- **have high subtractibility and high excludability.**

   ✓**Eg. Individual pit (waste water).**

◈ **Important criterion for public sector decisions;**

- **Economic efficiency:**

  ✓ **deals with efficiency of resource allocation**

- **Equity:**

  ✓ **distribution of costs and benefits over different social classes and different regions.**

  ✓ **(Eg. Block tariffing in public water supply.)**

- **Inter-generation effects or long term aspects:**

  ✓ **distribution of costs and benefits over time.**

- **Feasibility of implementation:**

  ✓ **should be evaluated in technical, financial, social, and administrative senses**

◈ **Economic analyses may be based on a number of cost classifications:**

- **First (or Initial) Cost :**

  ✓ **Cost to get activity started such as property improvement, transportation, installation, and initial expenditures.**

- **Operation and Maintenance Cost :**

  ✓ **They are experienced continually over the useful life of the activity.**

- **Fixed Cost :**

  ✓ **Costs which could not vary with level of production.**

- **Variable Cost :**

  ✓ **Variable costs are related to the level of operational activity**

- **Incremental or Marginal Cost :**

  ✓ **Incremental (or marginal) cost is the additional expense that will be incurred from increased output in one or more system units**

- **Sunk Cost :**

  ✓ **It cannot be recovered or altered by future actions. Usually this cost is not a part of engineering economic analysis.**

- **Life-Cycle Cost :**

  ✓ **This is cost for the entire life-cycle of a product, and includes feasibility, design, construction, operation and disposal costs.**

- **Opportunity Cost: an expired Benefit.**

◈ **Explained in quote; "A bird in hand is more than two in bush!"**

- **Would you rather have:**

  ✓ **$100 today, or**

  ✓ **$100 a year from now?**

- **Basic assumption:**

  ✓ **Given a fixed amount of money, and**

  ✓ **A choice of having it now or in the future,**

- **Most people would prefer to have it sooner rather than later**

- **Reasons:**

  - ✓**money has earning power over time (Cost of money)**

  - ✓**Inflation**

  - ✓**Risk**

- **This assumption is not universally satisfied:**

  - ✓**E.g. saving money for graduate school**

- **But it is nearly universal, especially in business**

◈ **One consequence of the time value of money:**

- **Suppose you are willing to exchange a certain amount now for some other amount later**

- **Then the later amount has to be discounted**

◈ **The time value of money manifested the idea of:**

- **An interest rate (if projecting into the future) Or,**

- **Equivalently, a discount rate (if rolling back to the present),**

- **Inflation or deflation and**

- **Risk.**

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◈ **Time value of money deals with changes in the value of money over some period of time (due to investment opportunities, uncertainty, etc.)**

◈ **This is the single most important concept in engineering economics!**

◈ **Interest:**

- **It is the increase between an original sum of money borrowed and the final amount owed, or the original amount owned (or invested) and the final amount accrued.**

- **In simple terms interest is the price or cost of the use of money.**

- **When interest is expressed as a percentage of the original amount per time unit, the result is an interest rate.**

- **This rate is calculated as:**

$$Percent\ interest\ rate\ i = \frac{Final\ owned - Principal}{Pricipal} * 100\%$$

◆ **Equivalence**

- **Issue: Time Value of money**

  - **Money now has a d/t value than the same amount at a d/t date**

  ✓ **Would you prefer $75 today or 80in one year?**

  ✓ **It depends-Rate of return on investment**

- **Proper name: Discount rate i or r**

  ✓ **Future benefits/costs are reduced(i.e. discounted) to compare with present.**

- **Even though the amounts and timing of the cash flows may differ, the appropriate interest rate makes them equal.**

- **Example: 100 dollar today is equal with 106 dollar after one year considering 6%interest rate.**

◈ **Simple Interest (infrequently used)**

- **Total interest earned (charged) is linearly proportional to**

  ✓ **The initial amount of principal(loan)**

  ✓ **Interest rate**

  ✓ **Number of time period of commitment**

$$total\ interest\ i = P * n * i$$

Where P=principal amount lent or borrowed

N=number of interest periods

i=interest rate per period

◆ **Compounded Interest**

◆ **Interest earned (charged) for a period is base on**

◆ **Reaming principal plus**

◆ **Accumulated (unpaid) interest at the beginning of the period**

$$I_n(Interest\ in\ period\ n) = P_n * i$$

$$P_n = principal\ amount\ in\ period\ n$$

$$i = interest\ rate\ per\ period$$

$$I = \sum_n I_n$$

◈ **Compute the compound interest and loan balance for each year for the $1000 a certain person borrowed at 5% per year. Graphically compare the result for compound interest and simple**

✓ **Solution:**

| End of Year	Initial Amount (Principal)	Interest Rate	Simple interest interest	Final Value at the end of each yrs Balance	Comp. interest interest	Final Value at the end of each yrs Balance
0	$1,000.00	5%		$1,000.00		$1,000
1			$50.00	$1,050.00	$50	$1,050
2			$50.00	$1,100.00	$52.50	$1,102.50
3			$50.00	$1,150.00	55.13	1157.63

Interest= (principal + all accrued interest)X(interest rate) --- for compound Interest
Interest=(principal)x(number of periods)x(interest rate)--- for Simple interest

◈ **Compute the compound interest and loan balance for each year for the $1000 a certain person borrowed at 5% per year. Graphically compare the result for compound interest and simple**

   ✓ **Solution:**
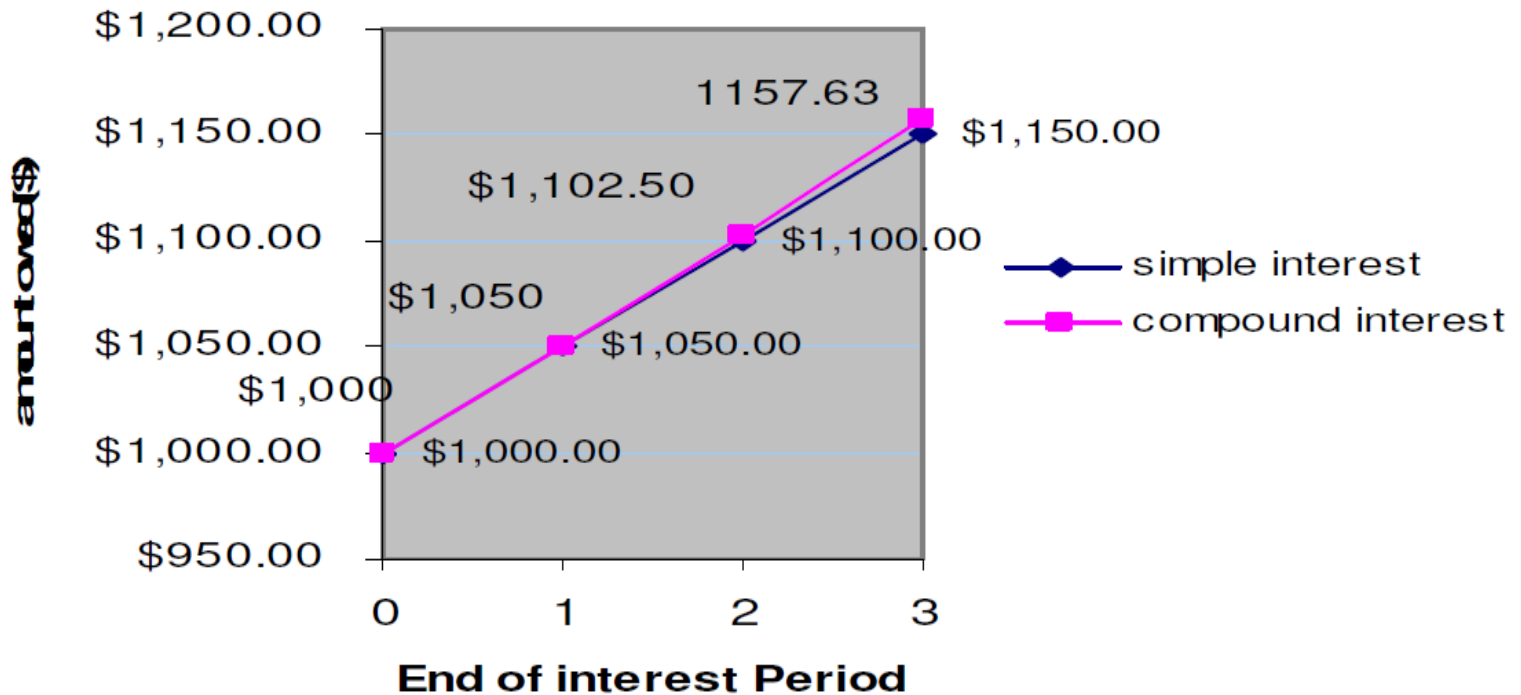
◈ Nominal interest rate (r)

- **Even though financial institutions may use more than one interest period per year in compounding the interest, they usually quote the interest on an annual basis.**

- **The annual base interest rate which doesn't consider the compounding period is said to be Nominal interest rate.**

◈ Effective Interest rate (i_e)

- **The effective interest rate represents the actual interest earned or charged for a specified time period**

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

where, r = nominal interest rate (per year)

i= actual (effective interest rate) per year

m= number of interest periods per year

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i_e = effective annual interest rate

◈ **As a limit interest may be considered to be compounded an infinite number of times per year, i.e. continuously.**
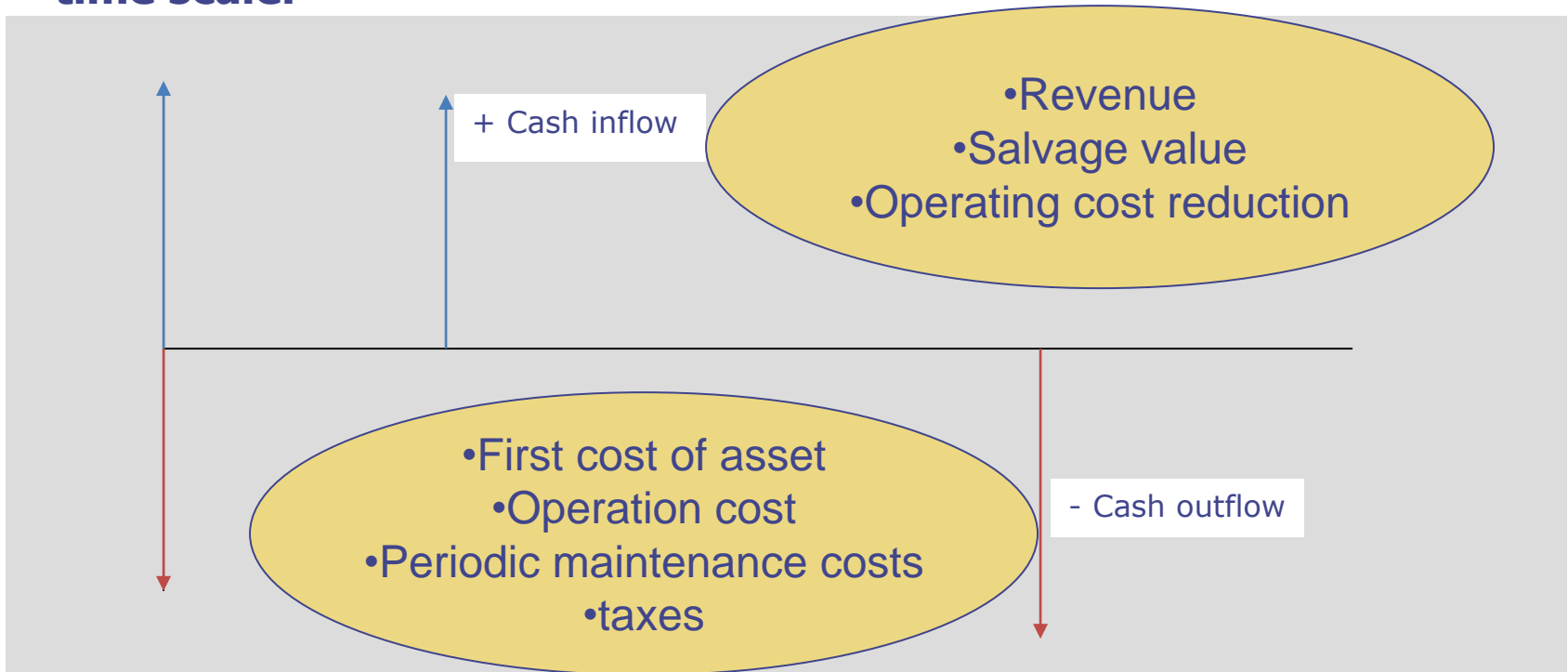
$$i_e = \left(1 + \frac{r}{m}\right)^m - 1$$

Let

$$i_e = \lim_{m \to \infty} \left(1 + \frac{r}{m}\right)^m - 1 \quad \text{, but} \quad \left(\left(1 + \frac{r}{m}\right)^{\frac{m}{r}}\right)^r = \left(1 + \frac{r}{m}\right)^m$$

$$Let, \ y = \frac{m}{r} \qquad \lim_{y \to \infty} \left(1 + \frac{1}{y}\right)^y = e$$

$$i_e = \lim_{y \to \infty} \left(1 + \frac{r}{m}\right)^m - 1 = e^r - 1$$

❖ **It is simply a graphical representation of cash flows drawn on a time scale.**

◈ **Important elements for cash flow diagram.**

- **A time interval divided into an appropriate number of equal periods**

- **All cash outflows (deposits, expenditures, etc.) in each period**

- **All cash inflows (withdrawals, income, etc.) for each period**

◈ **Cash inflows:**

- **Revenues**

- **Salvage value**

◈ **Cash outflows:**

- **First cost of asset,**

- **Operation cost**

- **Periodic maintenance costs**

- **Taxes**

Notation

◈ **To simplify the subject of economic analysis, symbols are introduced to represent types of cash flows and interest factor; the following symbols will be used here:**

- **i=effective interest rate per interest period**

- **N=number of compounding periods**

- **P= present sum of money (present value) equivalent value of cash flows at a reference point in time called the present**

- **Future= future sum of money (future value) equivalent value of cash flows at a reference point in the time called the future**

- **A= end of period cash flows in a uniform series of payment continuing for a specified time, starting at the end of the first period and continuing to the end of the last period**

1. Derivation of single-payment formulas (P/F and F/P)

◆ **In this case, a formula is developed which allows determination of the amount of money that is accumulated (F) after n-years (periods) from a single investment (P) when interest is compounded one time per year (period).**

◆ **If an amount of money P is invested at some time t=0, the amount of money F1, that will be accumulated 1-year hence at an interest rate of i- per year will be.**

1. Derivation of single-payment formulas (P/F and F/P)
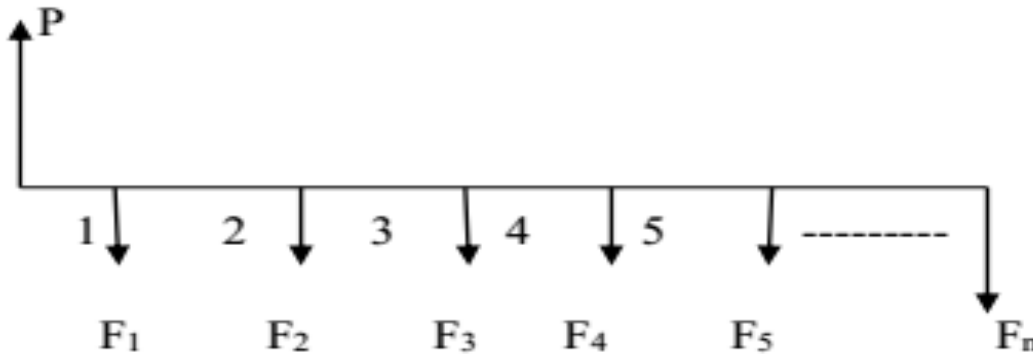
$F_1 = p + ip = P(1+i)$……………………..at first year

At second year,

$F_2 = F_1 + iF_1 = P(1+i) + P(1+i)i$

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

$F_2 = P(1+i)^2$

At third year,

$F_3 = F_2 + F_2 i$

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

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

$F_3 = P(1+i)^3$

1. Derivation of single-payment formulas (P/F and F/P)

Therefore, formula can be generalized as;

$$F_n = P(1+i)^n \ldots\ldots\ldots\ldots (1.1)$$

The factor $(1+i)^n$ is called the *single payment compound-amount factor (SPCAF) or the F/P factor.*

By rearranging equation (1.) discounting equation can be given as:

$$P = F\left[\frac{1}{(1+i)^n}\right] \qquad \ldots\ldots (1.2)$$

The expression in the brackets is known as *single-payment present-worth factor (SPPWF), or the P/F factor.*

2. Derivation of the Uniform Series Present Worth Factor and Capital Recovery   Factor (P/A and A/P)

◆ Uniform series of payments- often called an annuity (A)
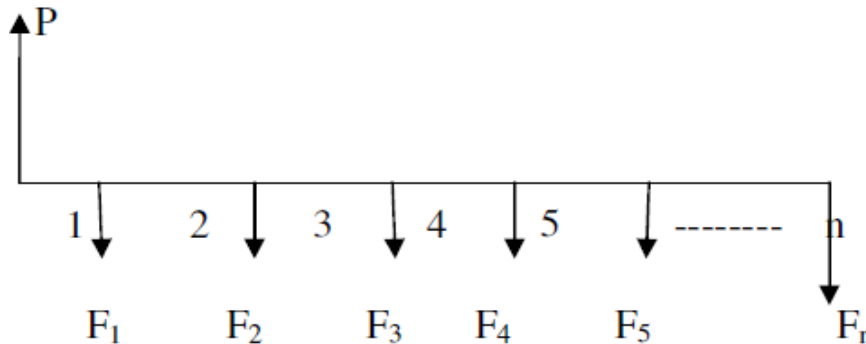
In annuity $F_1 = F_2 = F_3 = F_4 = \ldots\ldots\ldots = A$

$$P_1 = \frac{F_1}{(1+i)} \qquad P_2 = \frac{F_2}{(1+i)^2} \qquad P_3 = \frac{F_3}{(1+i)^3} \qquad \text{and} \qquad p_n = \frac{F_n}{(1+i)^n}$$

$$P_{total} = p_1 + p_2 + p_3 + \ldots\ldots + p_n$$

$$= \frac{F_1}{(1+i)} + \frac{F_2}{(1+i)^2} + \frac{F_3}{(i+i)^3} + \cdots + \frac{F_n}{(1+i)^n}$$

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2. Derivation of the Uniform Series Present Worth Factor and Capital Recovery   Factor (P/A and A/P)

Since $F_1, F_2, F_3\ldots$ & $F_n = A$ replace the value

$$P = A\left[\frac{1}{(1+i)^1}\right] + A\left[\frac{1}{(1+i)^2}\right] + A\left[\frac{1}{(1+i)^3}\right] + \ldots + A\left[\frac{1}{(1+i)^N}\right]$$

$$P = A\left[\frac{1}{(1+i)^1} + \frac{1}{(1+i)^2} + \ldots + \frac{1}{(1+i)^n}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(a)}$$

Multiplying both sides by $1/(1+i)$;

$$\frac{P}{1+i} = A\left[\frac{1}{(1+i)^2} + \frac{1}{(1+i)^3} + \ldots + \frac{1}{(1+i)^{n+1}}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(b)}$$

Subtracting equation (a) from equation (b)

$$\frac{P}{1+i} - P = A\left[-\frac{1}{(1+i)^1} + \frac{1}{(1+i)^2} + \ldots + \frac{1}{(1+i)^{n+1}}\right]$$

2. Derivation of the Uniform Series Present Worth Factor and Capital Recovery   Factor (P/A and A/P)

After some simplification of the above equation, we come up with:

$$P = A\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right]....i \neq 0, \text{ (P/A, i\%, n) in standard notation} \qquad ...... (1.3)$$

The terms in brackets is called the uniform-series present-worth factor (US-PWF) or the P/A factor.

$$A = P\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right] \qquad ..... (1.4)$$

◈ In equation 1.4 the terms in the bracket is called capital-recovery factor (CRF), or A/P factor, yields the equivalent uniform annual worth A over n years of a given investment P when the i.

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3. Derivation of the Sinking Fund Factor and the Uniform –Series Compound Amount Factor (A/F And F/A)

◈ While the sinking-fund factor (SFF), or A/F factor, and the uniform-series compound-amount factor (USCAF), or F/A factor, could be derived using the F/P factor, the simplest way to derive the formula is to substitute into those already developed. Hence, Interest rate is i.

$$A = F \left[\frac{i}{(1+i)^n - 1} \right] \qquad \text{A/F factor} \qquad \qquad \dots.. (1.5)$$

$$F = A \left[\frac{(1+i)^n - 1}{i} \right] \qquad \text{F/A factor} \qquad \qquad \dots\dots (1.6$$

◈ In equation 1.5, the term in the bracket is called sinking fund factor and in equation 1.6 it is called uniform series compound amount factor.

4. Derivation Of The Gradient formula (factor) (P/G, i%, n) or (G/P, i%, n)

◆ A uniform gradient is a cash flow series which either increasing or decreasing uniformly.

◆ This is the cash flow, whether income or disbursements, changes by the same arithmetic amount each interest period.
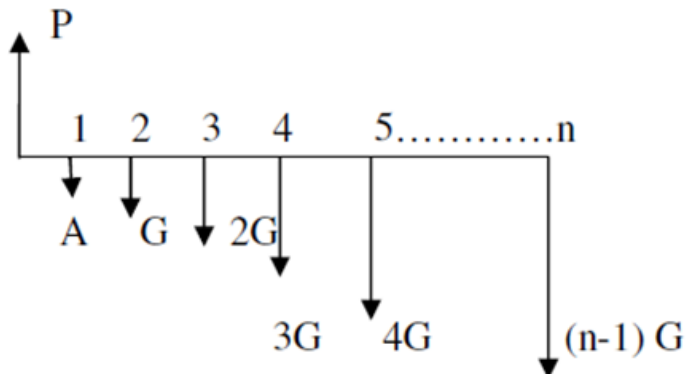
- Symbolically Gradient is represented by "G"

- Payment which is occurs at the end of year one (A) is not part of the gradient series but rather base payment.

- Base payment is annuity which is expected to be uniform all over the year

- Gradient is starting from end of year two

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4. Derivation Of The Gradient formula (factor) (P/G, i%, n) or (G/P, i%, n)

◆ There are several ways by which the uniform gradient factors can be derived which means using either of the above interest factors.

◆ For the time being, let's use single-payment present worth factor

$$(P/F, i\%, n) \text{ or } P = F\left[\frac{1}{(1+i)^n}\right]$$

$$P = G\,(P/F, i\%, 2) + 2G\,(P/F, i\%, 3) + 3G\,(P/F, i\%, 4) + \ldots + (n\text{-}1)\,G\,(P/F, i\%, n)$$

$$P = \left[\frac{G}{(1+i)^2} + \frac{2G}{(1+i)^3} + \frac{3G}{(1+i)^4} + \frac{4G}{(1+i)^5} + \ldots + \frac{(n-1)G}{(1+i)^n}\right]$$

Factor out G. then

$$P = G\left[\frac{1}{(1+i)^2} + \frac{2}{(1+i)^3} + \frac{3}{(1+i)^4} + \frac{4}{(1+i)^5} + \ldots + \frac{(n-1)}{(1+i)^n}\right] \quad \ldots\ldots\ldots\ldots (1.7)$$

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4. Derivation Of The Gradient formula (factor) (P/G, i%, n) or (G/P, i%, n)

Multiplying both sides of equation 1.7 above by (1+i), then

$$P(1+i) = G\left[\frac{1}{(1+i)} + \frac{2}{(1+i)^2} + \frac{3}{(1+i)^3} + \frac{4}{(1+i)^4} + ... + \frac{(n-1)}{(1+i)^{n-2}} + \frac{(n-1)}{(1+i)^{n-1}}\right] .... (1.8)$$

Then, subtracting equation (1.8) from equation (1.7) it yields

$$P(1+i) - p = G\left[\frac{1}{(1+i)} + \frac{(2-1)}{(1+i)^2} + \frac{(3-2)}{(1+i)^3} + \frac{(4-3)}{(1+i)^4} + ... + \frac{(n-1)-(n-2)}{(1+i)^{n-1}} - \frac{(n-1)}{(1+i)^n}\right]$$

$$P(1+i) - p = G\left[\frac{1}{(1+i)} + \frac{1}{(1+i)^2} + \frac{1}{(1+i)^3} + \frac{1}{(1+i)^4} + ... + \frac{1}{(1+i)^{n-1}} + \frac{1-n}{(1+i)^n}\right]$$

4. Derivation Of The Gradient formula (factor) (P/G, i%, n) or (G/P, i%, n)

Then rearranging

$$P = \frac{G}{i}\left[\frac{1}{(1+i)} + \frac{1}{(1+i)^2} + \frac{1}{(1+i)^3} + \frac{1}{(1+i)^4} + \ldots + \frac{1}{(1+i)^{n-1}} + \frac{1}{(1+i)^n}\right] - \frac{Gn}{i(1+i)^n}$$

The term in the bracket is represent present worth equation. Therefore,

$$P = \frac{G}{i}\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right] - \frac{Gn}{i(1+i)^n}$$

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

$$P = G\left[\frac{(1+i)^n - in - 1}{i^2(1+i)^n}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1.9) \text{ equation of gradient}$$

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Methods of comparing alternative proposals

◆ **Basis of comparison**

- The usual goal of engineering economy studies is to minimize costs or maximize profits or savings.

- Comparing Alternatives involves only mutually Exclusive projects.

◆ **Mutually Exclusive alternatives/Projects**

- It implies that the selection of one alternative excludes the selection of any other alternative, or alternatives which possibly sole the same problem.

◆ **Service and Revenue Projects**

- Service projects are those projects whose revenue does not depend on the chose of the projects. (compare by the costs)

- Revenue projects are the type of projects which designed for the purpose of income generating (compared by the net Value)

Methods of comparing alternative proposals

◈ **Basis of comparison**

Situation	Criterion
1.Service projects or Alternatives involve cost only 2.Revenue projects or Alternatives involve both cost and benefits	1. Select alterative with lowest equivalent cost 2. Select alternative which maximizes the net equivalent benefit (the *do-nothing* alternative should always be considered if available)

Initial Project Screening

◈ **Purpose:** **To eliminate some alternatives that can be easily detected to be unfit using a simple technique.**

◈ **Method: Pay back period**

- **It is the time required to accumulate a sum of money from a net cash flow which is equal to the initial investment).**

- **This method was used in the 1950s as the main comparison method.**

- **But nowadays it only employed in the initial screening of projects as a result of its significant drawbacks.**

◈ **This method is simple but has drawbacks. Such as:-**

- **It doesn't consider time value of money (undiscounted)**

- **Fail to measure profitability**

- **Neglect the return after the payback period**

Initial Project Screening

◈ **Example : Which project has the smaller pay back period between projects A&B.**

Year	Project A	Project B
initial costs 0	- 2400	-4000
1	1300	1000
2	1100	1500
3	1000	1500
4	500	2500
5	400	4000

◈ **The pay back period of the project A is 2 years and the payback period of the project B is 3 years.**

Methods Of comparison

◈ **present worth method of Analysis**

◈ **Annual worth method of Analysis**

◈ **Future worth method of Analysis**

◈ **Rate of return method of Analysis**

◈ **Incremental Rate of return Method**

◈ **Break-even comparison method or break-even Analysis**

◈ **Benefit-cost Analysis**

Net Present Worth

◈ **Net Present worth Criterion**

- Determine the interest rate that the firm wishes to earn on its investment

- Estimate the service life of the project.

- Estimate the cash flow over each service period

- Determine the net cash flows, i.e.

  ✓ **Net cash flow=Cash Inflow-Cash Outflow**

◈ **The decision rule is:**

- If P(i)>0, accept the investment

- If P(i)=0, remain indifference

- If P(i)<0 reject the investment

Present worth Analysis

◈ **Important elements of present worth analysis.**

- **Interest rate (i):**

  ✓ **This interest rate is often is referred to as either a required rate of return or a minimum attractive rate of return (MARR).**

  ✓ **Usually this selection is a policy decision made by top management.**

  ✓ **(it should not be less than Banks interest rate)**

- **Analysis Period:**

  ✓ **It is the time span over which the economic effect of an investment will be evaluated**

Present worth Analysis : Analysis period

◈ **Case 1 (analysis period equal with projects life)**

  ✓ **It is a simple analysis.**

◈ **Case 2 (Analysis period differs from projects life)**

2.1. projects life longer than Analysis period

  ✓ **we analyses each alternatives for the analysis period and are left with unused considered as salvage value.**

2.2. Projects life shorter than Analysis period

  ✓ **Additional project to be replaced when the initial project has reached the limit of its useful life.**

2.3 Analysis period coincide with longest projects life

  ✓ **Revenue projects with different lives can be compared if they require only one time investment.**

Present worth Analysis : **Analysis period**

◈   **Case 3 (When the analysis period is not provided)**

3.1 when the useful lives of the projects are equal.

✓   **The analysis period is the useful life of the projects**

3.2 When the useful lives of the projects are different.

✓   **The LCM of the useful lives of the alternative is considered as analysis period.**

Example 1 (Alternatives with equal life span)

◆ **An engineer is in need of an automobile for business purposes, and finds that a suitable one can be obtained by either of two methods:**

(a) lease a car for Birr 10,000 per month for two years, paid monthly at the end of each month, or

(b) purchase the same type of car for Birr 500,000 now and sell it in two years for Birr 300,000.

In either case, the engineer pays all operating maintenance and insurance costs. He can borrow fund for either alternative from the local bank at 9 percent interest. Which is the least costly alternative, assuming interest is compounded monthly?

Example 2 (Alternatives with unequal life span

A country engineer has a choice of paving with either type A pavement or type B pavement. Type A pavement has a life expectancy of 10 years, after which part of the material can be salvaged and reused. Type B pavement only lasts for five years but is much less expensive. Which is the better alternative? Two sequential five-year installations of type B are compared to one ten-year life of type A.

Description	Pavement cost / Km	
	Type A	**Type B**
Purchasing price	20,000	5,000
Annual maintenance cost	1,000	2,000
Salvage value	2,500	0
Useful life, n	10	5
Interest, i	6%	6%

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Capitalized cost of perpetual lives (n →∞)

◈ **It is a present worth of a project that is assumed to last for ever.**

✓ **Public worth projects such as Dams, Irrigation systems,**

railroads, permanent universities, etc. analyzed by using

Capitalized cost

$$P = A\frac{[(1+i)^n - 1]}{i * (1+i)^n} \qquad \Rightarrow = \frac{A}{i}\left[\frac{(1+i)^n}{(1+i)^n} - \frac{1}{(1+i)^n}\right] = A/i$$

Procedures

a) Draw cash flow diagram showing all recurring (one-time) costs/incomes and at least 2 cycle of non-recurring (periodic costs/receipts.

b) Find the present value of all non-recurring costs/receipts.

c) Find equivalent uniform annual worth (value) through one life cycle of all recurring amounts and add it to all other uniform amounts occurring in year 1 through infinity. This is results in a total equivalent uniform annual worth (Aw).

d) Divide the annual worth obtained in step (iii) by the interest rate (i) to get capitalized costs.

e) Add the value obtained in step (ii) to the value obtained in step (iv). The result of this step is the **Present worth of the project/investment**.

Drawbacks of PW method

◈ **It is sensitive to the choice of an interest rate or discounting rate;**

Example: Assume F= 1000 and n=10

For   i = 10 %   P= 386

For   i = 15%   P= 246

For   i = 20%   P= 162

◈ **It is sensitive to the choice of base year;**

Example: Assume F= 1000 and i=10%

For   n = 20   P= 149

For   n = 15   P= 239

For   n = 10   P= 386

◈ **It doesn't give information about the degree of acceptability, especially if there are many investment alternatives for limited budget.**

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Example

Example: assume that the available budget is $800,000 only and five alternative investments are given below with their present value of costs and benefit expected.

Project	PVC	PVB	NPV(10%)	B/C(10%)
A	10,000	13,000	3,000	1.3
B	40,000	43,300	3,300	1.08
C	20,000	30,300	10,300	1.52
D	40,000	49,400	9,400	1.24
E	50,000	55,800	5,800	1.11

Example

- ✓ **When the projects ranked based on NPV and B/C approach, it looks like as follow:**

> NPV   C, D, E, B and A
>
> B/C   C, A, D, E and B

- ✓ **If we use the NPW ranking, we will get a net amount of Birr 22,000.**

- ✓ **And if the budget invested according to B/C ranking the net amount expected to be Birr 23,900.**

- ✓ **This implies that the NPW ranking couldn't lead to the profitability of investments compared to B/C ratio method.**

Annual worth method of Analysis

◈ **Judging proposed investments**

    ◈ **Another way of judging investments:**

        ✓ **Again based on minimum rate of return i***

    ◈ **With annual equivalent cash flow:**

        ✓ **All costs and benefits (present or future) converted to equivalent annual amounts**

    ◈ **Easy for projects with different lives:**

        ✓ **Yields the cost of one year of service**

Annual worth method of Analysis

◈ **Calculation of annual amount**

　　◈ **Reminders**

　　　✓ **Convert future to annual:**

$$A = F\ i/[(1+i)^n - 1]$$

　　　✓ **Convert present to annual:**

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

Annual worth method of Analysis

◈ **Decision rules**

    ◈ **To evaluate a simple project.**

        ✓ **AW>0, Accept the investment**

        ✓ **AW=0, Remain indifferent**

        ✓ **Aw<0, Reject the investment**

        ✓ **When mutually exclusive service projects are compared the one with the minimum annual equivalent or least negative annual worth is selected.**

    ◈ **Compare options with different lives:**

        ✓ **Choose option with lowest annualized cost (Or highest annual equivalent benefit)**

Annual worth method of Analysis

◈ **Advantage**

 ◈ **Consistency report formals**

  ✓ **Financial managers more commonly work with annual base report both for internal and external report.**

 ◈ **Need for unit costs/profits**

  ✓ **In many situations projects must be broken into unit costs/Profits for ease of comparison**

 ◈ **Unequal project lives:**

  ✓ **Complication can be avoided by annual worth method for comparing projects having unequal lives.**

Annual worth method of Analysis

◈ **Example**

  ◈ **Two roofs are under consideration for a building needed for 20yrs. Their anticipated costs and life's are given below in the table. By using Annual worth method, suggest which roof would you select and why?**

	Roof C	Roof D
Cost New	50,000	25,000
Replacement rate	0%	8%per yr
Life of roof (yrs)	20	10
Salvage Value	0	0
Interest rate (%)	10	10

Future Worth Method of Computing Alternative

◈ **Future worth (FW) comparisons of alternative investments or projects:**

  ✓ **are frequently used when the owner or manager expects to sell or otherwise liquidate the investment at some future date and wants to estimate of net worth at that future date.**

Future Worth Method of Computing Alternative

Example

◈ **A construction company is considering the purchase of one of the two new front end loaders whose data are listed below. Compare using future worth method.**

	Front End Loader A	Front end loader B
First cost (Birr)	-100,000	-40,000
Annual net income	+16,000	+13,00
Useful Life (yrs)	10	5
Replacementcost escalation	NA	10%/yr compounded
Salvage Value	+10,000	+10,000
Interest rate (%)	8	8

Internal Rate of return method of Analysis

◆ **Judging proposed investments**

   ◆ **Don't need to pre-specify minimum rate of return i* in judging projects**

   ◆ **Internal rate of return (IRR) is:**

      ✓ **The interest rate that makes the present worth of a project exactly 0.**

   ◆ **Project is desirable if i*< IRR**

      ✓ **Not otherwise (since present worth would be negative)**

Rate of return method of Analysis

◈ **Step-by-step procedure for finding ROR/IRR.**

Step 1. Make a guess at a trial rate of return.

Step 2. Count the costs as negative (-) and the income or savings as positive (+).Then find the equivalent net worth of all costs and income. Use present worth, annual worth or future worth.

Step 3. If the equivalent net worth is positive, then the income from the investment is worth more than the cost of the investment and the actual present return is higher than the trial rate, (i)

Rate of return method of Analysis

◈ **Step-by-step procedure for finding ROR/IRR.**

Step 4. Adjust the estimates of the trial rate, of return and proceed with steps 2 and 3 again until one of (i) is found that results in a positive (+)equivalent net worth , and another higher value of (i) is found with a negative (-) equivalent net worth.

Step 5. Solve for the correct value of (i) by interpolation.

Rate of return method of Analysis

◈ **Example**

    ◈ **Assume a bond sells for Birr 950. The bond holder will receive Birr 60 per year interest as well as B 1,000 (the face amount of this bond) at the end of ten years. Find the rate of return.**

Incremental rate of return

◈ **The incremental rate of return (IROR) is defined as the rate of return for additional initial investment when comparing against a lower cost investment.**

◈ **Two types of investment decision occur.**

• **The first type involves costs only.**

  ✓ **Under such conditions the rate of return for each investment is negative and, thus need not be calculated.**

Incremental rate of return

- **The second type involves both costs and revenues,**

    ✓ The question raised to be answered in this type is "which alternatives yields the lowest equivalent cost?" To determine the following procedure should be followed;

◈ **Procedures**

i. list alternatives in order of ascending first cost;

ii. Step wise determine IROR for each difference in alternatives compared. *(the same procedure used as IRR)*

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Incremental rate of return

◈ Decision rule of IROR

- The decision of selecting the desirable alternative using IROR method is based on the MARR.

  - ✓ **If IROR > MARR, discard the lower cost alternative (defender)**

  - ✓ If IROR < MARR, discard the higher initial cost alternative (challenger)

Incremental rate of return

◆ **Decision rule of IROR**

✓ **Matrix**

Challenger ⟶

	B	C	D
A	IROR	IROR	IROR
B		IROR	IROR
C			IROR

Defender ⟶ (vertical, upward)

Incremental rate of return

◈ **Way of selecting: Matrix**

- Check the first row of the matrix and get the largest value of IROR.

- **Check the IROR and compare with MARR, if it is less than MARR accept the defender and the comparison will over otherwise select challenger temporarily.**

- Then check the row of the challenger where it is defender for the larger value of IRR, and follow the same step as above.

Incremental rate of return

◈ **Example:**

- Suppose that a cement production company need to compare five alternatives for equipment purchase. Assumed that each had the first cost and IROR of each challenger with respect to their defender are listed below. Which alternative is best by using MARR=15%.

Alternatives	First cost
A	1,000,000
B	1,200,000
C	900,000
D	1,150,000
E	1,400,000

Incremental rate of return

◈ **Example:**

- **IROR values of the incremental values of alternatives**

Incremental	A-C	D-C	D-A	B-C	B-A	B-D	E-C	E-A	E-D	E-B
IROR , %	24.1	14	5.2	20.8	13.9	10.1	11.2	7.9	8.2	9.6

◈ **Solution**

Breakeven Point Analysis Method

◈ **The breakeven point is the point where the revenue and total cost relationships intersect**

◈ **For non-linear functions: It is possible to have more than one breakeven point**

◈ **Breakeven analysis is commonly used to study relationships among costs, revenue, and volume:**

   •   **Define cost and revenue functions**

   •   **Linear (or non-linear) functions of volume, price, etc.**

◈ **Objective: Find the value (volume, price, etc.) that maximizes profits**

Breakeven Point Analysis Method

◈ **The breakeven point for a problem can be expressed as:**

- **Units per time period**

- **Hours per month**

- **Price per unit and Etc.**

Breakeven Point Analysis Method

◈ The break-even point may be found by following the logical three-step procedure

1. **Find the annual equivalent of the capital costs**

2. **Find the independent variable and set up an equation for each** alternative cost combination. The equation usually takes the form of

   • **Total annual cost = equivalent capital Cost + (cost/ variable unit) * (Number of variable units/yr)**

     TAC= FAC+ VAC

3. **Find the break even point**

Breakeven Point Analysis Method

Example

◆ A contractor is thinking of selling his present dump truck and buying a new one. The new truck costs 30,000 and is expected to incur. O&M costs of 0.10 per ton-mile. It has a life of 15 years with no significant salvage value. The presently owned truck can be sold now for 10,000. If it is kept, it will cost 0.15 per ton-mile for O&M, and have an expected life of five years, and no salvage value. Use i = 10%, find the break-even point in terms of ton miles per year.

Solution

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Benefit-Cost Ratio Analysis Method

◈ **Benefit-cost ratio analysis** is a technique for evaluating a project or investment by comparing the economic benefits with the economic costs of the activity.

◈ Benefit-cost analysis has several objectives.

- First, B/c analysis can be used to evaluate the economic merit of a project.
- Second the results from a series of benefit-cost analyses can be used to compare competing projects.

◈ Discounting is a technique that converts all benefits and costs into their value in the present.

- Discounting is based on the premise that a Birr received today is worth more than a Birr received in the future.

$$P_V = \frac{F_V}{[1 + r]^t}$$

Benefit-Cost Ratio Analysis Method

◈ **Benefit-cost ratio analysis** is a technique for evaluating a project or investment by comparing the economic benefits with the economic costs of the activity.

◈ The benefit-cost ratio (B/C) is calculated as the NPV of benefits divided by the NPV of costs:

◈ **General equation of Benefit- cost analysis is;**

$$B/C = \frac{\sum\left(\dfrac{B_t}{(1+i)^t}\right)}{\sum\left(\dfrac{C_t}{(1+i)^t}\right)}$$

Benefit-Cost Ratio Analysis Method

◈ **Strong side o f B/C**

- **Criteria can be used to rank projects According to degree of acceptability**

- **Criteria can be used to decide whether a project should be financed or funded.**

- **Criterion which enable to make decision among different alternatives.**

Benefit-Cost Ratio Analysis Method

◈ **Weak side of B/C**

- **In case of mutually exclusive projects or projects different size and if one want to decide in favor of the project with the highest NPV, the B/C ratio doesn't give information on that.**

- **Sensitive to discounting rate**

- **When a project generates cost saving, such as cost saving can be either be represented as a net benefit or a negative cost. By using the latter we can increase the B/C ratio.**

Benefit-Cost Ratio Analysis Method

◈ **Methods of calculating B/C**

1. Conventional B/C ratio:- the benefits (usually annual) are determined for users. Thus the benefits are defined as;

Bn=Un= net annual benefit (saving cost = the cost saved by the implementation of the new project).

$$Conventional\, B/C = \frac{Net\, Saving\, to\, sers}{Owners\, Net\, apacity + Owner's\, net\, O\, \&\, M\, Cost}$$

Benefit-Cost Ratio Analysis Method

◈ **Methods of calculating B/C**

2. Modified B/C ratio method:-This method uses the same input data but not operating and maintenance cost (Mn) is treated as negative benefits they are placed in the nominator rather than in the denominator.

$$Modified \, B/C = \frac{Un - Mn}{Cn} = \frac{Bn - Mn}{Cn}$$

Cn = Net capital cost of replacing the present facility with the future facility

Benefit-Cost Ratio Analysis Method

◆ **Example:**

A flood control project is proposed for a certain area. There is a question as to the location of the dam and the numbers of alternative sites have been narrowed down to two, site A and site B. estimate of the costs associated with each of the site are listed below. The funds to construct the projects are available from bonds bearing interest rate of 6%. The expected life of the project at either site is 40 years and no salvage value is expected. Determine the value of B/C using Modified B/C ratio method.

Description	Existing Situation	Site A	Site B
Cost of construction	0	3,000,000	8,000,000
Annual O&M cost	0	56,000	94,000
Annual cost of flood damages	620,000	290,000	120,000
Annual loss due to land is lost to reservoir	0	20,000	46,000

Benefit-Cost Ratio Analysis Method

◈ **Solution**

   ◈ **Site A**

   $Un = 620,000-290,000-20,000$

   $= 310,000$

   $Mn = 56,000$

   $Cn = 3, 000, 000 (A/P,6\%,40)$

   $= 199,384.6$

$$Modified\ B/C = \frac{Un - Mn}{Cn} = \frac{310,000 - 56,000}{199,384.6}$$

$$= 1.274$$

Benefit-Cost Ratio Analysis Method

◆ **Solution**

◆ **Site B**

Un = 620,000-120,000-46,000

= 454,000

Mn = 94,000

Cn = 8, 000,000 (A/P,6%,40)

= 531,692.3

$$Modified\ B/C = \frac{Un - Mn}{Cn} = \frac{454,000 - 94,000}{531,692.3}$$

= 0.677

Therefore, Site A is selected because of its higher value of B/C ratio.

Project Investment Evaluations

◈ **Project investment should be evaluated by all desirable and undesirable output including Taxes and Deprecation of equipment and components of investment.**

◈ **Projects should be evaluated with compatibility of Government's policy, Like tax laws.**

◈ **Considering Depreciation in project evaluation has an advantage of tax reduction.**

Project Investment Evaluations

Tax

◈ **Importance of tax for a country**

- schools and collages, national defense, law enforcement, fire protection, construction a and operation of roads, parks, and so on are public service and financed by government.

- Such funds obtained from taxes revenue.

◈ **Sources of country's revenue**

Major Source Of Revenue	Level Of Government
Property "ad valorem" tax Sales tax Income tax	Local(country, city, school, etc) State Federal

Project Investment Evaluations

Tax
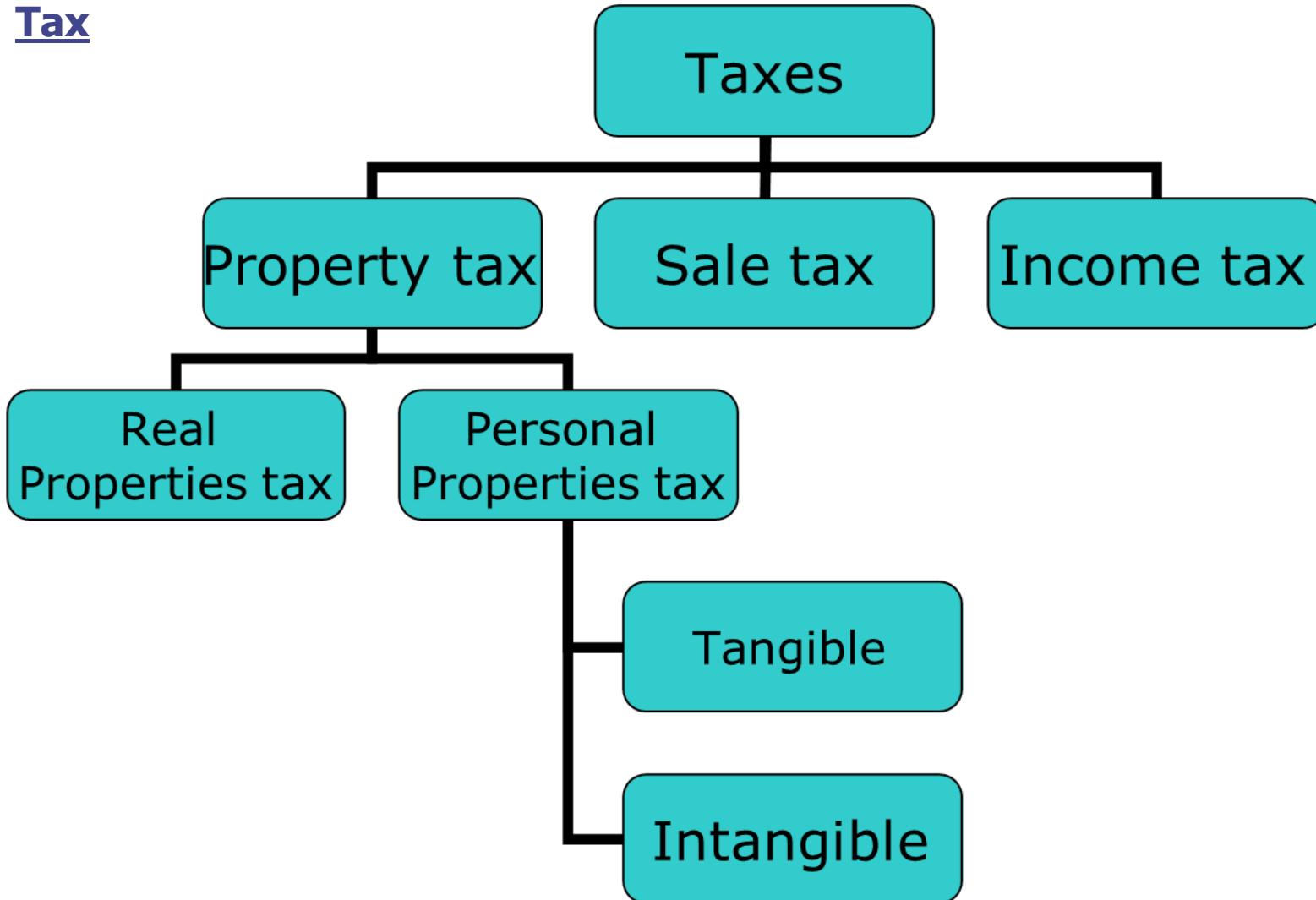
Project Investment Evaluations

Tax

◈ **Personal Propertie**

- **Tangible property** is any readily movable property that has inherent value (rather than being a piece of paper representing value)

✓ Example, a bulldozer, a car, clothing, jewelry, and appliance that are not fixed to a building

- **Intangible property** consisting largely of paper represents a right or title to the value inherent in some other object, property, or enterprise,

✓ Example, money, bond, stocks, mortgages, notes, accounts receivable, and other certificates of indebtedness of promises to pay

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Project Investment Evaluations

Tax

◈ **Sale taxes**

- The largest single source of income for state government in about two-third (2/3) of the state is sales tax.

- **This usually consists of a fixed percentage of tax on retail sales, collected by the retailer at the time of sale to the customer, and forwarded periodically to the state treasure.**

- The amount typically 15 percent. Some cities and countries are empowered by their respective states to levy an additional sale tax, and have done so.

Project Investment Evaluations

Tax

- **Income tax**

- The Federal government derives most of its revenue from income taxes

  - ✓Example: salary

Project Investment Evaluations

Capital Gain and loss

◆ When an asset is sold, and if the selling price is higher than these costs, the balance represents a profit called capital gain and if the selling price is lower, then the difference represents a loss called **capital loss**.

◆ **Profits on qualified assets held longer than one year may be considered as long-term capital gains and 60% of the gain may be excluded from taxable income.**

◆ **Ordinary income**: is a revenue obtained from the investment or planned out put of the investment

Project Investment Evaluations

Example

- **Assume an investor in the 30% tax bracket, purchases a land for $10,000. Two years latter he sells the land for $12,000 for a capital gain of $2,000 only 40% of the gain taxed at investor's ordinary income tax level of 30%. How much should the investor pay income tax,**

Solution

✓ **Selling price** = $12,000

✓ **Purchasing price** = $10,000

✓ **Capital gain** = $2,000

✓ **40% of capital gain reported as ordinary income.**

✓ **Taxable income** = 0.4X$2,000 = $800

✓ **Income tax due to 30%** = 0.3X$800 = $240

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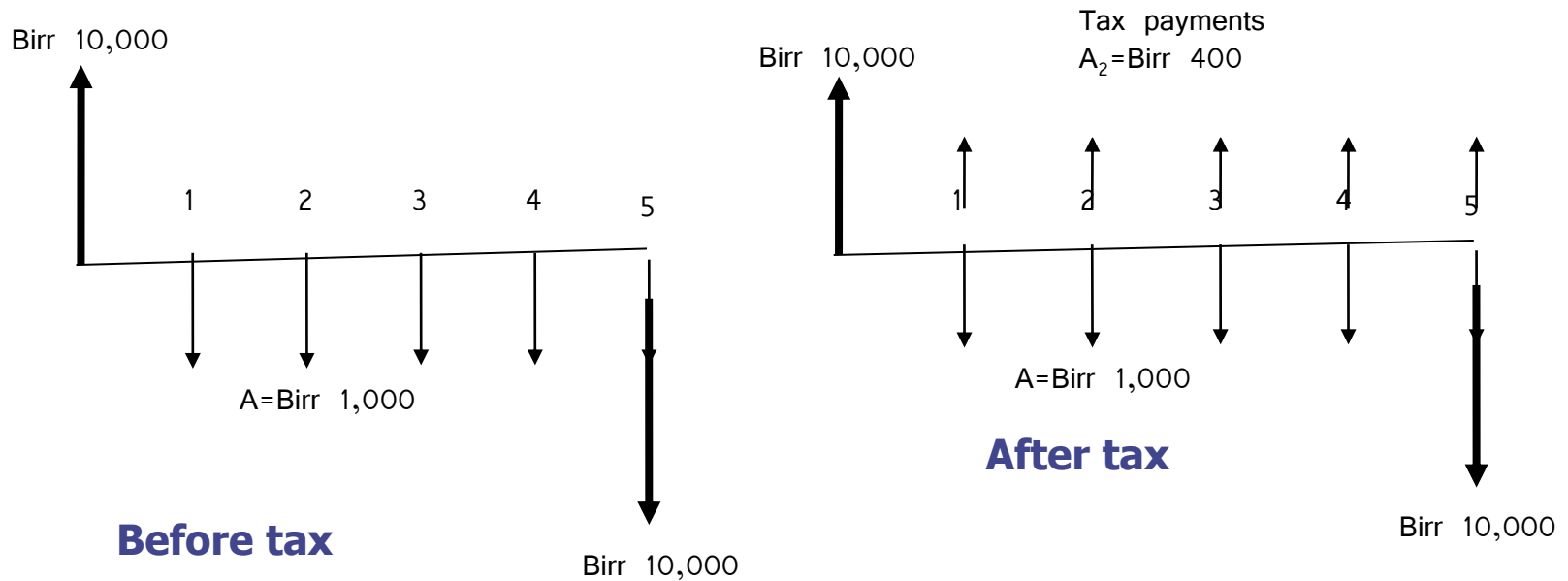## Project Investment Evaluations

Effect of taxes on cash flow

✓ **When evaluating the feasibility of any project to taxes, the taxes may be treated as other expenses of doing business.**

Before tax

After tax

Project Investment Evaluations

Depreciation

◈ **Depreciation is the loss in value of property such as machine, building, vehicle, or other investment over a period of time, caused by one or more of the following**

- ✓ **Unrepaired wear:** accumulates as a function of hours of use, severity of use

- ✓ **Deteriorations:** The gradual decay, corrosion, or erosion of the property

- ✓ **Obsolescence:** reduction of value and due to competition from newer and/or more productive models. (driven either by Technology or Style)

- ✓ **Reduction in demand:** normally results in decreasing value (increased depreciation) of an asset in accordance with the market place "law" supply and demand

Project Investment Evaluations

Depreciation accounting

◈ **Depreciation accounting is the systematic division of the depreciable value of capital investment into annual allocations over a period of years.**

◈ **Reasons**

- **To provide owners and manager with an estimate of the current value of their capital investment.**

  ✓ **Depreciation accounting for this purpose should approximate actual market values.**

- **To account for depreciation in a manner that yields the maximum possible tax benefits.**

  ✓ **Depreciation accounting for this purpose may not exceed strict legal guideline but need not approximate market values.**

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Project Investment Evaluations

Important parameters to Determine Depreciation

◈ **Estimate the purchasing price or cost when new.**

◈ **Estimate the economical life (time between purchase new and disposal at resale or salvage value), or recovery period for tax purpose.**

◈ **Estimate the resale or salvage value (zero for tax purpose).**

Project Investment Evaluations

Depreciation Methods

◆ **Straight line method**

◆ **Sum –Of-Year Digit method**

◆ **Decline balance method**

◆ **Sinking fund method (this method is not widely used)**

Project Investment Evaluations

Straight line method

◈ **Straight line (SL) method depreciation is the simplest method to apply the most widely used method of deprecation.**

◈ **The annual depreciation, Dm, is constant and thus the book value, BVm, decrease by a uniform amount each year.**

- **The equation for SL depreciation is**

  ○ **Depreciation rate**, $Rm = 1/N$ ....(1)

  ○ **Annual Depreciation**, $Dm = Rm*(P-F)$

  $$= (P-F)/N \ ......(2)$$

Project Investment Evaluations

Straight line method

Given the data below, find the annual depreciation and graph showing the depreciation each year.

- **Dragline purchase price, P=Birr 80,000**

- **Resale value after 7 yrs, F= Birr 24,000**

Solution

- **Purchase price,**   P=Birr 80,000

- **Resale value after 7 yrs,** F= Birr 24,000

- **Value to depreciate N=7 equal installments**,

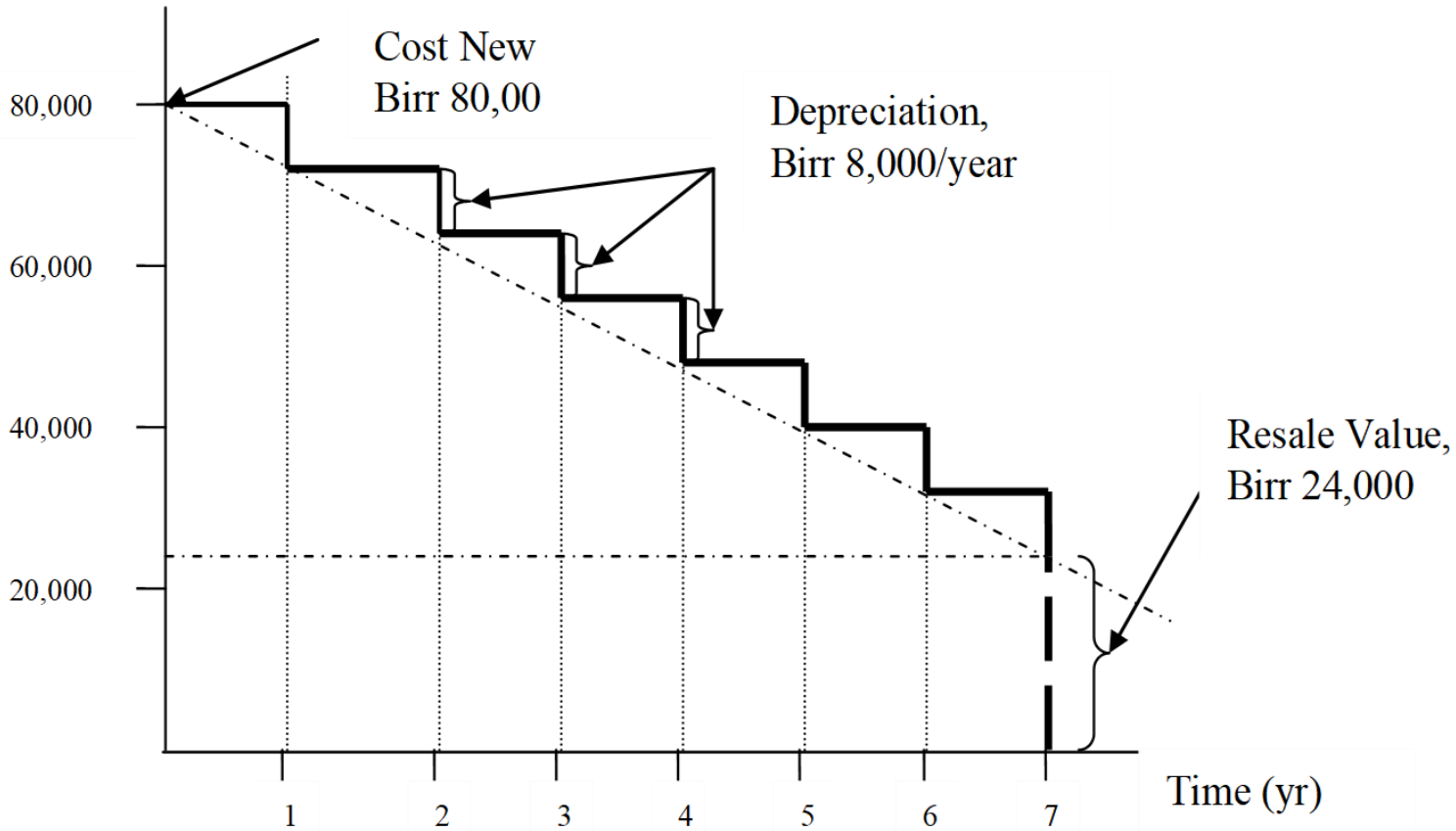   (P-F)= Birr 56,000

- Dm = (P-F)/N= 56,000/7 =Birr 8,000

Project Investment Evaluations

Straight line method

Solution

Cost New Birr 80,00

Depreciation, Birr 8,000/year

Resale Value, Birr 24,000

Project Investment Evaluations

The Sum-Of-Year Digit Method

◈ **This is an accelerated depreciation (fast write-off) method,**

◈ **This method calculates depreciation for each year as the total original depreciable value times a certain fraction.**

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

2) The annual depreciation at end of year m is

$$Dm = (P - F)\frac{N - m + 1}{SOYD}$$

3) The Book Value at the end of year m is

$$Bvm = P - (P - F)\left[\frac{m(N - m/2 + 0.5)}{SOYD}\right]$$

Project Investment Evaluations

The Sum-Of-Year Digit Method: **Example**

◈ **Using the same, Birr 80,000 draggling as in example 1, find the allowable depreciation using the SOYD method.**

Solution

✓ **A machine with a seven year life uses a denominator**

SOYD= N*(N+1)/2=28

✓ **The depreciation allowed for the first year is 7/28 of total depreciation; the allowance for the second year is 6/28 of the total, and so on to 1/28 for the seventh year. Using the sum of the year digits method,**

✓ **Purchase price (P) =Birr 80,000**

✓ **Resale value after 7 yrs (F) = Birr 24,000**

✓ **Depreciable Value (P-F) = Birr 56,000**

Project Investment Evaluations

The Sum-Of-Year Digit Method: Example

Solution:

Year m	Depreciation allowed For this year, Dm (in Birr)		Book Value, Bvm at EOYm	
1	7/28 X Birr 56,000	14,000	80,000-14,000	66,000
2	6/28 X Birr 56,000	12,000	66,000-12,000	54,000
3	5/28 X Birr 56,000	10,000	54,000-10,000	44,000
4	4/28 X Birr 56,000	8,000	44,000-8,000	36,000
5	3/28 X Birr 56,000	6,000	36,000-6,000	30,000
6	2/28 X Birr 56,000	4,000	30,000-4,000	26,000
7	1/28 X Birr 56,000	2,000	26,000-2,000	24,000
total				**56,000**

Project Investment Evaluations

Declined balance method

◈ The declined balance methods are the accelerated depreciation methods that provide for a larger share of the cost of depreciation to be written of in the early year less in the later years.

1. The depreciation rate, R is the depreciation multiple divided by the estimated life, n.

   • For double decline Balance method, R= 2/N

   • For 1.75 decline balance depreciation, R= 1.75/N

   • For 1.5 decline balance depreciation, R=1.5

2. The depreciation Dm for any given year, m, and given depreciation rate, R is

$$D_m = RP(1-R)^{m-1} \quad \text{or} \quad (BV_{m-1})R$$

Project Investment Evaluations

Declined balance method

3. The book value for any year BVm is :

Bvm=P(1-R)m provided that Bvm≥ F

4. The age m, at which book value, Bvm will decline to any future value, F, is:
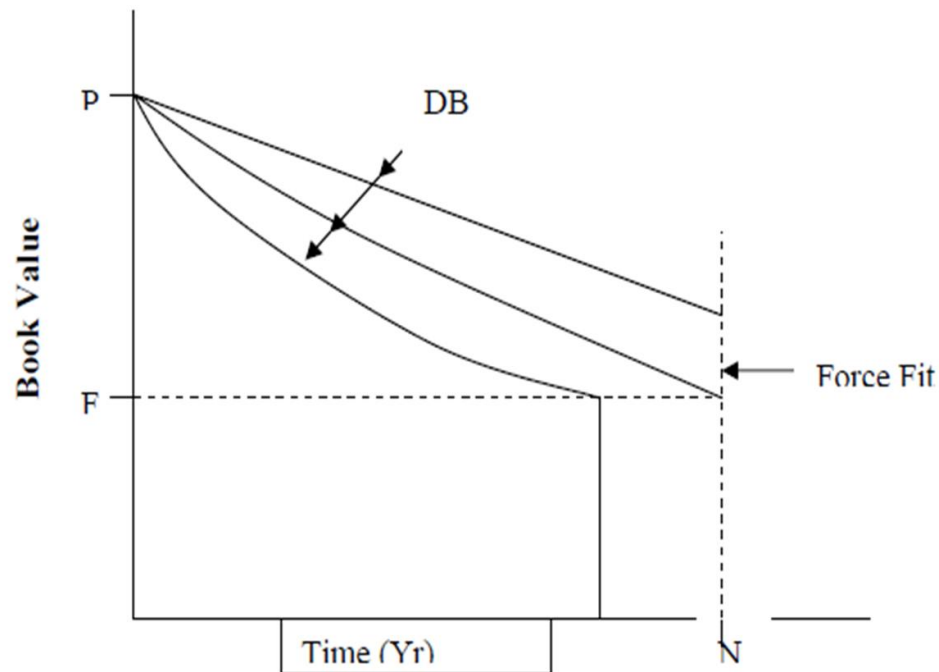
$$m = \frac{\ln(F/P)}{\ln(1-R)}$$

Figure   DB Depreciation

Economic Analysis of a Project

Benefit Cost Analysis

◈ **BCA is a method that applies a systematic process for calculating and comparing benefits and costs of private or public investments**

◈ **The cost benefit analysis process estimates the benefits and costs of an investment for two reasons:**

1. To determine if the project is viable; if it is a good investment

2. To provide a basis for comparing projects when different options are considered

◈ **The main result of a CBA is the benefit-cost ratio (BCR).**

◈ **However, two other important assessment criteria are generally used and calculated when doing a CBA: the net present value (NPV) and the internal / economic rate of return (IRR / ERR).**

Economic Analysis of a Project

Benefit Cost Analysis

- ◈ **The main result of a CBA is the benefit-cost ratio (BCR).**

- ◈ However, two other important assessment criteria are generally used and calculated when doing a CBA: **the net present value (NPV) and the internal / economic rate of return (IRR / ERR).**

- ◈ The Benefit-cost analysis is commonly used to evaluate public (government) projects.

- ◈ Benefits of a nonmonetary nature need to be quantified in dollar terms as much as possible and factored into the analysis.

- ◈ **A broad range of project users distinct from the sponsor should be considered—benefits and costs to all these users can (and should) be taken into account.**

Economic Analysis of a Project

Benefit Cost Analysis

◈ **Benefits of a nonmonetary nature need to be quantified in dollar terms as much as possible and factored into the analysis.**

◈ **A broad range of project users distinct from the sponsor should be considered—benefits and costs to all these users can (and should) be taken into account.**

Economic Analysis of a Project

Framework of Benefit-Cost Analysis

◈ **Identify all the users and sponsors of the project.**

◈ **Identify all the benefits and costs of the project.**

◈ **Quantify all benefits and costs in dollars or some unit of measure.**

◈ **Select an appropriate interest rate at which to discount**

◈ **benefits and costs to a present value.**

Economic Analysis of a Project

Benefit-Cost Ratio Criterion

◆ **The Net B/C ratio expresses as the net benefit expected per dollar invested.**
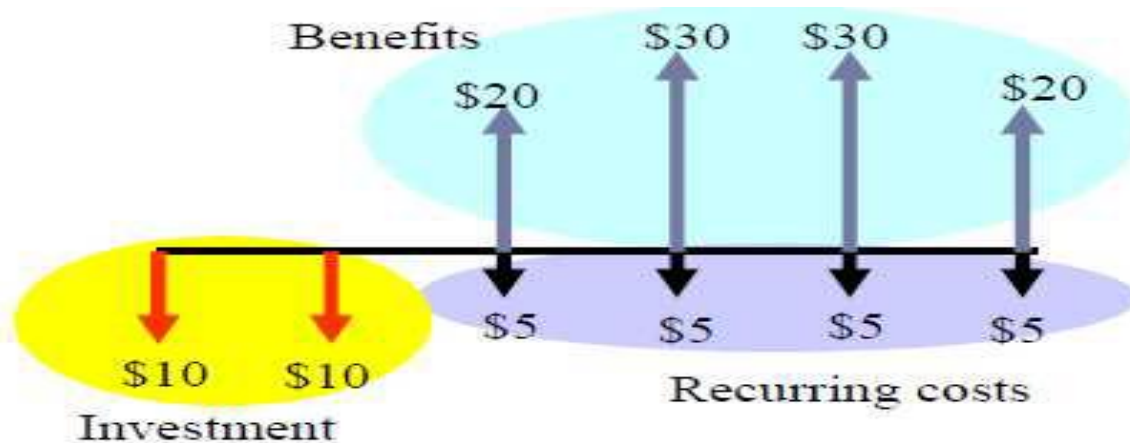
$$Benefit - cost\ ratio\ \left(\frac{B}{C}\right) = \frac{Equivalent\ Net\ Benefits}{Equivalent\ Net\ Costs}$$

$$= \frac{PW\ of\ Benefits}{PW\ of\ Costs}$$

◆ **Decision Rule: If B/C ratio > 1, the project can be justified/acceptable.**

Economic Analysis of a Project

Example 1: Benefit-Cost Ratio Computation

◈ **Compute Benefit-Cost Ratio for given CFD:**

◈ **Solution:**

✓ **Benefit, B = $20 (P/F,10%,2) + $30 (P/F,10%,3) + $30 (P/F,10%,4) + $20 (P/F,10%,5) = $71.98**

✓ **Cost, C = $10 + $10 (P/F,10%,1) + $5 (P/A,10%,4) (P/F,10%,1)**

✓ **= $25**

✓ **Benefit-cost ratio=B/C = 72/25 = 2.88 => Accept the project**

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Economic Analysis of a Project

Example 2 : B/C Ratio Analysis

◆ Each of the five mutually exclusive alternatives presented below 20 years and has no salvage value. MARR = 6%.

	A	B	C	D	E	F
PWC	$4,000	$2,000	$6,000	$1,000	$9,000	$10,000
PWB	$7,330	$4,700	$8,730	$1,340	$9,000	$9,500
B/C	1.83	2.35	1.46	1.34	1.00	0.95
NPV	$3,330	$2,700	$1,730	$340	0	-$500

Economic Analysis of a Project

Example : B/C Ratio Analysis

◈ **Solution:**

◈ The steps are the same as in incremental ROR, except that the criterion is now B/C, and the cutoff is I instead of the MARR:

1. Be sure you identify all alternatives.

2. (Optional) Compute the B/C ratio for each alternative. Discard any with a B/C < 1. (We can discard F).

3. Arrange the remaining alternatives in ascending order of investment.

Economic Analysis of a Project

Example : B/C Ratio Analysis

◆ **Solution:**

	D	B	A	C	E	~~F~~
Cost	$1000	$2000	$4000	$6000	$9000	~~$10000~~
PWB	$1340	$4700	$7330	$8730	$9000	~~$9500~~
B/C	1.34	2.35	1.83	1.46	1.00	~~0.95~~
NPV	340	2700	3330	1730	0	~~-500~~

4. Comparing $\Delta B / \Delta C$ with 1for consecutive alternatives select the best alternative

	B-D	A-B	C - A	E-A
Incremental Cost	$1000	$2000	$2000	$5000
Incremental Benefit	$3360	$2630	$1400	$1670
Incr.B/Incr. C	3.36	1.32	0.76	0.33

Economic Analysis of a Project

Example : B/C Ratio Analysis

◆ **Solution:**

 ◆ **Thus, for the example, the increments B-D and A-B are attractive**

 ◆ **We prefer B to D and we prefer A to B**

 ◆ **Increment C-A is not attractive as** $\Delta B/\Delta C$ **= 0.76 < 1**

 ◆ **Comparing A to E, again A is best**

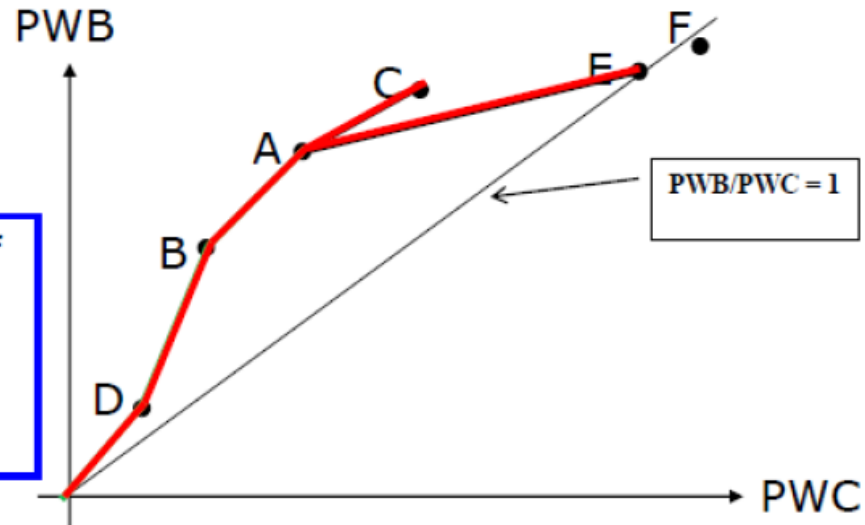 ◆ **Finally A is the best project.**

Economic Analysis of a Project

Example : B/C Ratio Analysis

◈ **Solution:**

✓ A, B, C, and D are above the
   45-degree line; their B/C ratio is > 1.
✓ F is below the line: B/C ratio is < 1.
✓ We can discard F if we wish.

Examine each separable increment of investment.
$\Delta B/\Delta C < 1 \Rightarrow$ increment is not attractive
$\Delta B/\Delta C \geq 1 \Rightarrow$ increment is desirable.

PWB

PWB/PWC = 1

PWC

Begin with D & B: $\Delta B/\Delta C > 1$. B "wins".
Next consider A: $\Delta B/\Delta C > 1$. A "wins".
C: $\Delta B/\Delta C < 1$; discard C.
E: $\Delta B/\Delta C < 1$; discard E.
F was discarded earlier
Conclude A is best.
Note: Alt. B has the highest B/C ratio

	B-D	A-B	C - A	E-A
Incremental Cost	$1000	$2000	$2000	$5000
Incremental Benefit	$3360	$2630	$1400	$1670
Incr.B/Incr. C	3.36	1.32	0.76	0.33

Economic Analysis of a Project

Example 3 : B/C Ratio Analysis

◈ **You are deciding between three alternatives and you need to pick the best one. The lifetimes of all machines is 20 years. Assuming a 5% interest rate, which machine should you select? Use B/C ratio to make your decision.**

	Alternative A	Alternative B	Alternative C
Benefits			
Taxes	$7,000 per year	$3,000 per year	$8,000 per year
Salvage Value	$30,000	$15,000	$25,000
Costs			
First Cost	$45,000 (present)	$25,000 (present)	$65,000 (present)
Operating Expenses	$1,500 per year	$2,500 per year	$1000 per year
Maintenance Costs	$2,000 per year	$3,000 per year	$1500 per year
Lifetime	20 years	20 years	20 years

Economic Analysis of a Project

Example 3 : B/C Ratio Analysis

◆ **Solution**

Analysis of Alternative A

◆ **B/C ratio for Alt A = Benefits/Cost**

= [7,000 (P/A, 5%, 20) + 30,000 (P/F, 5%, 20)] / [45,000 + (1,500+2000) (P/A, 5%, 20)]

= 98,542/88,617 = 1.1199 > 1 (Good)

Economic Analysis of a Project

Example 3 : B/C Ratio Analysis

◆ **Solution**

Analysis of Alternative B

B/C ratio for Alt B = Benefits/Cost

= [3000 (P/A, 5%, 20) + 15,000 (P/F, 5%, 20)] / [25,000 + (2,500+3000)

(P/A, 5%, 20)]

= 43,040 / 93,542 = 0.4601 < 1 (Bad, Not good)

✓ **If we do the same for Alternative C we get a B/C ratio of 1.135, which is >**

1 (Good)

Economic Analysis of a Project

Example 3 : B/C Ratio Analysis

◈ **Solution**

	Alternative A	Alternative B	Alternative C	(C - A)
Benefits				
Taxes	$7,000	$3,000	$8,000	$1,000
Salvage Value	$30,000	$15,000	$25,000	($5,000)
Costs				
First Cost	$45,000	$25,000	$65,000	$20,000
Operating Expenses	$1,500	$2,500	$1,000	($500)
Maintenance Costs	$2,000	$3,000	$1,500	($500)
Lifetime	20 years	20 years	20 years	
Benefits	$98,542.4000	$43,040.1000	$109,120.1000	$10,577.7000
Costs	$88,617.70	$93,542.10	$96,155.50	$7,537.80
B/C Ratio	1.111994556	0.46011475	1.134829521	1.403287431
Decision	Good, Compare	Not Good, Eliminate	Good, Compare	Good, prefer C

Economic Analysis of a Project

Example 3 : B/C Ratio Analysis

◈ **Solution**

✓ **Note that the benefits and costs are obtained from the previous analysis (we made the analysis in terms of Present Worth).**

✓ **For example, for Alternative A:**

✓ **Benefits = 7,000 (P/A, 5%, 20) + 30,000 (P/F, 5%, 20)= $98,542**

✓ **Costs = 45,000 + (1,500+2000) (P/A, 5%, 20) = $88,617**

✓ **In this case, since Incremental B/C of (C-A) = 1.40 we prefer Alternative C over Alternative A.**

✓ **Since we have no more alternatives we decide that Alternative C is the best one.**

Economic Analysis of a Project

Sensitivity Analysis

◆ **Sensitivity analysis is the assessment of the impact for an output of a system by changing its inputs**

◆ **Basically, it is a "What if" analysis testing which variables are important to project outcomes (NPV, EIRR)**

◆ **Applies to all projects with quantified benefits and costs**

◆ **Involves recalculating project outcomes (NPV, EIRR) for different values of major variables and combinations of variables**

Economic Analysis of a Project

Sensitivity Analysis

◈ **What are the chances that benefits & costs will be realized as anticipated?**

- **Identify variables to which project is sensitive**

- **Assess change in parameters required to change project decision**

- **Assess likelihood of these changes occurring**

- **Consider mitigating actions against main sources of uncertainty**

Economic Analysis of a Project

EFFECT OF INFLATION

- ◈ **Inflation is State in which the Value of Money is Falling and the Prices are rising.**

- ◈ **Inflation occurs when general level of prices & cost are rising**

- ◈ **Effect of inflation add inefficiencies in the market, and make it difficult for companies to budget or plan long-term.**

- ◈ **Uncertainty about the future purchasing power of money discourages investment and saving.**

Economic Analysis of a Project

EFFECT OF INFLATION

- **They add inefficiencies in the market, and make it difficult for companies to budget or plan long-term.**

- **Uncertainty about the future purchasing power of money discourages investment and saving.**

PROJECT APPRAISAL AND CASE STUDIES

KEY ELEMENTS FOR PROJECT APPRAISAL

◈ **Eligibility**

- ✓**Regional Development**

- ✓**Rational use of energy, efficiency**

- ✓**Environmental protection**

◈ **Legal Framework**

- ✓**Policies, public acceptance**

- ✓**Licensing, safety**

- ✓**Environmental compatibility**

- ✓**Procurement**

PROJECT APPRAISAL AND CASE STUDIES

KEY ELEMENTS FOR PROJECT APPRAISAL

◈ **Promoter's standing**

  ✓**Management capability**

  ✓**Business strategy**

  ✓**Financial robustness**

  ✓**Access to loan securities**

PROJECT APPRAISAL AND CASE STUDIES

KEY ELEMENTS FOR PROJECT APPRAISAL

◈ **Technology and Design**

- ✓ **Project Definition**

- ✓ **Viability and performance**

- ✓ **Adaptation to technical progress**

- ✓ **Local-specific requirements**

- ✓ **Appropriate technical capacity**

- ✓ **Life expectancy**

PROJECT APPRAISAL AND CASE STUDIES

KEY ELEMENTS FOR PROJECT APPRAISAL

◈ **Time Schedule**

✓**Project Definition**

✓**Preparation of feasibility studies**

✓**Environmental studies**

✓**Licensing requirements**

✓**Time needed for procurement**

✓**Local conditions (climatic, etc)**

PROJECT APPRAISAL AND CASE STUDIES

KEY ELEMENTS FOR PROJECT APPRAISAL

◈ **Procurement**

  ✓ **Technical characteristics-procedures**

  ✓ **Geographical location**

  ✓ **Promoter's experience**

  ✓ **Co-lender's requirements**

◈ **Investment Cost**

  ✓ **Local and foreign currencies**

  ✓ **Phasing of expenditure**

  ✓ **Margins for var. contingencies**

  ✓ **Cost justification**

PROJECT APPRAISAL AND CASE STUDIES

KEY ELEMENTS FOR PROJECT APPRAISAL

◈ **Environmental and Social Compatibility**

  ✓ **Impact analysis, mitigation measures**

  ✓ **Direct, indirect, long-distance effects**

  ✓ **Prevention vs. «end-of-pipe»**

  ✓ **Compliance with international standards**

  ✓ **Least-polluting technology**

  ✓ **Product quality**

PROJECT APPRAISAL AND CASE STUDIES

KEY ELEMENTS FOR PROJECT APPRAISAL

◈ **Market prospects**

✓ **Demand pattern**

✓ **Degree of competition**

✓ **Tariff level and structure**

✓ **Product quality**

◈ **Economic + Financial Viability**

✓ **Cost effectiveness**

✓ **Financial internal rate of return**

✓ **Economic internal rate of return**

✓ **Pay-back period, etc**

PROJECT APPRAISAL AND CASE STUDIES

SPECIAL ISSUES IN PROJECT APPRAISAL, MAKING TECHNICAL EXPERTISE AVAILABLE

◈ **During project preparation**

- ✓ **Feasibility Studies**

- ✓ **Feasibility Studies-Comments**

- ✓ **Financial Engineering**

- ✓ **Environmental and Social**

PROJECT APPRAISAL AND CASE STUDIES

SPECIAL ISSUES IN PROJECT APPRAISAL, MAKING TECHNICAL EXPERTISE AVAILABLE

◈ **During Appraisal**

- ✓ **Review of Project Design**

- ✓ **Phasing of Project Implementation**

- ✓ **Supervision Mechanisms**

- ✓ **Optimize Finance Plans**

- ✓ **Optimize Procurement Strategies**

- ✓ **Review of profitability aspects and tariffs**

PROJECT APPRAISAL AND CASE STUDIES

SPECIAL ISSUES IN PROJECT APPRAISAL, MAKING TECHNICAL EXPERTISE AVAILABLE

◈ **During Implementation**

- ✓**Establishment of Project Implementation Units; involvement of Consultants**

- ✓**Review of Procurement Procedures and Evaluation Process**

- ✓**Identification of Implementation Difficulties and Remedial Measures**

PROJECT APPRAISAL AND CASE STUDIES

SPECIAL ISSUES IN PROJECT APPRAISAL, MAKING TECHNICAL EXPERTISE AVAILABLE

◈ **Project Completion**

- ✓ **Project Review with Promoter**

- ✓ **Establishment of Lessons Learnt**

- ✓ **Identification of Follow-up projects**

PROJECT APPRAISAL AND CASE STUDIES

SPECIAL ISSUES IN PROJECT APPRAISAL, MAKING TECHNICAL EXPERTISE AVAILABLE

◈ **After identification of a feasible project, promoters should involve financiers at an early stage**

- ✓ **Detailed project preparation, including review of Carbon Credit Issues**

- ✓ **Special Requirements on Environment and Procurement**

- ✓ **Guarantees**

- ✓ **Insurance**

- ✓ **Risk Mitigation**

- ✓ **Acceptability of financial and economic profitability levels**