Fundamentals of Engineering Economics

أساسيات اقتصاديات الهندسة

Chapter 1: Engineering Economic Decisions

Economics

The study of the production and consumption of goods and the transfer of wealth to produce and obtain those goods.

Engineering Economics

- Previously known as engineering economy.
- Application of engineering and mathematical analysis to decision making in economics.
- Is a subset of economics concerned with the use and application of economic principles in the analysis of engineering decisions.
- Thus, it focuses on the decision-making process, its context and environment.
- It is pragmatic (practical) by nature, integrating economic theory with engineering practice such as price determination, competition and demand/supply.
- As a discipline though, it is closely related to others such as
  - statistics,
  - mathematics, &
  - cost accounting.
- Engineers seek solutions to problems, and the economic viability of each potential solution is normally considered along with the technical aspects.
- Fundamentally, engineering economics involves formulating, estimating, and evaluating economic outcomes when alternatives to accomplish a defined purpose are available.
- Considering the time value of money is central to most engineering economic analyses.

Time Value of Money (TVM)

is a financial concept that states money available today is worth more than the same amount in the future *because of its potential earning capacity* (cost of opportunity).

Cost of Opportunity

Money today can be invested to earn interest or returns. If you delay receiving money, you lose the opportunity to earn on that money.

Some other topics that may be addressed in engineering economics are:

- inflation,
- uncertainty (*risk*),
- replacements,
- depreciation,
- resource depletion,
- taxes,
- tax credits,
- accounting,
- cost estimations, or
- capital financing.

Major topics in engineering industrial economics are:

- the economics of the management,
- operation, growth and profitability of engineering firms,
- macro-level engineering economic trends and issues,
- engineering product markets and demand influences, and
- the development, marketing, and financing of new engineering technologies and products.

Why is engineering economics essential for engineering graduates?

- In today's competitive world of business, it has become essential that engineers should practice financial project analysis for engineering projects and make rational decisions.
- Engineering economy deals with justification and selection of projects.

- Therefore, all engineers, regardless of their employment, should know methods and tools used in *evaluation of projects*.

The purpose of engineering economy is to expose all engineering students to the methods which are widely used for evaluation of projects.
Even though, engineering economy deals mostly with selection of projects in business environment, the tools and methods can be used by:

- *non-profit organizations,* such as government, hospitals, and charitable entities, etc., &
- *individuals*.

Let us present few examples in different environments where engineering economy can facilitate the decision-making process (to determine the best choice):

- **Business Environment (Profit organization)**

A small manufacturing company needs to buy a forklift truck for material handling. Two different brands, say A and B, are being considered. Which truck should be bought? The decision will probably be based on minimization of cost.

- **Non-profit Organizations**

A project for widening a two-lane highway to four lanes is being considered by the county board. A four-lane highway may reduce the traffic accident rate but is expected to lower property values in the immediate neighborhood of the highway. Should the proposed highway be built? The county board must weigh the relative benefit of *lower accident rates* against the *possible loss in value of homes as well as the construction cost*.

- **Individuals**

A new college graduate needs a new car. Should this new car be bought or leased?

Economic factors are as important as the physical laws and science that determine what can be accomplished with engineering.

The following explanation shows how engineering is composed of physical and economic components:

- Physical environment:

Engineers produce products and services depending on physical laws.

$$Efficiency = \frac{System\ output}{System\ input}$$

- Economic environment:

Much less of a quantitative nature is known about economic environments; this is due to *economics being involved with the actions of people, and the structure of organizations*.
Engineers need to manipulate systems to achieve a balance in attributes in both the *physical* and *economic environments*, and within the bounds of *limited resources*.

Following are some examples where engineering economy plays a crucial role:

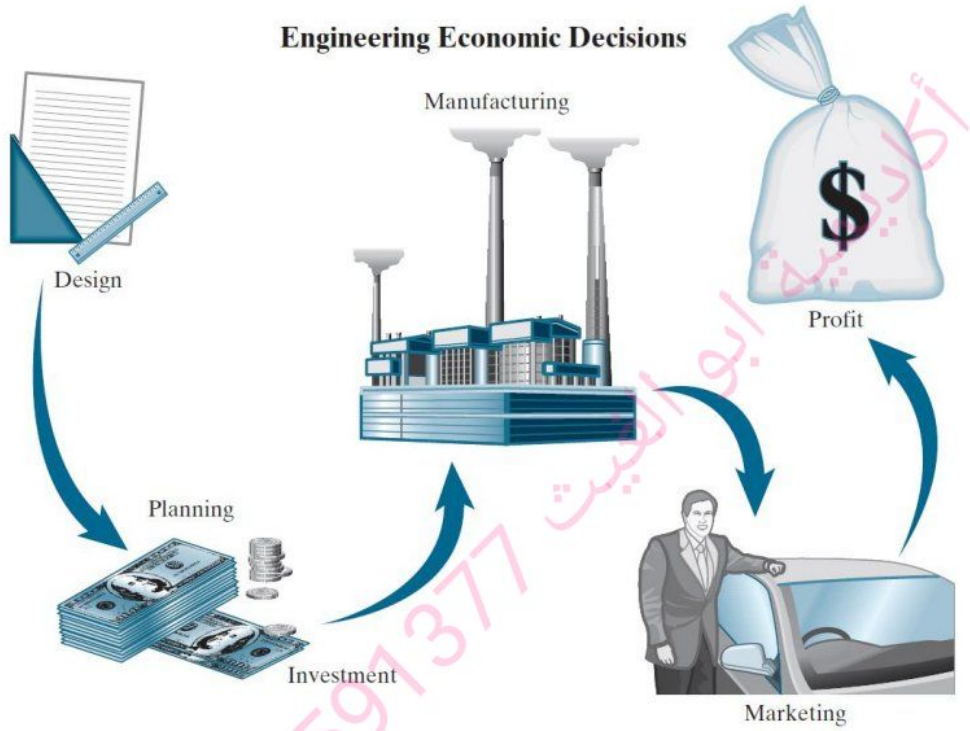
1. Choosing the best design for a high-efficiency gas furnace.
2. Selecting the most suitable robot for a welding operation on an automotive assembly line.
3. Considering the choice between reusable and disposable bottles for high-demand beverages.

With examples 1 and 2 in particular, note that coursework in engineering should provide sufficient means to determine a good design for a furnace, or a suitable robot for an assembly line, but it is the *economic evaluation* that allows the further definition (constraint) of a best design or the most suitable robot.

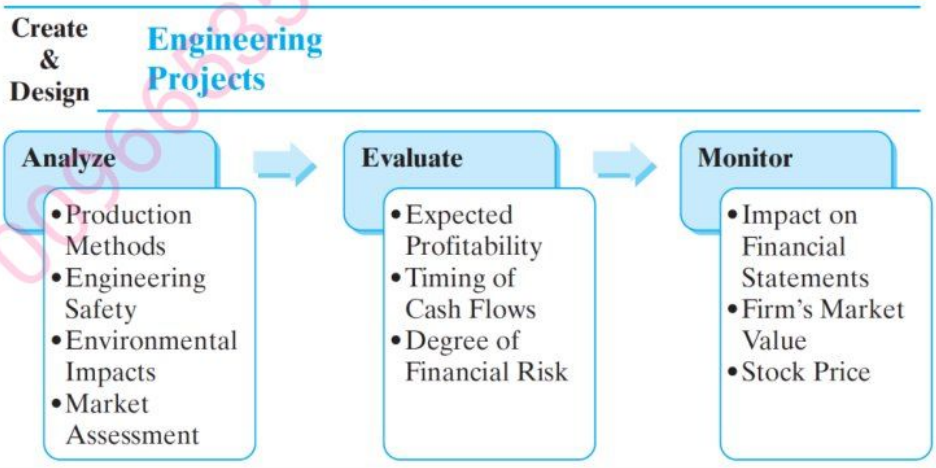
Rational Decision-Making Process

Rational: means a set of reasons or logical basis for a course of action or belief.

1. Recognize a decision problem	→ Need a mobile
2. Define the goals or objectives	→ Want a user-friendly system
3. Collect all the relevant information	→ Search for specifications and prices
4. Identify a set of feasible decision alternatives	→ Choose between Apple and Huawei
5. Select the decision criterion to use	→ Want minimum cost
6. Select the best alternative	→ *Select Huawei*



Role of Engineers in Business



The three financial statements are:

1. the balance sheet,
2. income statement, &
3. statement of cash flows.

What makes economic decisions different from other design decisions?

The answer is simple, as it is all about: **time-variance (changing over time)**.

Design situations are time-invariant (uncertainty/risk is not involved); however, economic situations do change over time (uncertainty/risk is always involved):

In a design situation, engineers use known physical properties, the principles of engineering, correlation and engineering judgement to arrive at a workable and optimal design.

In other words, engineering design to meet a particular need is done today, next year or in five years, time the financial design will not need to change significantly.

In contrast, while an economic situation, the measurement of **investment attractiveness** (& economic desirability) always involves prediction the future, for example:

- Estimating a required investment
- Forecasting a product demand
- Estimating a manufacturing cost
- Estimating a selling price
- Estimating a product life

Economic decisions have to be based on the best information available at the time of the decision and a thorough understanding the **uncertainties** in the forecasted data.

Some of the engineers' roles in industry business:

- Making capital expenditure decision.
- Engineering decision account for the majority of product costs.
- Engineers must consider the effective use of fixed capital assets such as building and machinery.
- With purchase of any fixed asset.
- One of the primary tasks is to plan for the acquisition of equipment.
- Prediction about the future.

Cash Flows vs. Profits

- While profits (revenue minus expenses) show the company's financial performance over a period, they don't fully reflect its ability to reinvest, grow, or sustain itself.
- Cash flows—the actual cash available after accounting for operational and capital expenses—*are more critical*. They determine the company's ability to fund new projects, pay dividends, reduce debt, and ensure long-term growth.
- *Profit is a theoretical measure based on accounting rules*, while cash flow is a *practical measure* of ***liquidity***.

A company can be profitable but still have negative cash flow or struggle with *liquidity* due to factors like:

- **Revenue earned but not yet received:** If most sales are on credit (accounts receivable), profits may look high, but cash is unavailable.
- **Large upfront investments:** High capital expenditures may drain cash even if the company reports a profit.
- **Debt repayment obligations:** Profit does not account for cash used to repay loans.

Market Value of a Company

The market value of a firm, often reflected in its *stock price*, depends on investors' perception of the company's current and future ability to generate wealth for shareholders.

Financial statements & engineering projects:

- Financial statements provide the basis for future investment analysis.
- In practice, we seldom make investment decision based solely on an estimate of projects profitability, because we must also consider the projects overall impact on the financial strength and position of the company.

Types of strategic engineering economic decisions:
Once project ideas are identified, they are typically classified as:

1) new products or product expansion,
2) equipment and process selection,
3) cost reduction,
4) equipment replacement, or
5) service or quality improvement.

At this point, our intention is not to *provide a solution* for each example but to *describe the nature* of decision-making problems a typical engineer might face in the real world.

New Products or Product Expansion	Investments in this category are those that increase the revenues of a company if output is increased. There are two common types of expansion decision problems: • The first type includes decisions about expenditure to increase the output of existing production or distribution facilities. In these situations, we are basically asking, "Shall we build or otherwise acquire a new facility?" • The second type of decision problem includes the consideration of expenditures necessary to *produce a new product* or to *expand into a new geographic area*.
Equipment and Process Selection	Which of several proposed items of equipment shall we purchase for a given purpose? • The choice often hinges on which item is expected to generate the largest savings (or return on the investment). • The choice of material will dictate the manufacturing process involved. • Many factors will affect the ultimate choice of the material, and engineers should consider all major cost elements, such as machinery and equipment, tooling, labor, and material. • Other factors may include press and assembly, production and engineered scrap, the number of dies and tools, and the cycle times for various processes.
Cost Reduction	• A cost-reduction project attempts to lower a firm's operating costs. • Typically, we need to consider whether a company should buy equipment to perform an operation now done manually or in some other way spend money now in order to save more money later. • Or perhaps the firm needs to decide whether to produce a part for a product *in-house* or to buy it from a supplier to reduce the total production cost. This is commonly known as a *make-or-buy (or outsourcing) analysis*.
Equipment Replacement	This category of investment decision involves considering the expenditure necessary to replace worn-out or obsolete equipment. • For example, a company may purchase 10 large presses with the expectation that it will produce stamped metal parts for 10 years. After five years, however, it may become necessary to produce the parts in plastic, which would require retiring the presses early and purchasing plastic-molding machines.
Service or Quality Improvement	• The service sector of the U.S. economy dominates both *gross domestic product (GDP)* and total employment. • It is also the fastest growing part of the economy and the one offering the most fertile opportunities for productivity improvement. For example,

	service activities now approach 80% of U.S. employment, far outstripping sectors such as manufacturing (14%) and agriculture (2%). • Investments in this category include any activities to support the improvement of *productivity, quality, and customer satisfaction* in the service sector, such as in the *financial, healthcare, and retail industries*.

The most crucial factors in engineering economic decisions:

The factors of [1] time and [2] uncertainty (risk) are the defining aspects of any engineering economic decisions (or any investment project).

The four fundamental principles of engineering economics are as follows:

- **Principle 1:** An earlier dollar is worth more than a later dollar.
- **Principle 2:** All that counts is the differences among alternatives.
- **Principle 3:** Marginal revenue must exceed marginal cost.
- **Principle 4:** Additional risk is not taken without expected additional return.

An earlier dollar is worth more than a later dollar

- A fundamental concept in engineering economics is that money has a time value associated with it (TVM).
- Because we can earn interest on money received today (**compound interest**), it is better to receive money earlier than later.
- This concept will be the basic foundation for all engineering project evaluation.
- As noted by *Albert Einstein*, the most powerful force in the universe is compound interest.

$$\mathbf{1,000,000} \times 10\% = 1{,}100{,}000$$
$$1{,}100{,}000 \times 10\% = 1{,}210{,}000$$
$$1{,}210{,}000 \times 10\% = 1{,}331{,}000$$
$$1{,}331{,}000 \times 10\% = 1{,}465{,}100$$
$$1{,}465{,}100 \times 10\% = \mathbf{1{,}610{,}510}$$

All that counts is the differences among alternatives

The opportunity cost of a choice is the value of the best alternative given up.

Marginal revenue must exceed marginal cost

Here, the *marginal revenue* is the additional revenue made possible by increasing the activity by one unit (or a small unit). Similarly, *marginal cost* is the additional cost incurred by the same increase in activity.

Additional risk is not taken without expected additional return

Investors demand a minimum return that must be greater than the anticipated rate of *inflation* or than any perceived *risk*.

Chapter 1 Questions

1.What is Engineering economics?

Previously known as engineering economy, is a subset of economics concerned with the use and "...application of economic principles" in the analysis of engineering decisions.
Thus, it focuses on the decision making process, its context and environment.

2. What are the economic theory integrating with engineering practice?

Such as price determination, competition and demand/supply.

3. What are the discipline, closely related to engineering economics?

statistics, mathematics and cost accounting.

4. Time value of money?

that receiving $13.5 million today is likely to prove a better deal than taking 4853,333 a year for 29 years. (or) should you buy something today or buy it later.

5.What is meant by alternatives or optimum?

opportunity or cost of making one choice over another must also be considered.

Optimum solution: for any kind of problem, ie., decision making, having N type of solution a available. From the among N solution, we choose any one of, according to our situati or sources.

What are topics that may addressed in engineering economics?

Inflation, uncertainty, replacement, depreciation, resource depletion, taxes, tax credi accounting, cost estimation.

Why engineering economics essential for engineering graduates?

Engineers should practice financial project analysis for engineering projects and make a rational decision(accordance with reason or logic).
Engineering economics deals with justification and selection of projects.

Which is the main criteria in the business environment?(for taking decision making)

Profit is the main criteria to take decision in the business environment.

What are the non-profit organization?

Government, Government hospitals, charitable entities etc.,

Definition of profit?

It is financial gain, especially, difference between the amount earned and in the amount spent in buying, operating or producing some thing.

What are the steps in engineering economics decision?

In personal decision:(How do we make)

1. Recognize a decision problem
2. Define the goals or objectives
3. Collect all the relevant information
4. Identify a set of feasible decision alternatives
5. Select the decision criterion to use
6. Select the best alternative

What are major topics in engineering industrial economics?

The economics of the management, operation, growth and profitability of engineering firms.

How do predict the future? (in engineering economics)

Estimating a required investment.
Forecasting a product demand.
Estimating a selling price.
Estimating a manufacturing cost.
Estimating a product life.

Role of engineers in business?

Create a design,
Analysis,
Evaluate

What are the five main types of strategic engineering economic decision are

Service improvement,
Equipment and process selection
Equipment replacement
new product and product expansion
Cost.