Foundations of Engineering Economy

Session 2-3

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Section 1: Foundations of Engineering Economy

1.1. Why Engineering Economy is Important to Engineers (and other professionals)
1.2. Role of Engineering Economy in decision making
1.3. Performing an Engineering Economy Study
1.4. Interest rate and rate of return
1.5. Economic Equivalence
1.6. Type of interest: Simple and Compound Interest
1.7. Terminology
1.9. MARR
1.10. Cash Flows and their representation
Section 1.1: Why Engineering Economy is Important to Engineers (and other professionals)

• Engineers “Design”

• Engineers must be concerned with the economic aspects of designs and projects they recommend and perform

• Engineers must work within the realm of economics and justification of engineering projects

• Work with limited funds (capital)

• Capital is not unlimited – rationed

• Capital does not belong to the firm
  • Belongs to the Owners of the firm

• Capital is not “free”; it has a “cost”
Section 1.1 Definition

ENGINEERING ECONOMY IS INVOLVED WITH THE FORMULATION, ESTIMATION, AND EVALUATION OF ECONOMIC OUTCOMES WHEN ALTERNATIVES TO ACCOMPLISH A DEFINED PURPOSE ARE AVAILABLE.

ENGINEERING ECONOMY IS INVOLVED WITH THE APPLICATION OF DEFINED MATHEMATICAL RELATIONSHIPS THAT AID IN THE COMPARISON OF ECONOMIC ALTERNATIVES.
Sample questions

• Knowledge of Engineering Economy will have a significant impact on you, personally.
  – Make proper economic comparisons
    • In your every day life (personal)
      – To purchase or to lease a car
      – What type of car to buy
      – Should you invest in the stock market or pay your credit cards
      – Should you buy or rent a house
      – What are graduate studies worth financially over my professional career?
    • In your profession (Engineering and Business decisions)
      – What is the expected profit of a particular investment?
      – Should you pursue a particular risky business venture or invest your money in a money market account
      – What type of process should you use
      – When should you replace a particular machine?
      – Should you buy or produce a particular sub-assembly?
Section 1.2: Role of Engineering Economy in Decision Making

• 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

• Engineering economy is based mainly on estimates of future events – must deal with the future and risk and uncertainty
Section 1.2: Role of Engineering Economy in Decision Making

• The parameters within an engineering economy problem can and will vary over time.

• Parameters that can vary will dictate a numerical outcome – apply and understand..

• Sensitivity Analysis, which plays a major role in the assessment of most, if not all, engineering economy problems.
Section 1.2: Problem Solving Approach

1. Understand the Problem
2. Collect all relevant data/information
3. Define the feasible alternatives and identify the criteria for decision making using one or more attributes
4. Evaluate each alternative
5. Select the “best” alternative
6. Implement and monitor
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Major Role of Engineering Economy
Section 1.2 Problem Solving Approach

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One of the most difficult tasks
Section 1.2 Problem Solving Approach

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Tools
Present Worth, Future Worth
Annual Worth, Rate of Return
Benefit/Cost, Payback, Capitalized Cost, Value Added
Section 1.2: Time Value of Money

• Time Value of Money
  • Money can “make” money if Invested
  • Centers around an interest rate

The change in the amount of money over a given time period is called the time value of money; by far, the most important concept in engineering economy
Section 1.3: Performing a Study

• To have a problem, one must have alternatives (two or more ways to solve a problem)

• Alternative ways to solve a problem must first be identified

• Estimate the cash flows for the alternatives

• Analyze the cash flows for each alternative
Section 1.3: Alternatives

• To analyze must have:
  • Concept of the time value of $$
  • An Interest Rate
  • Some measure of economic worth

• Evaluate and weigh

• Factor in noneconomic parameters

• Select, implement, and monitor
Section 1.3: Needed Parameters

• First cost (investment amounts)
• Estimates of useful or project life
• Estimates of future cash flows (revenues and expenses and salvage values)
• Interest rate
• Inflation and tax effects
Section 1.3: Cash Flows

- Estimate flows of money coming into the firm – revenues, salvage values, etc. (magnitude and timing) – positive cash flows
- Estimates of investment costs, operating costs, taxes paid – negative cash flows
Section 1.3: Alternatives

• Each problem will have at least one alternative – **DO NOTHING**
  • May not be free and may have future costs associated
  • Do not overlook this option!
Section 1.3: Alternatives

- Goal: Define, Evaluate, Select and Execute

The Question: Which One do we accept?
Section 1.3: Mutually Exclusive

• Select One and only one from a set of feasible alternatives

• Once an alternative is selected, the remaining alternatives are excluded at that point.
Section 1.3: More Alternatives

• Goal: Define, Evaluate, Select and Execute

Do Nothing  Alt. 1  .............  Alt. j

Which one do we accept?
Section 1.3: Default Position

• If all of the proposed alternatives are not economically desirable then…

• One usually defaults to the DO-NOTHING alternative
Section 1.3: Taxes

• Taxes represent a significant negative cash flow to the for-profit firm.

• A realistic economic analysis must assess the impact of taxes
  • Called an AFTER-TAX cash flow analysis

• Not considering taxes is called a BEFORE-TAX Cash Flow analysis
Section 1.3: Taxes

• A Before-Tax cash flow analysis (while not as accurate) is often performed as a preliminary analysis.

• A final, more complete analysis should be performed using an After-Tax analysis.

• Both are valuable analysis approaches.
Assignments

- Assignments due for next class
  - Read Chapter 1
  - Explore the student’s resources available in the textbook website.
Interest Rate

• The *borrower’s* perspective: *pay* interest

• Interest paid = Amount owed now – original amount

• Interest Rate = \[ \frac{\text{interest accrued per time unit}}{\text{original amount}} \times 100\% \]
Rate of Return

• The lender’s perspective: earn interest

• Interest earned = total amount now – original amount

• Rate of Return = \[
\frac{\text{interest accrued per time unit}}{\text{original amount}} \times 100\%
\]

• Also know as Return on Investment
Example 1

• Suppose you borrowed $10000 exactly a year ago in a bank and you pay $10,700 today
• What is 1) the interest paid 2) the annual interest rate?
Example 2

• Suppose you put $50 today in a bank that provides an annual interest rate of 5%. What amount will you get back next year?

• Read examples 1.3, 1.4, 1.5
Equivalence

• Example
  – You travel at 68 miles per hour
  – Equivalent to 110 kilometers per hour

• Is “68” equal to “110”?

• No, not in terms of absolute numbers

• But they are “equivalent” in terms of the two measuring scales
  – Miles
  – Kilometers
Economic Equivalence

- Economic Equivalence
- Two sums of money at two different points in time can be made economically equivalent if:
  - We consider an interest rate and,
  - No. of Time periods between the two sums

Equality in terms of Economic Value
$100 now is said to be equivalent to $106 one year from now, if the $100 is invested at the interest rate of 6% per year.

• Read Example 1.6
Types of Interest

• Simple Interest
• Calculated on the principal amount only
• Easy (simple) to calculate
• Read Example 1.7
Simple Interest Example

• Suppose you have $100 and the simple interest rate is 5%.

• How much will your amount grow to in
  – 1 year?
  – 2 years?
  – 3 years?

• Can you derive a general expression of how much your amount would grow to in $n$ years?
Compound Interest

• Compound Interest
  – Interest that not only applies to the initial amount but also to the interest that has accumulated so far
  – Calculating compound interest is slightly more involved
  – Compound interest is the most widely used form of interest today

• Read Example 1.8
Compound Interest Example

• Suppose you have $100 and the compound interest rate is 5%.

• How much would your amount grow to in
  – 1 year?
  – 2 years?
  – 3 years?

• Can you derive a general expression of how much your amount would grow to in $n$ years?
Contrast: Simple and Compound Interest

• For our example,
  • Simple interest after
    – 1 year:
    – 2 years:
    – 3 years:
  • Compound interest after
    – 1 year:
    – 2 years:
    – 3 years:
Simple and Compound Interest Formulas

- Simple interest: Amount after \( n \) years (or interest periods) = (Original Amount) \( \times (1+n\times\text{Interest Rate}) \)

- Compound Interest: Amount after \( n \) years = (Original Amount) \( \times (1+(\text{Interest Rate}/100))^n \)
More on Compound Interest

• Albert Einstein is said to have referred to compound interest as the eighth wonder of the world, the human race's greatest invention, or the most powerful force of the universe.

• Why so? What’s the big deal about compound interest?
Compound Interest: Example

- In 1626, Peter Minuit of the Dutch West India company paid $24 to purchase Manhattan Island in New York from the Indians. In retrospect, if Mr. Minuit had invested $24 in a savings account that earns 8% compound interest, how much would it be worth, say in 2000?
Compound Interest: Example

• Amount owed in 2000, based on simple interest = $24*(1+374*0.08) =$742.08

• Amount owed in 2000 based on compound interest = $24(1+0.08)^{374}=$75,979,388,483,896

• 75 trillion dollars!
Compound Interest: Example

- It is hard to comprehend the magnitude of 75 trillion
- If the amount were divided equally among the population in 2000, each person would get $277,297.
- No way of estimating the cost of Manhattan island today but most real-estate experts would agree that it not anywhere near 1 trillion dollars
- US national debt as of May 15, 2001 was 5.64 trillion dollars
- Source: Engineering Economics, by Chan Park
Terminology

- $P =$ value or amount of money at a time designated as present or as time 0.
  - Also referred to as present worth (PW), present value (PV), net present value (NPV), discounted cash flow (DCF), and capitalized cost (CC)
Terminology

• $F =$ value or amount of money at some future time.
  – Also $F$ is called future worth (FW), future value (FV)
Terminology

• $A = \text{series of consecutive, equal, end-of-period amounts of money.}$
  
  – Also $A$ is called the annual worth (AW) and equivalent uniform annual worth (EUAW)
  
  – Expressed as dollars per year, or dollars per month, or dollars per day

• It is important to note that the symbol $A$ always represents a uniform amount (i.e., the same amount each period) that extends through consecutive interest periods.
Terminology

• $n =$ number of interest periods
  – expressed as some unit of time: usually in years, months, days

• $i =$ interest rate or rate of return per time period
  – Expressed as percent per year, percent per month, percent per day

• Read Examples 1.10, 1-11, 1-12, 1-13, 1-14.
Terminology – Example 1

• A new college graduate has a job with Boeing Airspace. She plans to borrow $10,000 now to help in buying a car. She has arranged to repay the entire principal plus 8% per year interest (compound interest) after 5 years. What does she owe after 5 years? Identify the engineering economy symbols involved in the problem and their values.
Terminology – Example 2

• You plan to make a lump-sum deposit of $5000 into an investment account that pays 6% per year. You plan to withdraw an equal end-of-year amount of $1000 for 5 years, starting next year. At the end of the year, you plan to choose your account by withdrawing the remaining money. Define the engineering economy symbols involved.
Minimum Attractive Rate of Return (MARR)

- Firms will set a minimum interest rate that the financial managers of the firm require that all accepted projects must meet or exceed.
- The rate, once established by the firm is termed the Minimum Attractive Rate of Return (MARR)
- The MARR is expressed as a per cent per year
- Numerous models exist to aid the financial managers is estimating what this rate should be in a given time period.
- An investment is a commitment of funds and resources in a project with the expectation of earning a return over and above the worth of the resources that were committed.
- Economic Efficiency means that the returns should exceed the inputs.
- In the for profit enterprise, economic efficiencies greater than 100% are required!
Cash Flows and their representation

- Cash flows are inflows and outflows of money
- Every person or company has cash receipts – revenue and income (inflows) – and cash disbursements – expenses or costs (outflows)
- Plus signs indicate cash inflows and minus signs indicate cash outflows
Cash Flows and their Representation

• Samples of Cash Inflow estimates:
  – Salaries, revenues
  – Income tax savings
  – Receipts from stock and bond sales

• Samples of Cash Outflow estimates:
  – Engineering design costs
  – Periodic maintenance costs
  – Income taxes
Cash Flows and their Representation

• Cash flow estimates are just estimates.
  – Always some uncertainty involved in estimating cash flows in the future
Cash Flows

• Once cash inflow and outflow estimates are developed, the net cash flow can be determined: 
Net cash flow = cash inflows – cash outflows

• **Important:** End of period convention means that all cash flows are assumed to occur at the end of an interest period.
  – When several receipts and disbursements occur within a given interest period the net cash flow is assumed to occur at the *end* of the interest period
Cash flow Diagrams

• Cash flow diagram is an important tool in economic analysis
• It is a graphical representation of cash flows drawn on a time scale
• In a cash flow diagram, \( t=0 \) is the present, and \( t=1 \) is end of time period 1.
Cash Flow Diagrams
Cash Flow Diagrams

- A sign convention is applied
  - Positive cash flows (inflows) are normally drawn upward from the time line
  - Negative cash flows (outflows) are normally drawn downward from the time line
Cash Flow Diagrams

Positive CF at t = 1

Negative CF’s at t = 2 & 3
Cash Flow Diagrams – Example 1

• Assume $5,000 is borrowed today and payments are $1100 per year starting next year for 5 years

• Draw the cash flow diagram from the lender’s perspective
Lender’s perspective

\[ A = +$1100/yr \]

0 1 2 3 4 5

-\$5,000
Borrower’s perspective

\[ P = +$5,000 \]

\[ A = -$1100/yr \]
Cash Flow Diagram – Example 2

• A father wants to deposit an unknown lump-sum amount into an investment opportunity 2 years from now that is large enough to withdraw $4000 per year for state university tuition for 5 years starting 3 years from now.

• If the rate of return is estimated to be 15.5% per year, construct the cash flow diagram.
Cash Flow Diagrams – Example 2
Assignments

- Assignments due at the beginning of next class:
  - Read the textbooks examples from Chapter 1
  - Answer the true-false questions, matching quizzes and multiple choice quizzes related to chapter 1, on the textbook website and submit your answer electronically to me.
  - Read Chapter 2