Programme: Bsc in *Hydraulic and Water Resources Engineering*

Course offered By:

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Faculty of Hydraulic and Water Resources Engineering

Arba Minch Water Technology Institute

Course Name: Engineering Economics

Code: ----------HE-3262

Credit Hours:---------- 3CP

Prerequisite: ----------None

Academic Year:-------2019/20

Semester:---------- II

Target Group:---------- G3HWRE

Course Objectives & Competences to be Acquired

Course Objective

- To introduce the basic principles of engineering economy, time-value of money, different economic methods of comparing alternative proposals and project investment evaluation mechanisms.

Outcomes:

After completion of this course students will be equipped with

- Engineering students at list judge their design projects on the basis of the cost implications when compared with the expected benefits.

Course outline

Chapter-I

1. BASIC PRINCIPLES IN ENGINEERING ECONOMICS

1.1 Quantifying alternatives for easier decision making

1.2 Time value of money

1.3 Interest formulae and Equivalence

1.4 Cash Flow Diagram

1.5 Project Concept

Course outline

Chapter-II

2. METHOD OF COMPARING ALTERNATIVE PROPOSALS

2.1 Present worth method of comparing alternatives.

2.2 Annual payment method of comparing alternatives.

2.3 Future worth method of comparing alternatives

2.4 Rate of return (ROR) method of comparing alternatives.

2.5 Incremental rate of return (IROR) on required investment.

2.6 Break-even comparison

2.7 Benefit-cost ratio method of analysis.

Course outline

Chapter-III

3. PROJECT INVESTMENT EVALUATION

- 3.1 Taxes
- 3.2 Depreciation
  - 3.2.1 Book value
  - 3.2.2 Straight Line Method
  - 3.2.3 Declining Balance Method
  - 3.2.4 Sum of year Digit Method
  - 3.2.5 Sinking fund method
- 3.3 Replacement analysis
- 3.4 Project Risk and Uncertainties
- **3.5 PROJECT APPRAISAL AND CASE STUDIES**

Mode of Evaluation(Tentative)

Att. &Quiz ---------- 10 %

Mid Term Exam ---------- 20%

Assignment---------- 20 %

Final Exam ---------- 50 %

Attendance crucial!

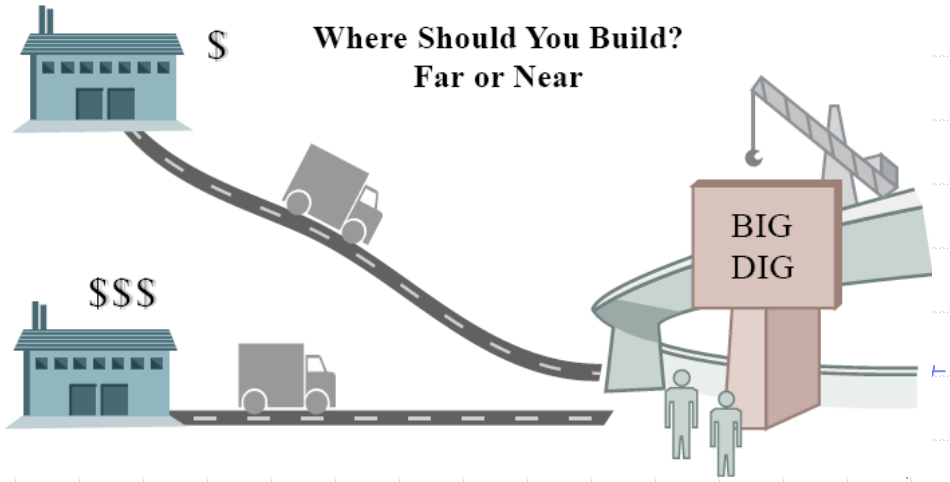
1. INTRODUCTION

What is Engineering Economics ? (brainstorming)

What is Engineering Economics

- Engineering economics is Systematic evaluation of the economic merits of proposed solutions to engineering problems
- *Engineering economy*, quite simply, is about determining the economic factors and the economic criteria utilized when one or more alternatives are considered for selection

Example

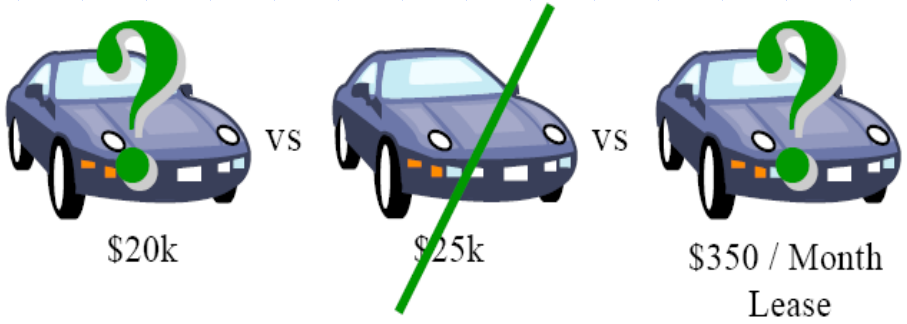


Engineering Economics

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

Why Is Engineering Economics Important?

- 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
- **In other word it is heart of making decisions.**
- **What can go wrong when we don't have the concepts of engineering economics?**
- _____?
- _____?
- _____?

What Kinds of Questions Can Engineering Economics Answer?

- **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?

What Kinds of Questions Can Engineering Economics Answer?

- 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!**

What Kinds of Questions Can Engineering Economics Answer?

ENGINEERING ECONOMICS INVOLVES:

FORMULATING, ESTIMATING, AND EVALUATING ECONOMIC OUTCOMES

WHEN CHOICES OR ALTERNATIVES ARE AVAILABLE

How Does It Do This?

BY USING SPECIFIC

MATHEMATICAL RELATIONSHIPS

TO COMPARE THE CASH FLOWS OF THE DIFFERENT ALTERNATIVES

(typically using spreadsheets)

Where Does Engineering Economics Fit?

Here is an approach to problem-solving:

- **Understand the problem**
- **Collect all relevant data/information**
- **Define the feasible alternatives**
- **Evaluate each alternative**
- **Select the "best" alternative**
- **Implement and monitor the decision**

Where Does Engineering Economics Fit?

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

Where Do I Get the Data?

- **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!**

What If I Don't Like the Answers?

- **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!**

Engineering Economics Helps Make 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!*

Key Concept: *Time Value of Money*

- **Would you rather have:**
  - $100 today, or
  - $100 a year from now?

"A bird in hand is more than two in a bush!"

Time Value of Money

- **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**

Time Value of Money

- **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
- **This assumption is *not* universally satisfied:**
  - E.g., saving money for graduate school
- **But it is nearly universal, especially in business**

Time Value of Money

- **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 _____?

3 .Time Value of Money

- **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*.**

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!

What Does This Mean for Us?

- **In this course, we will learn methods to:**
  - *Compare different cash flows over time*
- **Using the *interest rate* or *discount rate*:**
  - How much more a dollar today is worth,
  - Compared to a dollar in one year
- **For example, if the interest rate is 5%:**
  - $1 today is worth as much as $1.05 next year

Simple interest

- Simple interest *(infrequently used)*
  - Total interest earned (charged) is linearly proportional to
    - the initial amount of principal (loan)
    - Interest rate
    - Number of time periods of commitment

$$Total\ Interest = I = P \cdot N \cdot i$$

P=principal amount lent or borrowed

N=number of interest periods

i = interest rate per period

Compounded Interest *(interest of the interest)*

- Compound interest
  - Interest earned (charged) for a period is based on
    - Remaining principal plus
    - Accumulated (unpaid) interest at the beginning of the period

I_n (Interest in Period n) $= P_n i$

P_n = Principal in period n

i = interest rate per period

$$I = \sum_n I_n$$

Nominal and Effective Interest Rates

- **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.

Eg. An euro remains an euro.

- **Effective Interest rate (i_e)**

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

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

Nominal and Effective ……

where,

r = nominal interest rate (per year)

i= actual (effective interest rate) per year

m= number of interest periods per year

i_e= effective annual interest rate

Interest Formula and Equivalence

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:

$$i = \frac{Final owned - \mathrm{Pr}incipal}{\mathrm{Pr}incpal} * 100\%$$

Interest Formula and Equivalence

Equivalence

Issue: Time Value of money

- Money now has a different value than the same amount at a different date
  - Would you prefer $75 today or $80 in one year?
  - It depends - Rate of return on investment
- Proper name: Discount Rate, i or r
  - Future benefits / costs are reduced (ie, "discounted") to compare with present

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

Example: _____?

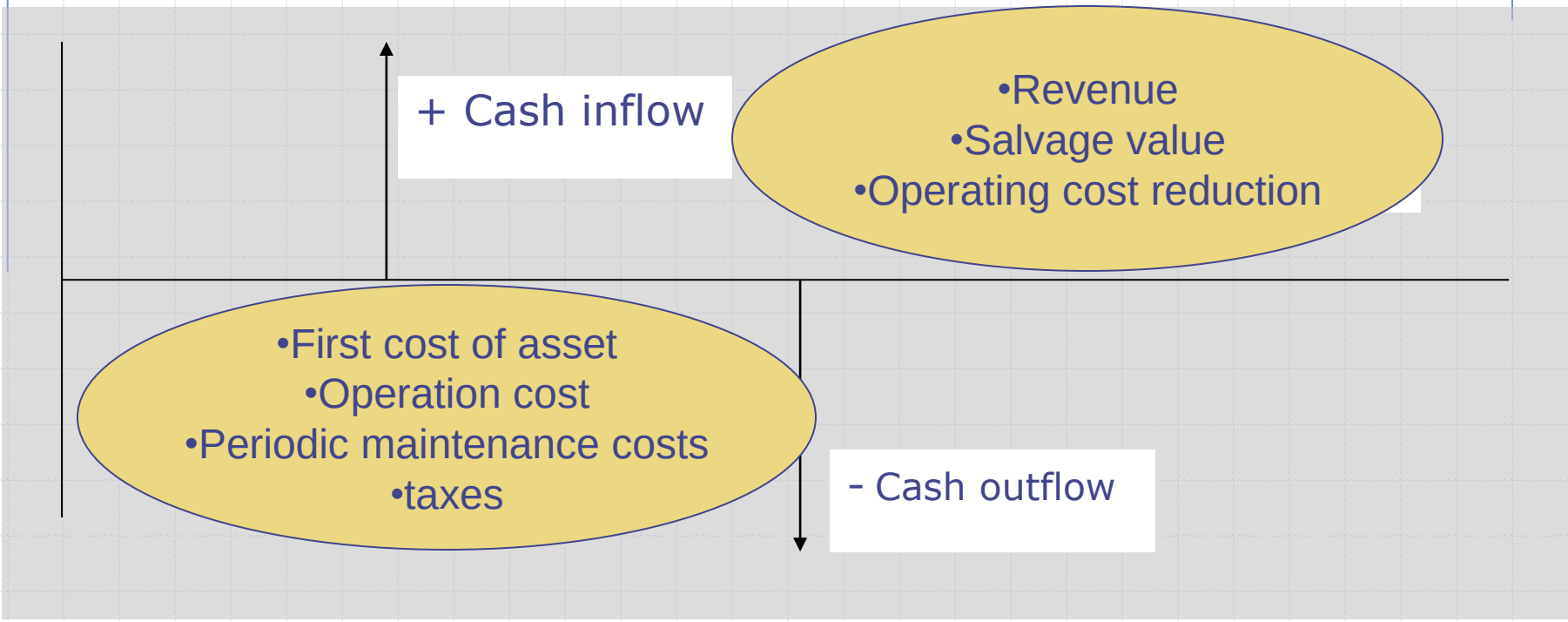
Cash Flow Diagram

Important elements for cash flow diagram.

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

- **Cash inflows:**
  - Revenues
  - Salvage value
- **Cash outflows:**
  - First cost of asset
  - Operation cost
  - Periodic maintenance costs
  - Taxes

Cash Flow Diagram



Notation

- 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
- F = 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 payments continuing for a specified time, starting at the end of the first period and continuing to the end of the last period

Interest Factor Derivation

- Derivation Of The Single Payment Factors (F/P And P/F)

Future Amount =

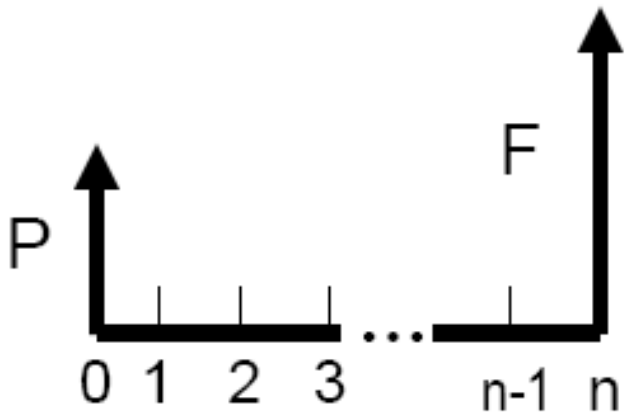
$$P(1 + i)^N =$$

P (caf)

caf ≡ Compound Amount Factor

Common notation:

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

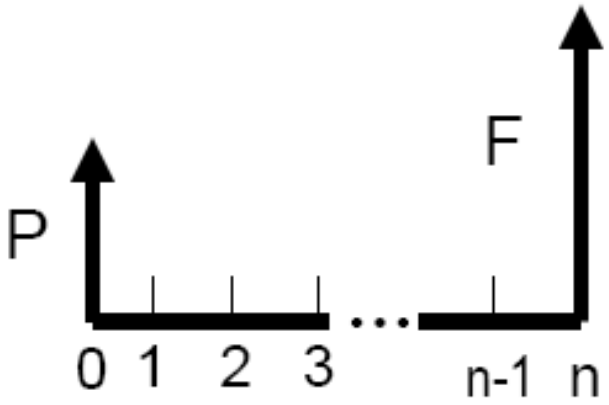


Interest Factor Derivation

Present Amount =

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

1/caf ≡ Present Worth Factor



Common notation:

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

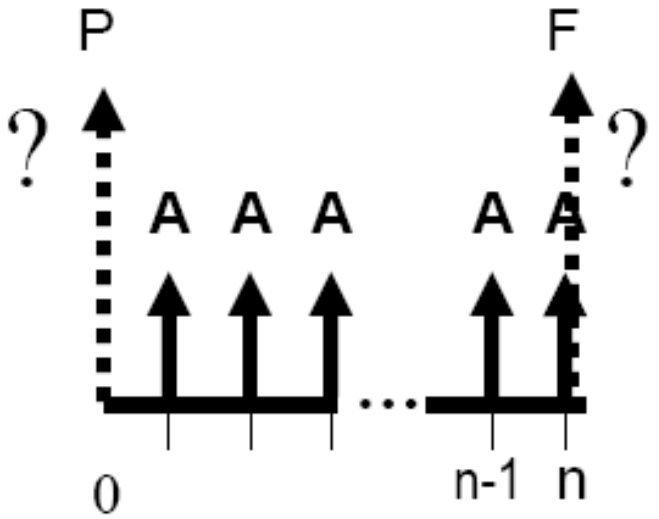
Interest Factor Derivation

Relating a uniform series of payment to P and F

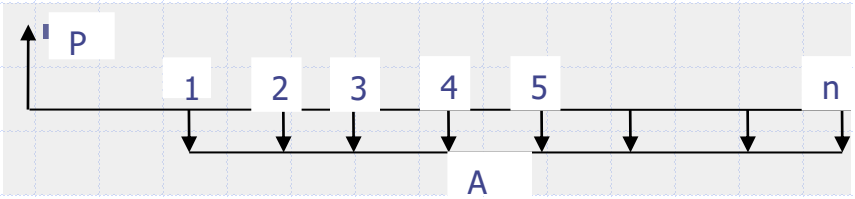
- Uniform series of payments - often called an *Annuity*
- By convention:
  - P at time 0
  - A at end of period
  - F at end of period

Therefore:

- 1st A, 1 period after P
- Last A, coincident with F



Interest Factor Derivation



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

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

$$Multiply both side by \frac{1}{1+i}$$

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

Interest Factor Derivation

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

$$P = A\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right] \ldots . i \neq 0$$

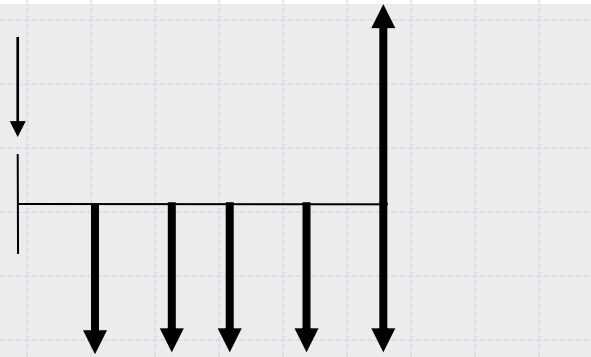
The terms in brackets is called the uniform-series present-worth factor (US-PWF) or the P/A factor.

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

Interest Factor Derivation

- **Derivation Of The Sinking Fund Factor And The Uniform – Series Compound-Amount Factor (A/F And F/A)**

$$A = F\left[\frac{i}{(1+i)^n - 1}\right] \qquad A/F \;\; Factor$$



$$F = A\left[\frac{(1+i)^n - 1}{i}\right] \qquad F/A \;\; Factor$$

Project Concept

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 subtractability.

Excludability: **the degree to which users can be excluded (example: Flood protection…)**

Subtractibility**: the degree to which consumption by one user reduces the possibility of consumption by the others. (example: Fisheries …)**

Projects…

- 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

CLASSIFICATION OF COST

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.

Costs…

- **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.

Exercise on chapter one

1. Visa credit card issued through CBE carries an interest rate of 1 % per month on the unpaid balance. Calculate the effective rate per semiannual period
2. If the card's interest rate is stated as 3.5 % per quarter , find the effective semiannual and annual rates.
3. A savings and loan offers a 5.25% rate per annum compound daily over 365 days per year. What is the effective annual rate?
4. Compute the compound interest and loan for each 5 year for the $2000 a certain person Borrowed at 8% per year. Graphically compare the result for compound interest and simple interest.
5. Define the following terms

i)Time value of money

ii) Mutually exclusive alternative

iii) Do Nothing (DN)

iv) Project

Assignment -I

1. Write the steps for problem solving approach in engineering economics?
2. The fundamental dimension length,mass,time ,and electric charge ,which one is the most important in economics analysis and why?
3. Compute the compound interest and loan for each 3 year for the $4000 a certain person Borrowed at 12% per year. Graphically compare the result for compound interest and simple interest.
4. The nominal rate of interest is 10% .Determine the effective rate of interest when money is compounded (ETB).

i) Yearly iii) Quarterly

ii) Half yearly iv) Daily

…Cont'd

5) **To raise money for a new business, a friend asks you to loan her some money. She offers to pay you $3000 at the end of four years. How much should you give her now if you want to earn 12% interest per year on your money?**

Reference Materials

Text Book:

- Blank L.T. & Antony J. Tarquinii (1989); Engineering Economy

References:

- Collin A. & William B. 1982, Engineering Cost Analysis, Courtland Ledbetter, Harper and Row Publishers.
- Bill G. Eppes & Daniel E. Whitema, 1997, Cost Accounting for the Construction Firm.
- JCE, 1969, An Introduction to Engineering Economy
- Fabryoky,W.J., 1998, Economic Decision Analysis

Annual Equivalent Cash Flow

- **A**n AW analysis is commonly preferred over a PW analysis because the AW value is easy to calculate
- The measure of worth—AW in dollars per year— is understood by most individuals
- It's assumptions are essentially the same as those of the PW method
- Annual worth is known by other titles. Some are equivalent annual worth (EAW), equivalent annual cost (EAC), annual equivalent (AE), and EUAC (equivalent uniform annual cost)

…Cont'd

- The alternative selected by the AW method will always be the same as that selected by the PW method, and all other alternative evaluation methods, provided they are performed correctly
- The annual worth (AW) method is commonly used for comparing alternatives.
- All cash flows are converted to an equivalent uniform annual amount over one life cycle of the alternative.
- The major advantage over all other methods is that the equal service requirement is met without using the least common multiple (LCM) of alternative lives

…Cont'd

- The AW value is calculated over one life cycle and is assumed to be exactly the same for any succeeding cycles, provided all cash flows change with the rate of inflation or deflation

- If this cannot be reasonably assumed, a study period and specific cash flow estimates are needed for the 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

Calculation of annual amount

- Reminders
  - Convert future to annual:

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

  - Convert present to annual:

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

Decision rules for AW

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.**

Advantage of Aw

1. Consistency report formals

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

2. Need for unit costs/profits

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

3. Unequal project lives:

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

Example

- Two roofs are under consideration for a building needed for 20yrs. Their anticipated costs and life's are:

	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

Projects with *perpetual* lives

- What about *perpetual lives?*
  - How can we convert a cost in the present to an annual equivalent cost for an infinite number of years?
- We know that:
  - $P = A\,[1 - 1/(1+i)^n]/i$
    - $= A/i - A/[(1+i)^n i]$
- Taking limits gives $P = A/i$, or $A = Pi$

Example

- At 8% interest for 100 years:
  - A = .08004 P
- At 8% interest for infinite years:
  - A = .08 P
- Difference is only 1/20th of 1% of .08!

Projects with different lives

- Like the previous methods:
  - Least common multiple of lifetimes
  - Perpetual lifetimes

  annual equivalent cost makes sense only if the best option would be used for an extended period of time
- This may not always be the case

Review

- We learned how to
  - Find annual equivalent cost of a project:
    - Annual cost
    - First cost (convert from present to annual)
    - Salvage value (convert from future to annual)
  - Compare options with different lives:
    - Choose option with lowest annualized cost
      - (Or highest annual equivalent benefit)

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.

Example

A construction company is considering the purchase of one of the two new front end loaders whose data are listed below.

	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

- **In order to apply the rate of return method each alternative investment must have a numerically measurable return of income or some equivalent value**
- **It's calculated as the percent interest at which the present worth of the cost equals the present worth of the income**
- **It's also the percent interest at which the equivalent annual cost equals the annual income, as well as the percent interest at which the future worth of cost equals future worth of income**

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)

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**).

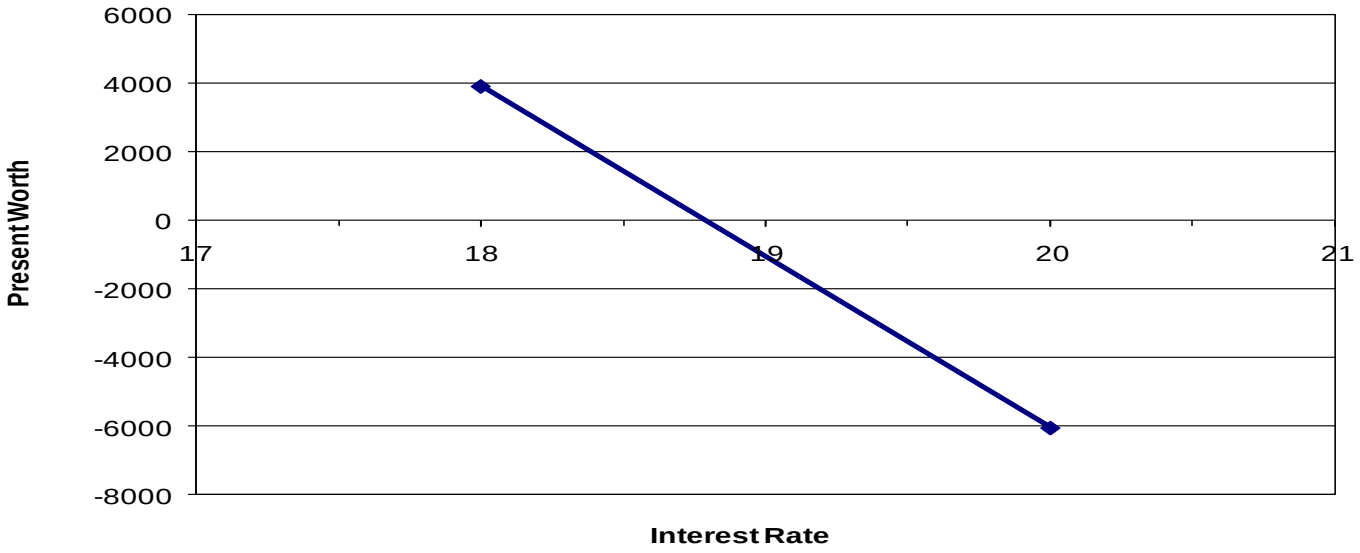
Step-by-step procedure for finding ROR.

- **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.

Example

- Consider a stream of costs and revenues over time
- Present worth equals:
  - $3924 at 18%
  - -$6051 at 20%

Example



- *Assume* function is linear in between
  - (True function actually lies slightly below)

Example

- Present worth equals:
  - $3924 at 18%, -$6051 at 20%
- Slope = Delta Y/Delta X
  - = (-$6051 - $3924)/(20 - 18) = -4987.5
- Want distance x such that height y = 0:
  - 3924 - 4987.5x = 0 $\Rightarrow$ x=.8 $\Rightarrow$ IRR=18+.8
  - (True value = 18.76)

Internal rate of return

- Note that we don't need to consider *present* worth:
  - As long as it is all in one time period

Problem To IRR

- In some instances there can be projects with out IRR

  When NPV>0 always

- Some Projects may have more than one IRR

  when NPV<0 some times

Review

- We learned how to
  - Find internal rate of return of a project:
    - Convert all costs, benefits to one time period
    - Try different interest rates until you find:
      - One where value of project is positive
      - One where value is negative
    - Interpolate to estimate IRR
  - Compare against minimum acceptable rate of return i* to assess desirability

Incremental rate of return

Definition

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.

1. The first type involves costs only.

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

IROR

2. 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

1. list alternatives in order of ascending first cost;

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

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)

Matrix

Challenger →

Defender ↑

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

Way of selecting

- 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.

Example

	B	C	D
A	6	9	8
B		7.5	11
C			12

Assume, MARR=8%

Therefore D is best

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

Breakeven Point analysis

- If all of the parameters for a problem are known except one:
- Then the unknown parameter can be calculated or approximated
- Set present worth, future worth, or annual worth equal to zero:
- And solve for (or approximate) the unknown parameter

Problems with costs and revenues

- 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

Fixed costs

- Do not vary with production or activity levels, price, etc.
- Examples:
  - Buildings
  - Insurance
  - Fixed overhead
  - Equipment
  - Etc.

Fixed costs

- Constant for all values of the variable in question
- Even if no level of activity:
- Fixed costs still continue!
- Must shut down the activity before fixed costs can be eliminated

Variable costs

- Vary with the level of activity
- Examples:
  - Direct labor (wages)
  - Materials
  - Indirect costs (e.g., fringe benefits)
  - Marketing
  - Advertising
  - Warranty
  - Etc.

Variable costs

- More activity (volume):
  - Greater variable costs
- Less activity (volume):
  - Lower variable costs
- Variable costs can also be affected by higher sales volume:
  - If non-linear function of volume

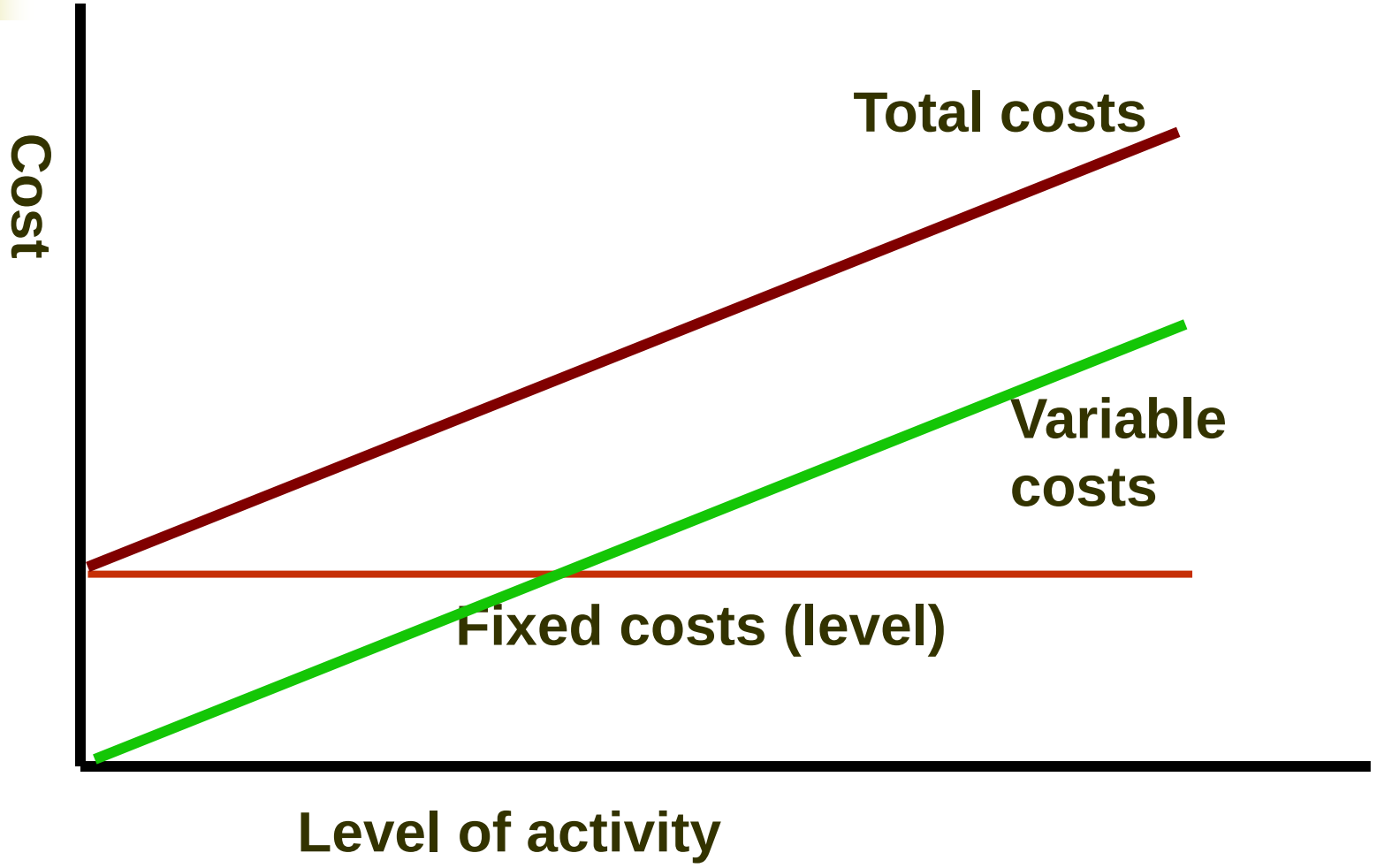
Total costs

- Total cost:
  - Fixed cost plus variable cost
- Profit:
  - Revenue minus total cost

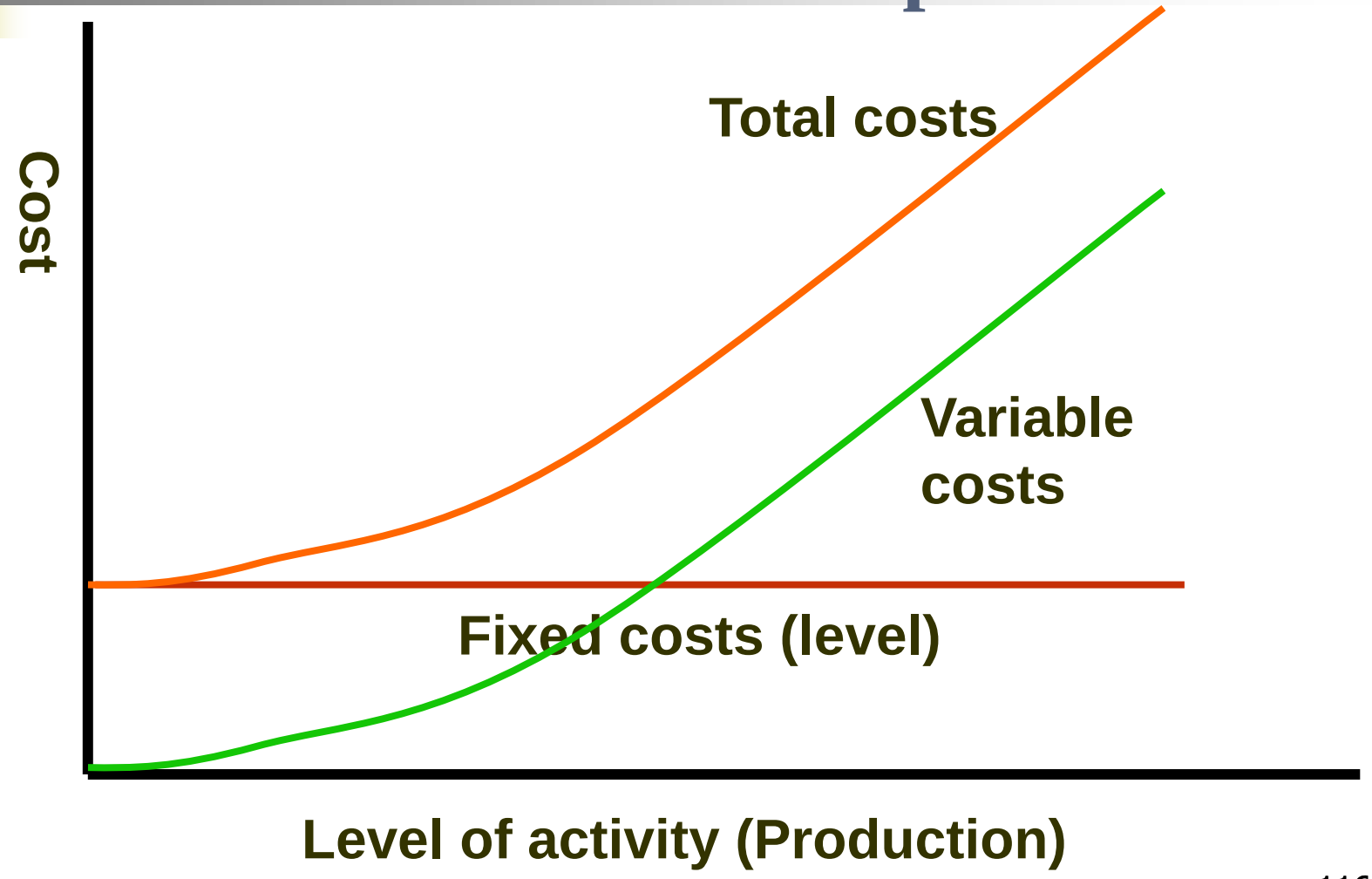
Cost and revenue relationships

- The relationship of cost and revenue to volume may be:
  - Linear, or
  - Non-linear
- Both are just approximations

Linear cost relationship



Non-linear cost relationship



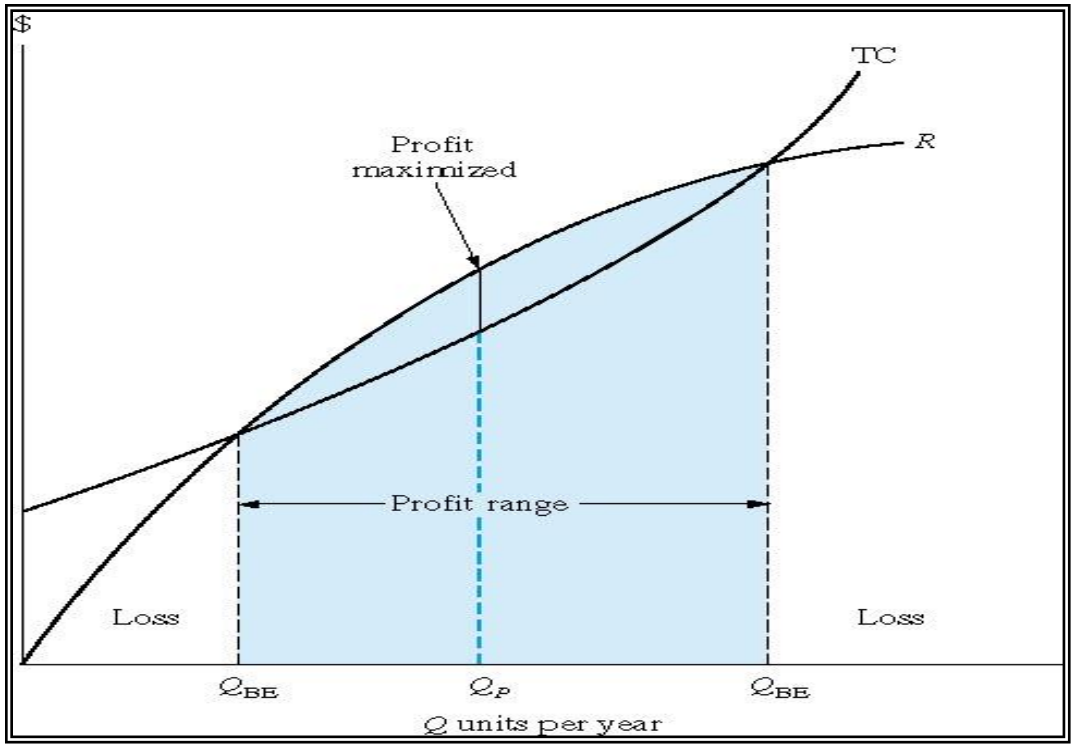
Breakeven point

- 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 point

- Assumed revenue and cost relationships tend to be static:
  - May not reflect the reality of a dynamic firm
  - (E.g., reductions in variable cost, to improve efficiency)
- However, the breakeven point can still be useful for planning purposes

Non-linear functions



Multiple breakeven points for a non-linear model!

Non-linear functions

- For non-linear functions:
  - There may be multiple breakeven points
  - Simply being above a breakeven point may not guarantee a positive profit
  - We want to find the level of volume or price that yields the maximum profit!

Comparing different alternatives By Break-even point

- find the annual equivalent of the capital costs
- 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
- Find the break even point

Summary

- The breakeven point for a problem can be expressed as:
  - Units per time period
  - Hours per month
  - Price per unit
  - Etc.
- At breakeven, you are indifferent about whether to do the project

Summary

- Revenue and cost can be:
  - Linear, or
  - Non-linear
- Breakeven analysis is a form of ***sensitivity analysis***

Benefit-Cost Ratio Method

General equation of Benefit- cost analysis is;

.

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

Strong side o f B/C Ratio

- 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.

Remember the example below;

Assume that the available budget is $800,000 only

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

- When the projects ranked based on NPV and B/C approach, it looks like as follow:
- NPV C, D, E, B and A =22,000
- B/C C, A, D, E and B =23,900

Weak side of …

i. **In case of mutually exclusive projects or projects different size and if one want to decide in favour of the project with the highest NPV, the B/C ratio doesn't give information on that.**
ii. **Sensitive to discounting rate**
iii. **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.**

Example: If the benefit-cost ratio of alternative A,B, and C are 1.5, 1.7and 1.65 respectively, the highest value 1.7 corresponding to alternative B doesn't necessarily mean it has the highest NPV.

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).

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

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

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.

Cash Flow descriptions

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

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

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

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

= 0.677

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

Assignment-II

1. From the AW data shown for projects regarding solid waste handling at a military training facility, determine which project, if any, should be selected from the 6 mutually exclusive projects. Fill the table below and select one of the best alternatives based on B/C ratio

Project Identification						
	A	B	C	D	E	F
AW of Cost,$	20,000	60,000	36,000	48,000	32,000	26,000
Life, Years	20	20	20	20	20	20
AW of benefits,$	?	?	?	?	?	?
B/C Ratio	0.8	1.17	1.44	1.38	1.13	1.08

……Cont'd

2. Four different machines are under consideration for improving material flow in a certain production process. An engineer performed an economic analysis to select the best machine, but some of his calculations were erased from the report by a disgruntled employee. All machines are assumed to have a 10-year life.

a. Fill in the missing numbers in the report.

b. Which machine should the company select, if its MARR is 18% per year and one of the machines must be selected?

…Cont'd

3 . Val-lok Industries manufactures miniature fittings and valves. Over a 5-year period, the costs associated with one product line were as follows: initial investment cost of $24,000 and annual costs of $17,000. Annual revenue was $27,000. What rate of return did the company make on this product?

4. A companies that use a minimum attractive rate of return (MARR) of 10% per year are evaluating new processes to improve operational efficiency. The estimates associated with candidate processes are shown.

…Cont'd

	Alternative 1	Alternative 1
First cost, $	40,000	50,000
Annual cost, $ per year	15,000	12,000
Salvage value,$	5,000	5,000
Life, years	3	6

The statement that is most correct is:

(a) The alternatives are revenue alternatives.

(b) The alternatives are cost alternatives.

(c) The alternatives are revenue alternatives and DN is an option.

(d) The alternatives are cost alternatives and DN is an option.

…Cont'd

5. A project engineer with Environ Care is assigned to start up a new office in a city where a 6-year contract has been finalized to collect and analyze ozone-level readings. Two lease options are available, each with a first cost, annual lease cost, and deposit-return estimates shown below. The MARR is 15% per year.

	Location -A	Location -B
First cost $	15,000	18,000
Annual lease cost, $ per year	3,500	-3,100
Deposit return $	1,000	2,000
Lease term, years	6	9

…Cont'd

A) Environ Care has a practice of evaluating all projects over a 5-year period. If the deposit returns are not expected to change, which location should be selected?

B) Perform the analysis using an 8-year planning horizon.

C) Determine which leases option should be selected on the basis of a present worth comparison using the LCM.

…Cont'd

6. A company purchases a piece of construction equipment for rental purpose. The expected income is $3100 annually for its useful life of 15 years. Expenses are estimated to be $355 annually. If the purchase price is $25,000 and there is no salvage value. What is the prospective rate of return, neglecting taxes?
7. An engineering technology group just purchased new CAD software for $5000 now and annual payments of $500 per year for 6 years starting 3 years from now for annual upgrades. What is the present worth of the payments if the interest rate is 8% per year?

…Cont'd

8. AkashUni-Safe in Chennai, India, makes Terminator fire extinguishers. It needs replacement equipment to form the neck at the top of each extinguisher during production. Select between two metal-constricting systems. Use the corporate MARR of 15% per year with (a) present worth analysis, and (b) future worth analysis.

	Machine-D	Machine-E
First cost , $	-62,000	-77,000
Annual operating cost ,$ per year	-15,000	-21,000
Salvage value, $	8,000	1,000
Useful life, years	4	6

…Cont'd

9. A particular gate valves can be repaired, replaced, or left alone. It will cost $12,500 to repair the valve and $25,000 to replace it. The cost due to a failure of the valve seat is $13,000; for a failure of stem, $21,000; and for a failure of the body, $35,000. All amounts are the present values of all expected future costs. The probabilities of failure of the value are known

Course of action	Valve Component		
	Seat	Stem	Body
Repair Valve	50%	41%	21%
Replace Valve	35%	27%	9%
No action	65%	53%	42%

…Cont'd

- What plan of action should be chosen based on a present worth economic basis?

A. Repair the valve

B. Replace the valve

C. Either repair or replace the valve

D. Do nothing

10. A Machine has an initial cost of $40,000 and an annual maintenance cost of $5,000. Its useful life is 10 years. The annual benefit from purchasing the machine is $18,000. The effective annual interest rate is 10 %. What is the machine's benefit-cost ratio?

A. 1.51

B. 1.56

C .1.73

D. 2.24

…Cont'd

12. Determine the payback period and the net present value (NPV) for each proposal using interest rate of 10 % per year, compounded annually. Which one of the proposal is best?

End of year			
	Proposal -A	Proposal -B	Proposal -C
0	-$ 75,000	-$ 75,000	-$ 75,000
1	25,000	20,000	0
2	25,000	25,000	0
3	25,000	30,000	0
4	25,000	35,000	$130,000

…Cont'd

11. A 70 kW micro- hydropower project is proposed ,which has a startup capital cost (P) of $120,00 ,Annual O & M expenses are expected to 20 % of startup cost the plant factor has been estimated ,following energy survey as being 0.5 the project is expected to have a 15 year life .The real discount rate (i) is 12 % calculate the unit cost of energy ?(hint use unit $ /kW). (BONUS)

Reference Materials

Text Book:

- Blank L.T. & Antony J. Tarquinii (1989); Engineering Economy

References:

- Collin A. & William B. 1982, Engineering Cost Analysis, Courtland Ledbetter, Harper and Row Publishers.
- Bill G. Eppes & Daniel E. Whitema, 1997, Cost Accounting for the Construction Firm.
- JCE, 1969, An Introduction to Engineering Economy
- Fabryoky,W.J., 1998, Economic Decision Analysis

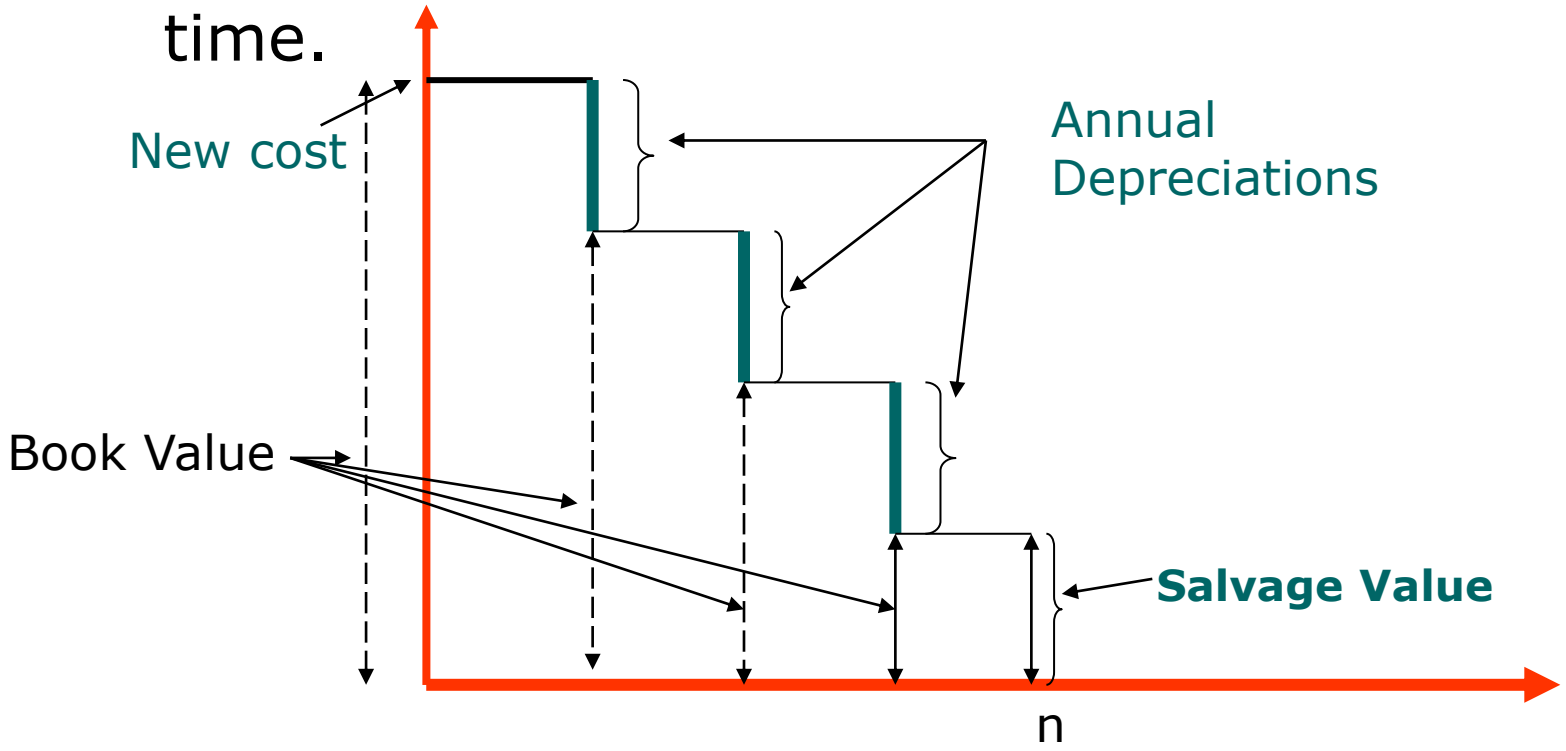
Depreciation

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**

Measuring depreciation

- Since Depreciation is the loss in value over a period of time it may be traced by simple graphing the market value as a function of time.



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.

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).

Depreciation Methods

- **Straight line method**
- **Sum –Of-Year Digit method**
- **Decline balance method**
- **Sinking fund method (this method is not widely used)**

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, $R_m = 1/N$ ……(1)
  - Annual Depreciation, $D_m = R_m*(P-F)$
    $= (P-F)/N$ ……(2)

Example 1

- 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

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

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

Example 2

- Using the same, Birr 80,000 draggling as in example 1, find and plot the allowable depreciation using the SOYD method. Solution

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

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/N

Declined balance method

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

or

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

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:

$$m = \frac{\ln(F/P)}{\ln(1-R)}$$

…Cont'd

- Note that the depreciation amount Dm is determined by the book value only, and is not influenced by the salvage value F (expecting the Bvm-Dm-1 ≥ F).

Therefore, the book value during later years may follow any of the following

- If F is Zero or very low, then Bvm may never reach F
- BV may intersect F before N (BV is not permitted to be less than F)
- BV may intersect F at N (very rare case)

Sinking Fund method

End of year	Sinking fund Balance or Accumulate Depreciation		Annual Depreciation
1	B5,902.70*(F/A,10%,1)	B5,902.70	5,902.70
2	B5,902.70*(F/A,10%,2)	B12,903	7,000.30
3	B5,902.70*(F/A,10%,3)	B19,588	6,685.00
4	B5,902.70*(F/A,10%,4)	B27,395	7,807.00
5	B5,902.70*(F/A,10%,5)	B36,037	8,642.00
6	B5,902.70*(F/A,10%,6)	B45,543	9,506.00
7	B5,902.70*(F/A,10%,7)	B56,00	10,457.00

Assignment-III

1. What is depreciation? Write causes of depreciation
2. A machine is purchased for $1000 and has a useful life of 12 years. At the end of 12 years, the salvage value is $130. By straight-line depreciation, what is the book value of the machine at the end of 8 years?
3. A piece of construction machinery costs $6000 and has an anticipated $2000 salvage value at the end of its five-year depreciable life. Compute the depreciation schedule for the machinery by:

(a) Straight-line depreciation;

(b) Sum-of-years-digits depreciation;

(c) Double declining balance depreciation.

…Cont'd

4. Consider the following data on an automobile: Cost basis of the asset, I = $10, 000, Useful life, N = 5 years, Estimated salvage value, S = $2,000.Use the straight-line depreciation method to compute the annual depreciation allowances and the resulting book values.
5. A compressor was purchased at a cost of $16,000 with an estimated salvage value of $2,000 and an estimated useful life of 7 years. Determine the depreciation allowance for each year and the book value at the end of each year, using the SOYD method

Reference Materials

Text Book:

- Blank L.T. & Antony J. Tarquinii (1989); Engineering Economy

References:

- Collin A. & William B. 1982, Engineering Cost Analysis, Courtland Ledbetter, Harper and Row Publishers.
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