Course Title

Engineering Economic Analysis

Lecture 1 (week 1)

Chapter 1

Introduction

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Learning Objective

From studying this chapter the students will be able to understand on the topics:

- Definition of Economics and Engineering Economics
- Why engineer needs the concept of economics?
- Role of Engineer in making decision
- The terminologies used in the engineering economic analysis.
- Principle of engineering economics.
- To develop cash flow diagram.

1.1 Definition of Economics

- Economics is the study of how individual or society manages its scarce resources.
- Allocation of the resources to fulfill the unlimited desires of the human beings.
- Economics is the social science that examines how people choose to use limited or scarce resources in attempting to satisfy their unlimited wants. [1]
- The science that deals with the production, distribution, and consumption of wealth, and with the various related problems of labor, finance, taxation, etc. [2]

1.2 Why Engineering Economics?

It is one of the most practical subject matter in the engineering curriculum, but it is always a challenging and an ever changing discipline. It deals with the concepts and technical analysis which is useful in evaluating the project. Engineering economics is the practical application of economic principles in the field of engineering technology. [3].

For any engineering design to be successful, it must be technically sound and produce benefits. The field of engineering economy is concerned with the systematic evaluation of the benefits and costs of the projects involving engineering design and analysis. The techniques and models of engineering economy assist people in making decisions.

Engineering economy quantifies the benefits and costs associated with engineering projects to determines if they make (or save) enough money to warrant their capital investment. Engineering economy can be used equally to analyse outcomes have met or not met a specified criterion, such as equivalent worth method and rate of return method. The objective of the engineering economics is to familiarize and develop the commercial and financial knowledge of engineers.

1.3 Engineering Economics Definition

- "Engineering economics deals with the methods that enables one to take economics decision towards minimizing the cost or maximizing benefits to business organization". [4]
- "Engineering Economics deals with the concepts and techniques of analysis useful in evaluating the worth of systems, products, and services in relation to their cost".
- In the simplest term, engineering economy is a collection of techniques that simplify comparisons of alternatives on an economic basis. [5]

1.4 Origin of Engineering Economics

Cost considerations and comparisons are fundamental aspects of engineering practice. However, the development of engineering economy methodology, which is now used in all engineering work, is relatively recent. This does not mean that, historically, costs were usually overlooked in engineering decisions. However, the perspective that ultimate economy is a

primary concern to the engineer and the availability of sound techniques to address this concern differentiates this aspect of modern engineering practices from that of the past. [6]

Engineering economics was originated by Arthur Mellen Wellington (1847- 1895), was an American railway engineer used the capitalized cost method of analysis to select the preferred length of rail lines and curvature of the lines in his book "The Economic Theory of the Location of Railways", which was published in the year 1887. The outcome of this book developed as a concept that engineers are not only planners and builders, they are also problem recognizer, manager and decision makers. [4] A text book "Principles of Engineering Economy", New York: The Ronald Press Company, 1930, was published by Eugene Grant. [3]

1.5 Role of engineers in decision making

For the development of any products, engineers are called upon to translate the idea into reality. A quality engineer should take his right decision at right time which is not a cakewalk for a person having no knowledge about economic feasibility of a project.[3] In any manufacturing or construction work, engineering is involved (about 85%) from conceptual design to distribution. It is the responsibility of an engineers to develop project which involves complex designs, beside that they should bear in mind that the product should be built in economic fashion that is the comparison of costs and benefits associated in the project in the unified framework. The cost incurred in a project should be minimum and the benefit generated from it should be maximum. The framework within which the decision is made is the field of engineering economics. Hence the study of engineering economics provides the basis of knowing the various financial and economic aspects technically involved with the project from its estimation phase to the work out phase.

A firm's growth and development largely depends upon a constant flow of ideas for new products, and for the firm to remain competitive, it has to make existing products better or produce them at a lower cost. Traditionally, a marketing department would propose a product and pass the recommendation to the engineering department. The engineering department would work up a design and pass it on a manufacturing, which would make the product. With this type of product development cycle, a new product normally takes several months (or even years) to reach a market. Decisions made by the engineers are commonly the result of choosing one alternative over another. Decisions often reflect a person's educated choice of how to best invest funds, also called capital. The amount of capital is usually restricted, just as the cash available to an individual is usually limited. The decision of how to invest the capital will invariably change the future, hopefully for the better: that is, it will be value adding. Engineers play a major role in capital investment decisions based on their analysis, synthesis, and design efforts.

An engineer looks for the solutions to different problems, whereas an engineering economist looks at the economic appropriateness of the project objectively and assesses the value of the project, because an understanding of economics is a key to feasible creative planning. [3] To enable engineers fully be part of economic development there should be broadening and strengthening version of engineering thoughts to achieve our ultimate economic development in all areas.

1.6 Principles of Engineering Economics

The principle of engineering economics can be highlighted in the seven points as below:

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

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

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

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

Principle 5
Consider All Relevant Criteria: Selection of preferred alternative requires the use of criteria or several criteria. The decision process should consider both the outcomes enumerated in the monetary unit and those expressed in some other unit of measurement or made explicit in the descriptive manner.

Principle 6
Make Uncertainty Explicit: Uncertainty is inherent in projecting the future outcomes of the alternatives and should be recognized in their analysis and comparison.

Principle 7
Revisit the Decision: Improved decision making results from an adaptive process to the extent practicable, the initial projected outcomes of the selected alternative should be subsequently compared with actual results achieved. [6]

1.7 Essential Terminologies in Engineering Economic Analysis

1. **Capital:**
- The financial resources involved in establishing and sustaining an enterprise or project.
- A term describing wealth which may be utilized to economic advantage.
- The form of wealth may be as cash, land, equipment, finished product, raw materials etc.
- It can also be referred as the initial investment for the project.

2. **Assets:**
- An economic resource of entity (including money resources, physical resources, and intangible resources).

- After the investment of the capital, assets are generated inside the organization or project.

3. Cash Flow:

- Actual statement showing actual amount coming into the firm and/or going out of the firm.
- Graphical representation of the actual money going out and coming in the organization is cash flow diagram.

4. Annuity:

- A series of equal payments or receipt occurring at equal interval of time.
- Amount paid annually/monthly/weekly etc. including reimbursement of borrowed capital and payment of interest.
- Here in the fig; 1, the series of equal magnitude amount A is occurring at equal interval of time. Therefore A is referred as annuity.

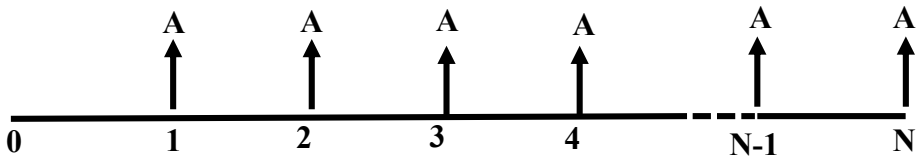

Fig 1; Annuity

5. Break-even point:

- It is the point where the total cost line and the total sales line intersects each other as shown in fig: 2.
- It is the point where there is neither profit nor loss. State of no loss and no gain condition. This topic will be studied in detail in Chapter: Risk Analysis.

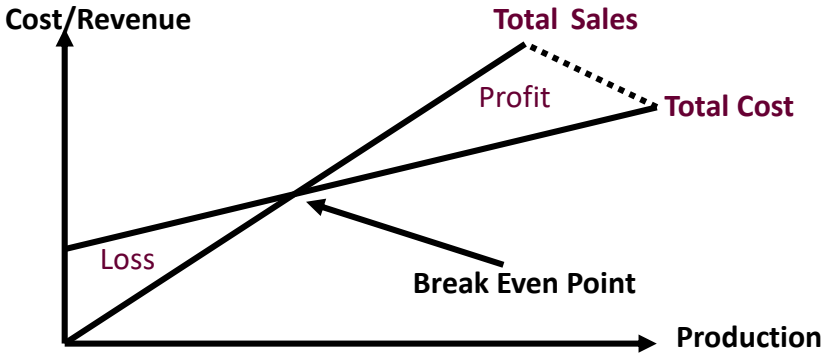

Fig 2: Breakeven point

6. Interest:

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

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

Compound Interest

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

7. Decision making:

- It is the process of choosing the best option among the various available alternatives.

Decision making under certainty

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

Decision making under uncertainty

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

Decision making under risk

- A decision problem in which the analyst elects to consider several possible futures, the probabilities of which can be estimated.

8. Economic life/Useful life:

- The timeframe an asset will be economically useful.
- The timeframe within which the assets at can be kept in productive use in a trade or business.

9. Analysis period/Study period:

- It is the time span over which the economic effects of an investments will be evaluated.

10. Compound rate:

- The rate which is used to calculate the future value of the present value is called the compound rate.

11. Discount rate:

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

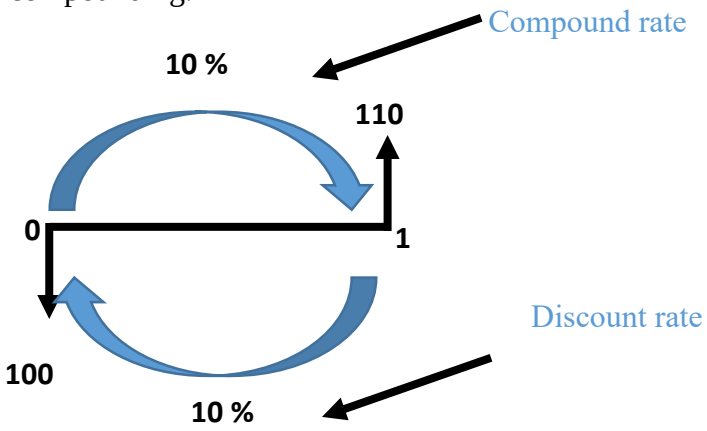

Fig 3: Compound and Discount rate

- The figure 3 represents compounding and discounting the present and future value with 10% interest rate

12. Depreciation :

- Decrease in the value of the asset with the passage of time. A form of capital recovery applicable to a property with two or more years' life span, in which an appropriate portion of the asset's value is periodically charged to current operations.

13. Salvage value :

- Receipt at project termination for sale or transfer of the equipment. In other words, it is the second hand value of the asset.

14. Scrap Value :

- Receipt at project termination after dismantling the asset or equipment.

15. Capital Recovery Cost :

- It is the annual equivalent cost of the capital cost. If the one time incurring cost in a project is converted into annual basis, it is called capital recovery cost.

16. Opportunity Cost:

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

17. Sunk Cost :

- It is the money that is invested in one project cannot be recovered to invest in the new project. Sunk cost is a cost, already paid, that is not relevant to the decision concerning the future that is being made. Capital already invested that for some reason cannot be retrieved.

18. Marginal Cost :

- Marginal costs are year by year estimates of the costs to own and operate an assets for that year. Marginal cost of the product is the cost of producing an additional cost of that product.
- Let the cost of producing 20 units of a product be $ 10,000, and the cost of producing 21 units of the same product be $ 10,045. Then the marginal cost of producing the 21^{st} unit is $ 45.

19. Inflation :

- An increase in the average price paid for goods and services bringing about reduction in the purchasing power of money.
- Decrease in the purchasing power of money with passage of time.
- The converse of inflation is deflation.

20. Economic Efficiency :

- It is the ratio of output to input of a business system.

  Economic Efficiency = (Worth/Cost) *100%

21. Intangibles:

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

22. Time value of money:

- Since money has the ability to earn interest, its value increases with time.
- It is the relationship between interest and time.

1.8 Definition of Cash Flow

The analysis of events and transactions that affects the cash position of company is termed as cash flow. A cash flow is the statement that shows the actual amount coming into the organization or project or going out from the organization or project. The cash flow may be estimated or observed values. Generally there are two types of transactions occurs in a cash flow:

(a) *Cash Inflow*: The actual amount coming into the organization is called the cash inflow. Examples of cash inflows are receipt, profit, gain, savings, revenue, income etc. The direction of the arrow is always pointing upward and sign convention is positive (+).

(b) *Cash Outflow*: The actual amount going out from the organization is called the cash outflow. Examples of cash outflows are loss, expenses, investment, costs, payment, deposit etc. The direction of the arrow is always pointing downward and sign convention is negative (-).

The difference between the cash inflow and cash outflow in any period of time is called the net cash flow of that period.

$$\textit{Net Cash Flow} = \textit{Cash Inflow} - \textit{Cash Outflow}$$

Cash Flow Diagram

The costs and benefits of engineering projects over time are summarized on a cash flow diagram (CFD). Specifically, CFD illustrates the size, sign, and timing of individual cash flows, and forms the basis for engineering economic analysis. It is difficult to solve a problem if you cannot see it. The easiest way to approach problems in economic analysis is to draw a picture.

The graphical representation of the actual money coming in and going out from the organization in a time scale is called the cash flow diagram. The cash flow diagram is a very important tool in engineering economic analysis, because it form the basis for evaluating alternatives. The cash flow diagram includes what is known, what is estimated, and what is needed. [3]. When the cash flow diagram is drawn, another person should easily understand and able to work on the problem by seeing the diagram.

Features of cash flow diagram

Horizontal line:

It denotes time which marked off in equal increment, one per period up to the duration of project. When time (t) = 0, it represents the present time (beginning of the year 1) and when t=1, it represent the end of time period 1 (end of year 1). In the figure below, year 0 is present time (beginning of year 1) and year 1 is the end of year 1. End of year 1 is the beginning of year 2) as shown in fig: 4.

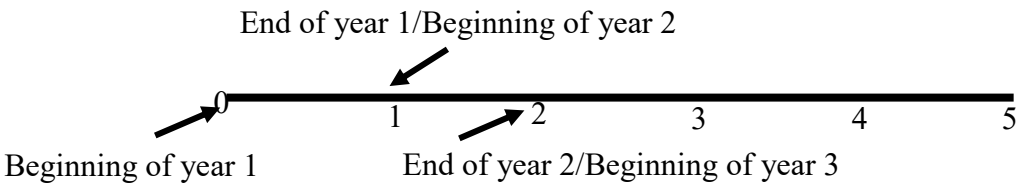

Fig 4: Time scale of cash flow

Arrows:

The direction on the cash flow diagram indicates whether its cash inflow or outflow and is very important in analysis. The upward pointing arrow is positive cash flow i.e. inflow. The downward pointing arrow is negative cash flow i.e. outflow. The positive sign convention is used for cash inflows and negative sign convention is used for the analysis of the problems. The Arrow lengths are approximately proportional to the magnitude of the cash flow as shown in figure 5.

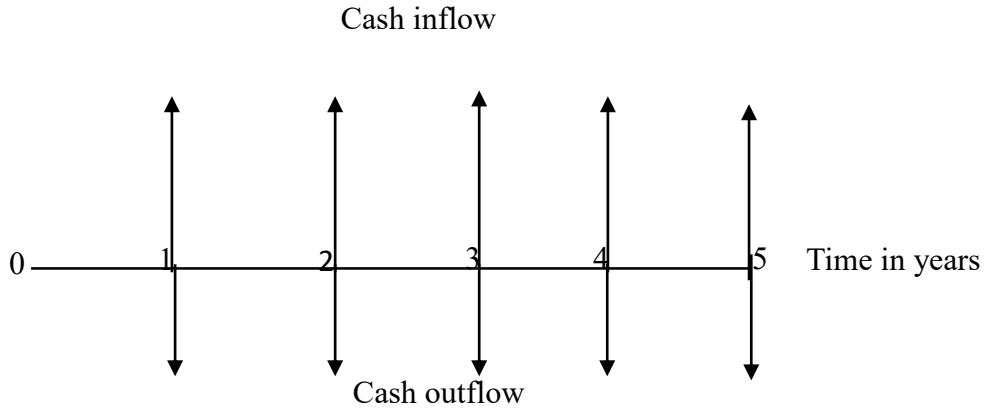

Fig 5: Cash Inflow and outflow

Perspective or Viewpoint

Generally, there are always two parties involved in the cash flow: First is the lender and second is the borrower. The viewpoint must be determined prior placing a sign in each cash flow and diagramming it. The lender's and borrower's cash flow is shown in fig 6 (a) and 6 (b) respectively.

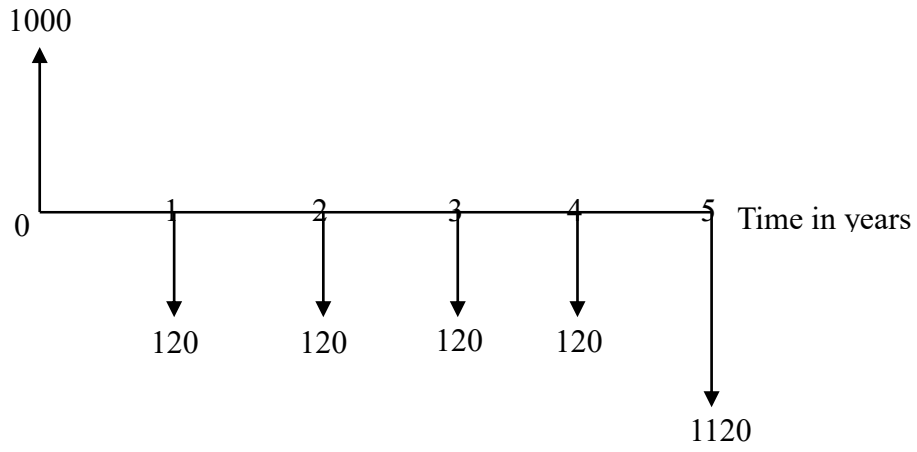

Fig 6 (a): Borrower's Point of view

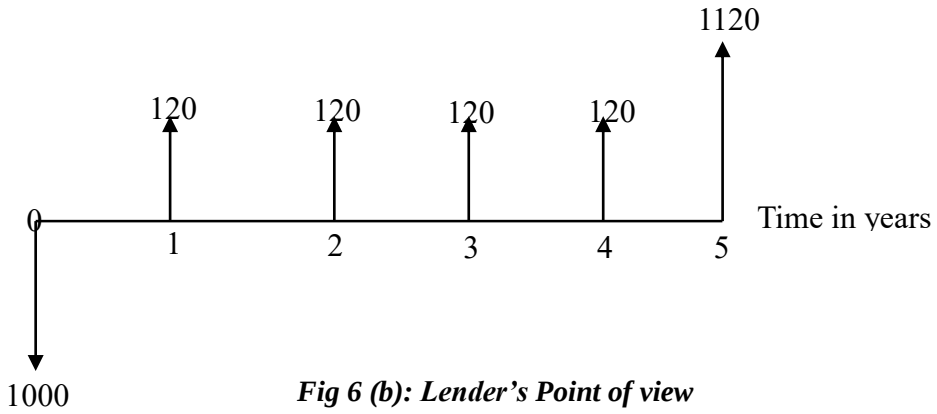

Fig 6 (b): Lender's Point of view

Types of Cash Flow

1. ***Single cash flow:*** the simplest case involves the equivalence of a single present amount and its future worth. The single cash flow formulas deal with the only two amounts; a single present amount P and its future worth F as in figure 7.

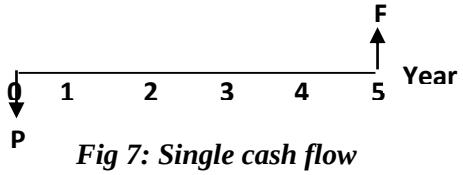

Fig 7: Single cash flow

2. ***Equal (uniform) series:*** In this type, transactions are arranged as a series of equal cash flows at regular intervals, known as an equal payment series (uniform series) (fig: (8). This describes the cash flows of the common instalment loan contract, which arranges repayment of the loan in equal periodic instalments.

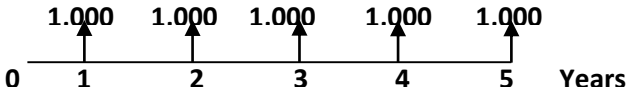

Fig 8: Uniform/equal series cash flow

3. ***Linear gradient series:*** While many transactions involve series of cash flows, the amounts are not always uniform; they may vary in some regular way. One common pattern of variation occurs when each cash flow in a series increases (or decreases) by a fixed amount. This type of cash flow pattern is called linear gradient series. (Figure 9)

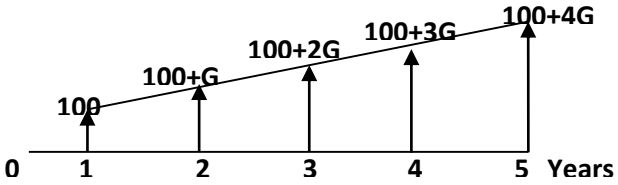

Fig 9: Gradient series cash flow

4. ***Geometric gradient series:*** Another kind of gradient series is formed when the series in cash flow is determined, not by a fixed amount like $ 1,000, but by some fixed rate,

expressed as a percentage. The curving gradient in the diagram of such a series suggests its name which is geometric gradient series. (Figure 9)

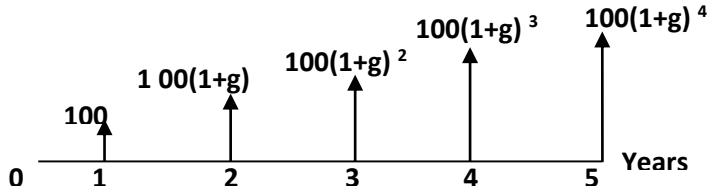

Fig 10: Geometric gradient series cash flow

5. ***Irregular/Uneven Series:*** A series of cash flow may be irregular. It doesn't exhibit an overall regular pattern. (Figure: 11)

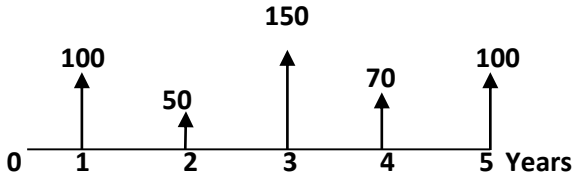

Fig11: Irregular series cash flow

References:

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