Engineering Economy

What is Economy?

- It is the study of choice and decision-making in world with limited resources.
- It is the study of how individuals, businesses and governments used their limited resources.

Engineering Economy

"Engineering is the profession in which a knowledge of the mathematical and natural science gained by study, experience, and practice is applied with judgment to develop ways to utilize economically, the materials and forces of nature for the mankind".

In the preceding definition the economical role of an engineer is emphasized as well as his technical role.

- Engineering Economy is about making decisions
- It is based on the systematic evaluation of the **costs and benefits** of proposed technical projects
- **Successful design is the one that must sound technical and produces benefit.**

In fact any engineering project must be **physically and technically realizable but also it must be economically feasible**, therefore economics weigh heavily in the design process.

The factors upon which a decision is based are commonly a combination of economic and noneconomic

elements. **Engineering economy deals with the economic factors.**

Non-Economic elements are:

- **Availability of certain resources,** e.g., skilled labor force, water, power, tax incentives.
- **Government laws that dictate safety,** environmental, legal, or other aspects.

Examples

For Engineering Activities

- Should a highway bypass be constructed around a city of 25,000 people, or should the current roadway through the city be expanded?
- Is it an economically wise decision to upgrade the composite material production centre of an airplane factory in order to reduce costs by 20%?
- If a computer-vision system replaces the human inspector in performing quality tests on an automobile welding line, will operating costs decrease over a time horizon of 5 years?

- Will we make the required rate of return if we install the newly offered technology onto our medical laser manufacturing line?

Role of Engineering Economy

Engineering Economy is a **collection of mathematical techniques** that simplify the comparison of alternatives. In this sense, engineering economy may be regarded as a **decision – assistance tool** by which one of the alternative methods will be chosen as the most economical one.

- Remember: People make decisions – not ―tools
- Engineering Economy is a set of tools that aid in decision making – but will not make the decision for you

Why Engineering Economy is Important to Engineers

- **Engineering, without economy, makes no sense at all**. Engineering economics is a powerful
- tool for engineers in decision making and analysis of new and running projects.
- Engineers design and create.
- Designing involves economic decisions.
- Engineers must be able to **incorporate economic analysis** into their creative efforts
- Often engineers must select and implement from multiple alternatives
- Understanding and applying **time value of money, economic equivalence, and cost estimation**
- are vital for engineers
- A proper economic analysis for selection and execution is a fundamental task of engineering.

The Steps In An Engineering Economy Study Are As Follows:

1. Identify and understand the problem; identify the objective of the project.
2. Collect relevant, available data and define viable solution alternatives.
3. Make realistic cash flow estimates.
4. Identify an economic measure of worth criterion for decision making.
5. Evaluate each alternative; consider noneconomic factors; use sensitivity analysis as needed.
6. Select the best alternative.

7. Implement the solution and monitor the results.

Time Value of Money

It is often said that money makes money. The statement is indeed true, for if we invest money today, by tomorrow we will have accumulated more money than we have originally invested. This change in the amount of money over a given time period is called **the time value of money**; **it is the most important concept in engineering economy.** On the other hand, if a person or a company borrows money today, by tomorrow more money than the original loan will be owed. This fact is also explained by the time value of money.

Meaning of Interest:

The appearance of the time value of money in actual life is termed **"interest" (I);** which is a measure of the increase between the original sum (borrowed or invested) and the final amount (owed or accrued).

Interest is payment from a borrower or deposit-taking financial institution to a lender or depositor of an amount above repayment of the principal sum (i.e. the amount borrowed).

It is distinct from a fee which the borrower may pay the lender or some third party.

Types of Interest:

1. **Simple Interest**
2. **Compound Interest**

Simple Interest:

If I borrow a present sum of money or a principal P at a simple interest rate i, the annual cost of interest is I=Pi.

If I repay the loan in a lump sum at the end of n years, the amount owed

is:

$$\textbf{Amount owed} = P + nPI = P(1+ni)$$

Where:

P= principle or present worth

I= annual cost of interest

i= annual interest rate

n= number of years

Example:

If I borrow $1,000 for 6 years at a simple interest rate of 10%, at the end of the 6 years I owe:

Amount owed =P(1+ni)=$1,000[1+6(0.1)]=$1,600

Compound Interest:

In compound interest, the interest due at the end of a period is not paid out but is instead added to the principal. Thus, during the next period, interest is paid on the total sum.

- First period: amount owed $_1$ =P(1+i)
- Second period: amount owed $_2$ = P(1+i)+iP(1+i)= P(1+i)^2
- nth period: amount owed $_n$ = P(1+i)^n

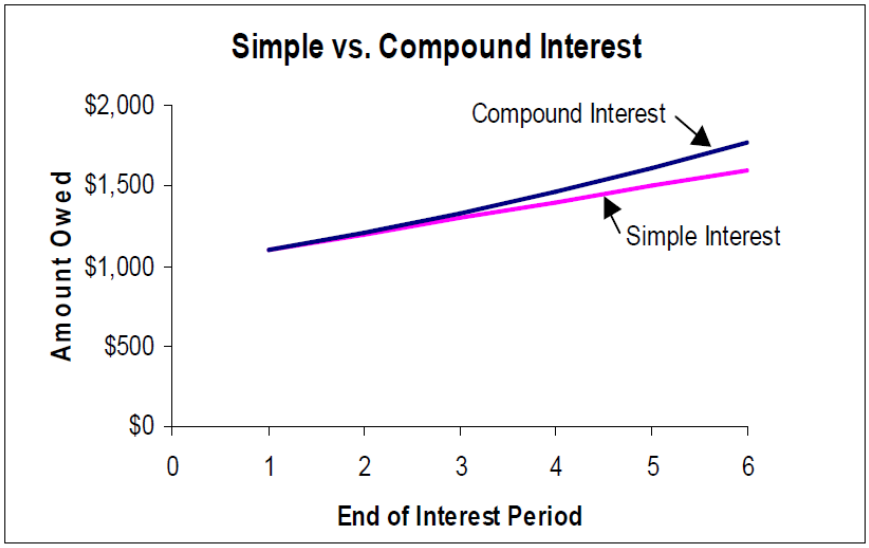
Simple vs. Compound Interest:

- For $1,000 loaned for 6 periods at 10% simple or compound interest

Simple Interest				
period	(1) amount owed at the beginning of the period	(2)=1,000 x 10% interest amount for period	(3)=(1)+(2) amount owed at the end of the period	
1	$1,000	$100	$1,100	=1,000(1+.1)
2	$1,100	$100	$1,200	=1,000(1+.2)
3	$1,200	$100	$1,300	=1,000(1+.3)
4	$1,300	$100	$1,400	=1,000(1+.4)
5	$1,400	$100	$1,500	=1,000(1+.5)
6	$1,500	$100	$1,600	=1,000(1+.6)

Vs.

Compound Interest				
period	(4) amount owed at the beginning of the period	(5)=(4)x10% interest amount for period	(6)=(4)+(5) amount owed at the end of the period	
1	$1,000	$100	$1,100	=1,000(1.1)
2	$1,100	$110	$1,210	=1,000(1.1)^2
3	$1,210	$121	$1,331	=1,000(1.1)^3
4	$1,331	$133	$1,464	=1,000(1.1)^4
5	$1,464	$146	$1,611	=1,000(1.1)^5
6	$1,611	$161	$1,772	=1,000(1.1)^6



Interest Rate:

An interest rate, or rate of interest, is the amount of interest due per period, as a proportion of the amount lent, deposited or borrowed (called the principal sum).

The interest rate used in calculations is known as the effective interest rate.

The total interest on an amount lent or borrowed depends on the

I. Principal sum,
II. The interest rate,
III. The compounding frequency, and
IV. Length of time over which it is lent, deposited or borrowed.

It is defined as the proportion of an amount loaned which a lender charges as interest to the borrower, normally expressed as an annual percentage.

Interest Period

The time unit which is most commonly (and unless otherwise stated) used to declare interest rates is one year (e.g. 10% per year, 10% per annum or just 10%). However, interest rates may sometimes be quoted over shorter periods of time (e.g. 1% per month). The time unit used to express an interest rate is called an "interest period".

INTEREST RATE (IR) AND RATE OF RETURN (ROR)

From a computational point of view, interest is the difference in money between what you end with and

what you started with. **Interest is paid when an entity borrows money and repays a larger amount; interest is earned when an entity save or invested money and obtained a return of a larger amount.**

Interest = amount owed now – original amount or principal

Interest rate, % = (Interest accrued per time unit/Original amount)x 100%

The time unit is called the interest period and is typically one year.

Interest paid over a specific period of time is expressed as a percentage of the original amount and is called the rate of return (ROR) or return on investment (ROI).

Rate of Return, % = (Interest accrued per time unit/Original amount)x 100%

The equations are the same but interest rate paid is more appropriate from the borrower's perspective and the rate of return earned is better for the investor's perspective i.e. IR – borrower and ROR or ROI – investor.

INFLATION

- Inflation is the devaluation of a currency relative to a previous value.
- Country's currency becomes worth less over time, thus requiring more of the currency to
- purchase the same amount of goods or services in a time period
- From the borrower's perspective it is another interest rate; from the investor's perspective, inflation reduces the ROR.

Inflation impacts:

- Purchasing Power (reduces)
- Operating Costs (increases)
- Rate of Return on Investments (reduces)

Cash Flow Diagram:

A **cash-flow diagram** is a tool used by accountants and engineers, to represent the transactions of cash which will take place over the course of a given project.

Transactions can include initial investments, maintenance costs, projected earnings or savings resulting from the project, as well as salvage and resale value of equipment at the end of the project.

Cash flow diagrams are used to depict the timing and magnitudes of the cash flow amounts in the present & future. Purchase costs; annual expenditures for maintenance, energy, and Labor charges; and salvage values occur in a cash flow series.

- Begin at year 0 (now) and end at the end of the project (year n-- represents project horizon)

- Cash flows each year can be a combination of receipts and payments
- Receipts are represented by upward arrows above the time line
- Payments are represented by downward arrows below the time line

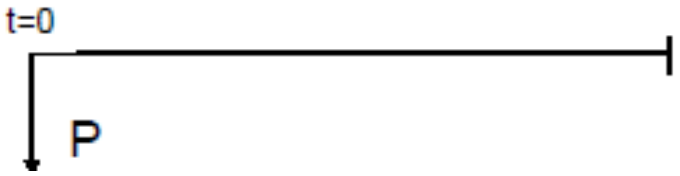
Types of Cash Flow Diagram:

I. **Single Payment Cash Flow**
II. **Uniform Series Cash Flow**
III. **Uniform Gradient Cash Flow**

Single Payment Cash Flow

Can occur at the beginning of a time line (t=0), at the end of the time line (t=n), or any time in between.

e.g., equipment costs



Uniform Series Cash Flow

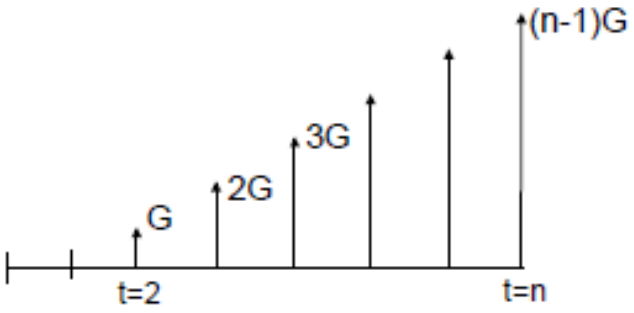
Consists of a series of equal transactions starting at t=1 and ending at t=n. *A* is typically used to represent the magnitude of each flow.

e.g., revenue (an up arrow) or material costs (a down arrow)

Uniform Gradient Cash Flow

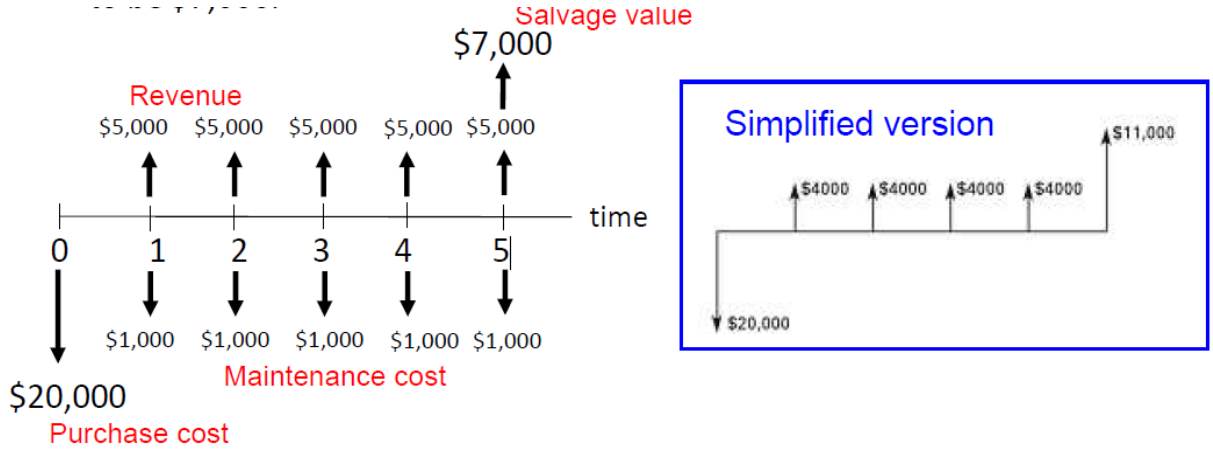
Starts with a cash flow (denoted as which time the cash flow is (n-1)G

e.g., Increasing maintenance costs with aging equipment



Example:

For example, a mechanical device will cost $20,000 when purchased. Maintenance will cost $1,000 per year. The device will generate revenues of $5,000 each year for 5 years, after which the salvage value is expected to be $7,000.



Value:

Value (economics), a measure of the benefit that may be gained from goods or service

Economic value is a measure of the benefit provided by a good or service to an economic agent. It is generally measured relative to units of currency, and the interpretation is therefore "what is the maximum amount of money a specific actor is willing and able to pay for the good or service"?

Functional Value:

This type of value is what an offer does, it's the solution an offer provides to the customer.

Monetary Value

This is where the function of the price paid is relative to an offerings perceived worth. This value invites a tradeoff between other values and monetary costs.

Social Value:

The extent to which owning a product or engaging in a service allows the consumer to connect with others.

Cost Estimating:

Most difficult, expensive, and time-consuming part of an engineering study. Used to describe the process by which the present and future cost consequences of engineering designs are forecast. Briefly introduce the role of cost estimating in practice

Purpose:

- Provides information used in setting a selling price for quoting, bidding, or evaluating contracts
- Evaluates how much capital can be justified for process changes or other improvements
- Establishes benchmarks for productivity improvement programs

- Determines whether a proposed product can be made and distributed at a profit (EG: price = cost + profit)

Approaches:

- **Top-down Approach**
- **Bottom-up Approach**

Top-down Approach

- Uses historical data from similar engineering projects
- Estimates costs, revenues, and other parameters for current project
- Modifies original data for changes in inflation / deflation, activity level, weight, energy consumption, size, etc…
- Best use is early in estimating process

Bottom-up Approach

- More detailed cost-estimating method
- Attempts to break down project into small, manageable units and estimate costs, etc….
- Smaller unit costs added together with other types of costs to obtain overall cost estimate
- Works best when detail concerning desired output defined and clarified

Fixed Costs

- Unaffected by changes in activity level over a feasible range of operations for the capacity or capability available
- Include insurance and taxes on facilities, general management and administrative salaries, license fees, and interest costs on borrowed capital
- When large changes in usage of resources occur, or when plant expansion or shutdown is involved fixed costs will be affected

Variable Costs

- Associated with an operation that vary in total with the quantity of output or other measures of activity level
- Example of variable costs include:
    - Costs of material and labor used in a product or service
    - Vary in total with the number of output units -- even though costs per unit remain the same

Incremental Cost (or incremental Revenue)

- Additional cost (or revenue) that results from an increasing the output of a system by one or more units

Recurring Costs

- Repetitive occur when a firm produces similar goods and services on a continuing basis
- Represent recurring costs because they repeat with each unit of output
- Example
    - A fixed cost that is paid on a repeatable basis is also a recurring cost
        - Office space rental

Nonrecurring Costs

- Unusual charge, expense, or loss that is unlikely to occur again in the normal course of a business. Non recurring costs include write offs such as design, development, and investment costs Typically involve developing or establishing a capability or capacity to operate
- Examples
    - purchase cost for real estate upon which a plant will be built
    - Construction costs of the plant itself

Direct Costs

- A direct cost is a price that can be completely attributed to the production of specific goods or services
- Labor and material directly allocated with a product, service or construction activity

Indirect Costs

- Indirect costs are costs that are not directly accountable to a cost object (such as a particular project
- Costs of common tools, general supplies, and equipment maintenance

Overhead

- Consists of plant operating costs that are not direct labor or material costs

Indirect costs, overhead and burden are the same

- Common method of allocating overhead costs among products, services and activities is called prime cost
- Allocates in proportion to the sum of direct labor and materials cost

Sunk cost: A cost which can not be recovered

- Occurred in the past and has no relevance to estimates of future costs and revenues related to an alternative

Opportunity cost

- The loss of other alternatives when one alternative is chosen.
- Cost of the best rejected (i.e., foregone) opportunity and is hidden or implied

Life Cycle Cost = **Investment Costs + Working Capital + O&M Costs + Disposal Costs or Salvage Value (if any)**

Utility

- The total satisfaction received from consuming a good or service
- Measure of the value which consumers of a product or service place on that product or service;

Demand

- Reflection of this measure of value, and is represented by price per quantity of output