Chapter 1 – Foundations of Engineering Economy

INEN 303
Sergiy Butenko
Industrial & Systems Engineering
Texas A&M University

Motivation

- **Engineering Economy**
  offers mathematical techniques to compare engineering projects from an economic point of view.

- **Time Value of Money**
  refers to the change in the amount of money over a given time period.

- **Key Elements - Money, Time & Interest Rate**

Engineering Economy Problems

**Individual**
- Should I borrow money to pay off a credit card?
- Should I buy or lease a new car?

**Corporations and Businesses**
- Are the savings resulting from an investment in a new machine adequate?
- Should a required new space be built or leased?

Economic Alternatives

- Some issues that need to be addressed when comparing two alternatives
  - Periodic costs and revenues (estimates)
  - Selection criterion (measure of worth)
  - Equal service/benefit
  - Tax advantages
  - Inflation
  - Uncertainty!

Engineering Economy – Objectives Restated

- **Cash flows**, inflows (revenues) and outflows (costs) of money over time, estimated for each alternative

- **Economic analysis** requires defining and evaluating measures of worth that account for time value of money to compare alternatives
Interest, Interest Rate and Rate of Return

- Interest is the manifestation of time value of money.

- Interest (paid or earned) = amount owed now – original amount (principal)

- When one party pays, the other earns – just different perspectives.

Interest, Interest Rate and Rate of Return

- Interest Rate and Rate of Return (ROR) are interest accrued over a specific time unit expressed as a percentage of the principal.

  \[
  \text{Rate} = \left( \frac{\text{interest accrued per time unit}}{\text{principal}} \right) \times 100\%
  \]

- Time unit of the rate is known as the "interest period".

Equivalence

- Weight: 1,000 grams = 1 kilogram
- Velocity: 96 km/hr = 60 mph
- Economic: involves time value of money

  - $100 today is equivalent to $106 a year from today at an interest rate of 6% per year.
  - $100 today is equivalent to $100/1.06 = $94.34 one year ago at interest rate of 6% per year.

Simple & Compound Interest

- Interest rate and principal are sufficient to calculate interest accrued for one interest period.

- For multiple periods, interest could accrue in two different ways.

Simple Interest

- Simple interest calculates the interest for each interest period as a fraction \(i\) of the original principle \(P\).

  \[
  \text{Interest} = P \times i \times n
  \]

  Thus interest accrued after \(n\) periods is,

  \[
  = P \times i + P \times i + \ldots + P \times i \quad (n\,\text{times})
  \]

Compound Interest

- Compound interest calculates the interest for each interest period as a fraction \(i\) of the original principle \(P\) plus the total interest accumulated from all previous periods.

  - Amount after 1 period is \(F_1 = P + P \times i = P(1+i)\)
  - Amount after 2 periods is \(F_2 = F_1 + F_1 \times i = F_1 \times (1+i) = P(1+i)^2\)
  - Amount after \(n\) periods is \(F_n = P(1+i)^n\)
  - Interest after \(n\) periods = \(P(1+i)^n - P\)
Illustrative Example

Ex. YYZ group invested $10,000 and withdrew a total of $10,500 exactly one year later. Compute the interest that would have accrued in three years from investment date, if interest was (i) simple (ii) compound.

Solution:

i = (interest/original amount) * 100%

= [($10,500 - $10,000)/$10,000] * 100%

= 5% per year

(i) Simple Interest = P*n*i = 10000*3*0.05 = $1500

(ii) Compound Interest = P(1+i)^n-P = 10000*1.05^3-10000 = $1576.25

Cash Flow Diagram

- Graphical representation of a sequence of cash inflows and cash outflows over a period of time.
- Often estimates are forecasted values or expected values
- These are estimates of an uncertain future
- Techniques presented in this course, assume uncertainty away!
- If interested, look into the last 2 chapters of your textbook

Example:

A person borrows $1,000 and pays back the loan in four periods. The amount at the end of periods 1, 2, and 3 is equal to $160 (interest) and the amount at the end of period 4 is $1,160 (principal plus interest.) Draw the cash flow diagrams for the borrower and the lender.
Solution: The cash flow diagram for the borrower is shown below:

Solution: The cash flow diagram for the lender is shown below:

Notations and Assumptions

- \( P \) = amount of money at present time (time 0)
  - Also referred to as PW (present worth), PV (present value) etc.
- \( F \) = amount of money at future time
  - FW (future worth), FV (future value) etc.
- Compound interest is assumed unless stated otherwise.

Minimum Attractive Rate Of Return

- \( MARR \) = minimum attractive rate of return
  - Hurdle rate for projects established by (financial) management

Cost of Capital

- Cost of capital (CC) is the interest paid to raise capital.
- Ex. Buy a music system using a loan at 10% interest per year. CC = 10%
- Multiple sources for capital financing means a Weighted Average Cost of Capital (WACC) results. \( ROR \geq MARR > WACC \)

\( \checkmark \) Read Section 1.9 MARR
Rule of 72

- Used to estimate the number of years (n), or the rate of return (i) required for a single cash flow amount to double in size
- Compound interest rate expressed as a percentage is used.
  - Estimated $n = \frac{72}{i}$ (i is given)
  - Estimated $i = \frac{72}{n}$ (n is given)

Example 1.10: Jennifer invests $1,000 and likes to double her investment in 7 years. What should be the compounded rate of return?

Solution:
- Estimated $i = \frac{72}{7} = 10.28\%$ per year.
- Find the exact value of $i$.

Rule of 100

- Used to calculate the exact number of years (n), or the rate of return (i) required for a single cash flow amount to double in size
- Simple interest rate expressed as %.
  - $n = \frac{100}{i}$
  - $i = \frac{100}{n}$
- Show why this is exact. Note: i is in % (eg i=6%)
Problem 1.21 p43

A local bank is offering to pay compound interest of 7% per year on new savings accounts. An e-bank is offering 7.5% per year simple interest on a 5-year certificate of deposit. Which offer is more attractive to a company that wants to set aside $1000,000 now for a plant expansion 5 years from now?

Problem 1.21 p43 – Contd.

What should the simple interest rate be, for e-bank to be “just” lucrative?
- Does it depend on the principal?

Problem

A manufacturing company borrowed $400,000 at 10% per year compound interest that requires them to make 3 consecutive, equal, periodic payments that pays off the loan. What is that equal amount?

Spreadsheet Introduction

To find the present value P:
PV (i%,n,A,F)

To find the future value F:
FV (i%,n,A,P)

To find the equal, periodic value A:
PMT (i%,n,P,F)

To find the number of periods n:
NPER (i%,A,P,F)

To find the compound interest rate i:
RATE (n,A,P,F)

To find the compound interest rate i:
IRR (first_cell:last_cell)

To find the present value P of any series:
NPV (i%,second_cell:last_cell) + first_cell