Engineering Economy

[1-1]
Introduction
Basic Concepts and Definitions

Scratch your head.

- The presidents of two small businesses play racquetball each week. After several conversation, they have decided that due to their frequent travel that they should evaluate the purchase of a plane jointly owned by the two companies.
- What are some of the typical economic-based questions they should answer as they evaluate the alternatives: 1. co-own…..2. continue as is?

Some questions

- How much will it cost each year? (estimation)
- How will they pay for it? (financing plan)
- Are there tax advantages? (Tax law)
- Which alternative is more cost-effective?
- What is the expected rate of return? (equation)
- What if we use different amount each year? (sensitivity analysis)

So……..what

- As you see from previous example how we incorporated engineering with economy.
- Economy……(cost, tax, and financing)
- Engineering……(mathematical model, and decision making)

What is Engineering Economy?

- Engineering economy is a subset of economy for application to engineering projects

- Engineers seek solutions to problems, and the economic viability (feasibility/sustainability) of each potential alternative or design is normally considered along with the *technical aspects*

- Engineering economy involves the evaluation of the costs and benefits of proposed projects

Why Engineering Economy is Important?

- There are lots of factors that are considered in making decisions
- These factors are combinations of economic and non-economic ones
- Engineers play a major role in investment by making decisions based on economic analysis and design considerations
- Thus, decisions often reflect the engineer's choice of *how to best invest funds* by choosing the proper alternative out of a set of alternatives

Role of Engineering Economy in Decision Making

- Engineers make decisions but tools and computers do not
- Tools assist engineers in making decisions
- Decisions affect what will happen in the future and thus the time frame of engineering economy is the future
- So, engineering economy analysis presents the best estimates of what is expected to occur

Role of Engineering Economy in Decision Making

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

This is the major role of engineering economy

Role of Engineering Economy in Decision Making

- The economic evaluation of alternatives is based on the so called "Measure of Worth" such as:
  - Present worth: amount of money at the current time
  - Future worth: amount of money at some future time
  - Payback period: Number of years to recover the initial investment and a stated rate of return
  - Rate of return: Compound interest rate on unpaid or unrecovered balances
  - Benefit/cost ratio

Role of Engineering Economy in Decision Making

- There are other factors that affect the decision making such as social, environmental, legal, political, personal, …
- This may place less reliance on the economic-based factors yet this also shows the importance of knowing all the involved factors including the economic ones

Time Value of Money

- Time Value of Money (TVM) is an important concept
- TVM is based on the concept that money that you hold today is worth more because you can invest it and earn interest
- For instance, you can invest your dollar for one year at a 6% annual interest rate and accumulate $1.06 at the end of the year
- You can say that the future value of the dollar is $1.06 given a 6% interest rate and a one-year period
- It follows that the present value of the $1.06 you expect to receive in one year is only $1

What is Interest?

- Interest is what you *earn* when you let people borrow your money
- Some call it the *price of renting your money*
- Interest can be thought of as the price a lender charges a borrower for the use of his money
- Interest is the difference between an ending amount of money and the beginning amount

Interest Types

- There are two types of interest:
  - Interest paid: when a person borrows money and repays a larger amount
  - Interest revenue: when a person *saved*, *invested*, or *lent* money and obtains a *return* of a larger amount
- Numerical values are the same for both yet they are *different* in interpretation

Interest Paid

- Interest paid = amount owed *now* – *original* amount

  where the interest is paid over a specific time unit

- If the interest is expressed as a percentage of the original amount then it is called the *interest rate* and expressed as in the following:

$$\textit{Interest rate}\ (\%) = \frac{\textit{Interest accrued}\ \text{per time unit}}{\text{original amount}} \times 100\%\textit{rued}$$

- The time unit of the rate is called the interest period

Interest Earned

- Interest earned = total amount *now* – *original* amount

- Interest earned over a specific period of time is expressed as a percentage of the original amount and is called rate of return (ROR) and is computed from the following:

$$\text{Rate of Return (\%)} = \frac{\text{interest accrued per time unit}}{\text{original amount}} \times 100\%$$

Interest – Example [1]

- An employee borrows $10,000 on May 1 and must repay a total of $10,700 exactly 1 year later

- Determine the interest amount and interest rate paid

- Interest amount = $10,700 - $10,000 = $700

- Interest rate = $700/$10,000 = 7% per year

Interest – Example [2]

- A company plans to borrow $20,000 from a bank for one year at 9% interest for a new recording equipment

- Compute the *interest* and the *total amount* due after 1 year

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- The total interest accrued:
  Interest = $20,000 × 0.09 = $1,800

- The total amount due is the sum of principal and interest:
  Total due = $20,000 + $1,800 = $21,800

Interest – Example [3]

- Calculate the amount deposited one year ago to have $1,000 now at an interest rate of 5% per year

  The total amount accrued ($1,000) is the sum of the original deposit and the earned interest. If "**y**" is the original deposit then,

  Total amount accrued = original + original × interest rate

  $1,000 = y + y(0.05) which gives a value of y = $952.38

- Calculate the amount of interest earned during this time period

  Interest = $1,000 – 952.38 = $47.62

Interest – Example [4]

- Calculate the amount deposited one year ago to have $1,000 as a **net benefit** now at an interest rate of 5% per year

  The total amount accrued after one year of deposition equals the sum of the original deposit and the earned interest. If "**y**" is the original deposit then,

  Total amount accrued = original + original × interest rate

  $y + 1{,}000 = y + y(0.05)$ which gives a value of y = $20,000

Simple and Compound Interest

- In the previous examples, the interest period was 1 year and the interest amount was calculated at the end of one period

- When more than one interest period is involved (e.g. after *3 years*), it is then necessary to state whether the interest is accrued on a *simple* or *compound* basis from one period to the next

Simple and Compound Interest

- Simple interest is named as such because the interest calculated is not compounded

- The total *simple* interest over several periods is computed as:

$$\textit{Interest} = (\textit{principal}) \times (\textit{number of periods}) \times (\textit{interest rate})$$

Simple Interest – Example

- A company loaned money to an engineering staff member for a radio-controlled model airplane. The loan is for $1,000 for 3 years at 5% per year simple interest

- How much money will the engineer repay at the end of 3 years?

- The interest for each of the 3 years is:

  Interest per year = $1,000 × 0.05 = $50

  Total interest for 3 years is $1,000 × 0.05 × 3 = $150

  The amount due after 3 years is $1,000 + $150 = $1,150

Simple Interest – Example

- The $50 interest accrued in the first year and the $50 accrued in the second year do not earn interest

- The interest due each year is calculated **only** on the $1,000 principal

End of Year	Amount Borrowed	Interest	Amount Owed	Amount Paid
0	$1,000	0	0	0
1	-	$50	$1,050	0
2	-	$50	$1,100	0
3	-	$50	$1,150	$1,150

Compound Interest

- Compound interest: it is the interest that accrued for each interest period and is calculated on the principal plus the total amount of interest accumulated in all previous periods

- Thus compound interest means *interest on top of interest*

- Compound interest reflects the effect of the time value of money on the interest

- Compound interest for ***one*** period = (principal + all accrued interest) × (interest rate)

Compound Interest – Example

- If an engineer borrows $1,000 at 5% per year compound interest, compute the total amount due after 3 years

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- The interest and total amount due each year are computed:

Year 1 interest: $1,000 × 0.05 = $50.00

Total amount due after year 1 = $1,000 + $50 = $1,050

Year 2 interest: $1,050 × 0.05 = $52.50

Total amount due after year 2 = $1,050 + $52.5 = $1,102.50

Year 3 interest: $1,102.5 × 0.05 = $55.13

Total amount due after year 3 = $1,102.5 + $55.13 = $1,157.63

Compound Interest – Example

- Another and shorter way to calculate the total amount due after 3 years is to combine calculations rather than perform them on a year-by-year basis. The total due each year is as follows:

Year 1: $1,000 × $(1.05)^1$ = $1,050.00
Year 2: $1,000 × $(1.05)^2$ = $1,102.50
Year 3: $1,000 × $(1.05)^3$ = $1,157.63

- In a general formula:

Total due = principal × $(1 + \text{interest rate})^{\text{number of years}}$

Inflation

- Inflation represents a decrease in the value of a given currency

- Also, inflation indicates a *loss in the purchasing power of money over time*

- For instance, $1 now will not purchase the same number of apples as $1 did 20 years ago

Economic Equivalence

- To compare alternatives that provide the same service over extended periods of time when interest is involved, we must reduce them to an equivalent basis
- Equivalence factors are needed in engineering economy to make cash flows (CF) at different points in time comparable.
- For example, a cash payment that has to be made today cannot be compared directly to a cash payment that must be made by the end of 5 years

Equivalence

- So, economic equivalence means that different sums of money at different times would be equal in economic value

Economic Equivalence

- For example, if the interest rate is 6% per year, $100 today (*present time*) is equivalent to $106 *one year from today*
- So, if someone offered you a gift of $100 today or $106 one year from today, it would make no difference from an economic perspective
- The two sums of money are *equivalent* to each other only when the interest rate is 6% per year
- That is, at a *higher* or *lower* interest rate, $100 today is not equivalent to $106 one year from today
- The same concept applies a year ago, that is a total of $100 today is economically equivalent to $100/1.06 = $94.34